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GSA TODAY

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INSIDE

Metamorphic CO_2 Degassing and Early Cenozoic Paleoclimate

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Challenger mission photo showing the Karakoram and Himalaya Mountain ranges. Photo from the U.S. Department of the Interior, U.S. Geological Survey EROS Data Center.

ABSTRACT

Due in part to enhanced atmospheric CO_2 content, the Eocene was the warmest period in the Cenozoic. Global carbon cycle modeling suggests that metamorphic CO_2 fluxes to the atmosphere of $\geq 10^{18}$ mol/m.y. would have markedly affected the Eocene paleoclimate. The Himalayan orogen, which formed during the closing of the Tethys and consequent Late Cretaceous–Early Tertiary collision of the Indian and Asian plates, is one of the world's largest early Cenozoic metamorphic belts. On the basis of estimates for the duration of prograde metamorphism, volumetric proportions and bulk compositions of CO_2-source rocks, and the total volume of crust undergoing metamorphism, we estimate that between 10^{18} and 10^{19} mol/m.y. of CO_2 were generated at depth by metamorphic degassing in the Himalayan orogen alone. Furthermore, considerable CO_2 may have been generated from early Cenozoic metamorphism in the Mediterranean Tethys and circum-Pacific orogenic belts. If a significant fraction of this CO_2 escaped to Earth's surface, perhaps through focused fluid flow along shear zones such as the Main Central thrust in the Himalaya orogen, there would have been detectable paleoclimatic consequences. India-Asia collision may have contributed to Eocene warming, in addition to proposed post-Eocene cooling.

INTRODUCTION

Freeman and Hays (1992) estimated late Eocene atmospheric CO_2 contents to be about twice the modern value, based on analysis of the carbon isotopic composition of porphyrins from ancient phytoplankton. Using a similar method on bulk organic carbon, M. A. Arthur et al. (1991, personal commun.) reported preliminary Eocene atmospheric CO_2 estimates that are about six times the modern value. This CO_2 would have contributed to greenhouse warming in the Eocene (Fig. 1). CO_2 released to the atmosphere from orogenic metamorphism would have contributed to this enhanced atmospheric content. In this paper, we focus on CO_2 released during Himalayan collisional orogenesis and attempt to quantify the paleoatmospheric consequences of this CO_2 degassing.

There remains considerable uncertainty regarding the sources and fluxes of CO_2 from Earth degassing (Touret, 1992; Varekamp et al., 1992). In contrast to emissions from volcanoes and mid-ocean ridges (e.g., Gerlach, 1991), the past and present fluxes from other sources have received little attention.

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HIMALAYAN METAMORPHIC CO_2 PRODUCTION

The following provides an analysis of factors affecting CO_2 production during Himalayan metamorphism. Quantification of the amount of metamorphic CO_2 produced at depth requires data on the timing and duration of prograde (increasing temperature) metamorphism, bulk compositions and volumetric proportions of CO_2 source rocks, and the total volume of the Himalayan orogen that underwent early Cenozoic metamorphism.

Timing and Duration of Metamorphism

The Himalayan orogen (Fig. 2) formed during Late Cretaceous–early Tertiary time from the closure of the Neo-Tethys and subsequent collision of the Indian and Asian plates (Searle, 1991). Two major phases of metamorphism affected the Himalayan orogen: postcollisional Barrovian-type regional metamorphism that affected a huge volume of rock within the orogen (Fig. 2B), followed in the Oligocene-Miocene by a less extensive, lower pressure regional metamorphism (Sorkhabi and Stump, 1993). The pervasive Barrovian metamorphism may have been the most significant CO_2-producing metamorphic event in the orogen.

Definitive radiometric evidence for early Cenozoic metamorphism is confined to the western part of the Himalayan orogen (i.e., west of Zanskar; Fig. 2B). Treolar et al.'s (1989) analysis implies that prograde metamorphism lasted 5–10 m.y. following

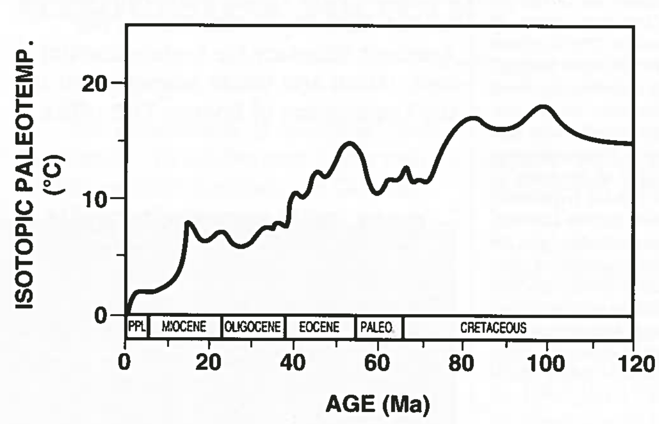

Figure 1. Deep-ocean paleotemperatures derived from benthic foraminiferal oxygen isotopes (from Douglas and Woodruff, 1981). These data indicate the temperature of ocean deep water (a sensitive indicator of global climate change).

collision at 50-55 Ma, and DiPietro (1991) concluded that prograde metamorphism in the Lower Swat area of northern Pakistan lasted 7–16 m.y. and culminated in the late Eocene (ca. 38 Ma). If so, prograde metamorphism would have postdated the late Paleocene warming. However, recent radiometric age determination suggests that metamorphism may have culminated by 45-50 Ma (Smith et al., 1992; Tonarini et al., 1993; Sorkhabi and Stump, 1993). If collision occurred as early as 65 Ma as suggested by Klootwijk et al. (1992) and Smith et al. (1992), prograde metamorphism would have been contemporaneous with the late Paleocene warming. In spite of the lack of definitive geochronologic data, several workers (Hodges and Silverberg, 1988; Hodges et al., 1988; Treloar et al., 1989; Searle et al., 1992) have alluded to the possibility that the Oligocene-Miocene metamorphic event overprinted an earlier Barrovian metamorphism that affected the entire Himalayan orogen.

Geochronologic studies (Treloar et al., 1989; DiPietro, 1991) suggest that prograde metamorphism lasted 5–15 m.y. Coupling this evidence with the duration of prograde metamorphism from the thermal modeling of England et al. (1992) for this orogen, we suggest that the duration of prograde metamorphism may have been as short as 10 m.y.

Bulk-rock Composition and Reaction Progress

Metamorphic CO_2 is produced by the breakdown (decarbonation) of carbonate minerals. We consider two primary metamorphic CO_2 source rock lithologies: carbonates and pelites.

As shown in numerous studies (e.g., Searle, 1991; DiPietro, 1991) all of the primary carbonate lithologies are common within the Himalayan orogen. However, the lack of available petrologic data for the Himalaya metacarbonate rocks precludes determining an average reaction progress for carbonate rocks in the Himalayan orogen. Thus, we computed CO_2 loss for a model carbonate-rock reaction progress

Paleoclimate *continued on p. 62*

Each month, *GSA Today* features a short science article on fast-breaking items or current topics of general interest to the 17,000 members of GSA. What do you think of these articles? Do you have an idea for an article that you would like to see published in *GSA Today*? If so, please contact Eldridge Moores, Science Editor, *GSA Today*, (916) 752-0352, fax 916-752-0951.

IN THIS ISSUE

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The Role of Geoscience in Environmental Matters Is Often Critical, but Geoscientists Typically Need To Take the Initiative

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

In the February issue of *GSA Today,* I pointed out that, as the mission and goals of federal programs are being redefined, a unique opportunity exists for geological scientists to demonstrate the greatest leadership toward solving the complex issues of today and the future. Many of these issues are environmental in nature, and the input of people who understand earth processes is essential to their resolution.

I cannot emphasize strongly enough the importance of bringing geological expertise to bear on important environmental issues and of educating the public about the relevance of geology to these issues! Considering my personal experience, I feel that, had this been done with the problem of disposal of high-level radioactive waste, that particular issue would not have become so polarized and so politicized that a solution now seems unlikely in the foreseeable future. We must not let that happen with other important environmental issues.

In my comments last month I indicated the importance of educating the media, of letting them know what geologic aspects need to be considered and what questions need to be asked. Opportunities continually arise for geoscientists to participate in this educational process, and, by way of illustration, I would like to describe one very significant change taking place in the U.S. Department of Energy (DOE) that will provide some of these opportunities—namely, involvement of the in the DOE decision-making process.

Since July 1992 I have been serving on the Advisory Committee to the Assistant Secretary for Environmental Restoration and Waste Management in the Department of Energy. This office consumes approximately 35% of the resources in the entire department (about $6 billion per year), and it is the single largest environmental program in the world. The two dozen members of the advisory committee (designated EMAC) represent a broad range of interests—citizen groups, unions, Indian nations, appropriate state and federal agencies and organizations, and several specialties (e.g., geoscience). Because of DOE's past reputation for being less than forthright with the public on such matters as radioactive waste disposal, several of us accepted appointment with some reservation.

Although the ultimate proof will be in the implementation, DOE has stated its commitment to involve in the decision process all stakeholders identified with each of its numerous sites destined for environmental restoration, waste management, or other future uses. This position supports specific recommendations presented in a white paper prepared for

IEE *continued on p. 59*

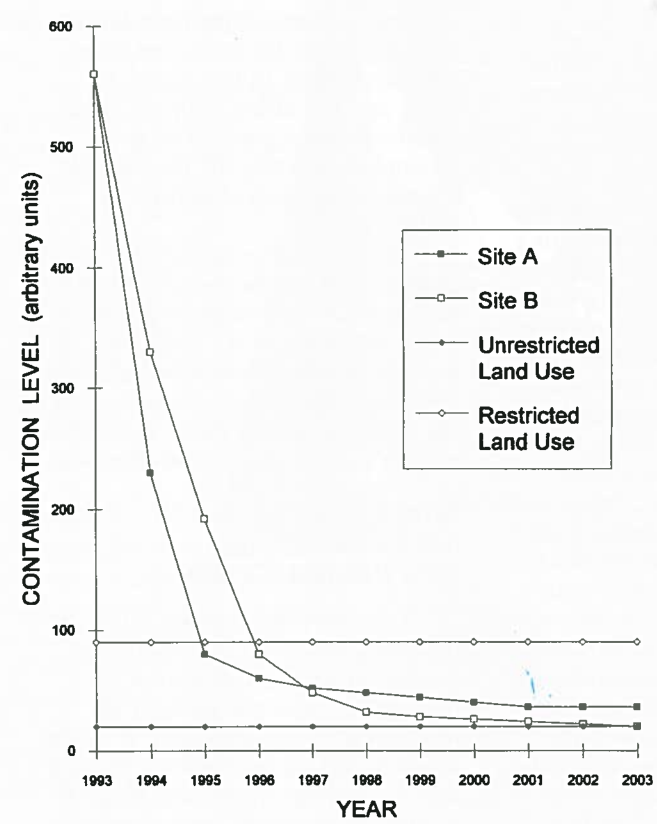

Figure 1. The point of diminishing returns (PDR) at site A occurs at about three years, but little additional benefit (in terms of land use) occurs with continuing cleanup after two years because the unrestricted use level (of contamination) can never be achieved with the applied technology. The PDR at site B occurs at about five years, but because the unrestricted use level (of contamination) is achievable, continued cleanup should be considered. In this example, a decision would be based on the proposed land use and on the available funds.

CALL FOR NOMINATIONS

1994 John C. Frye Environmental Geology Award

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. The award is a $1000 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund.

The 1994 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Seattle. Members of the selection committee are Chairman Frank E. Kottlowski, New Mexico Bureau of Mines and Mineral Resources; John P. Kempton, Illinois Geological Survey; and Diane L. Conrad, Vermont Division of Geology and Mineral Resources.

CRITERIA FOR NOMINATION

Nominations can be made by anyone, based on the following criteria:
(1) paper must be selected from GSA or state geological survey publications, (2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper, (4) **nominations must be sent to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301.**
Deadline: March 31, 1994.

BASIS FOR SELECTION

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

1993 AWARD RECIPIENT NAMED

The 1993 award was presented at the GSA Annual Meeting in Boston to Robert F. Walters, Walters Drilling Company and Adjunct Senior Scientist of the Kansas Geological Survey, for his paper *Gorham Oil Field, Russell County, Kansas,* Bulletin 228 (1991), Kansas Geological Survey. The report describes environmental impacts of the birth, development, and decline of a large oil field, as well as the successful mitigation efforts.

IEE *continued from p. 58*

the department by EMAC's Subcommittee on Land Use. Involvement would be through site-specific advisory boards (SSABs) that would be broadly representative of the diverse stakeholders in a given site's environmental restoration mission. SSABs would, among other functions, assist the department and regulators in organizing and coordinating public-involvement activities related to environmental restoration and waste management.

Continuous application of a cleanup technology at a given site will reduce contamination at a rate that typically diminishes with time. Depending on the nature of the contamination and on the technology, cleanup to levels acceptable for unrestricted land use might be achieved within a few years, achieved only after years of continuous cleanup, or not achievable within institutional lifetimes. One method of evaluating the effectiveness of contamination cleanup is to determine the point (in time) of diminishing returns for reducing the contamination level—that is, the point beyond which continued application of the technology will have negligible effect in reducing contamination (see Fig. 1). The evaluation of alternative land uses must consider the time and expense required, using existing technologies, to achieve sufficient cleanup for a specific use.

Although the hydrogeologist is typically best qualified to assess the potential for successful cleanup where ground water is involved, other geoscientists can provide significant insight where other factors are important. It is my opinion that many sites can never be cleaned up to acceptable standards—either because of limited funds or because of limited existing technology. However, perhaps these sites do not need to be cleaned up in the traditional sense—if the contaminants could be immobilized! Contaminants are of concern only if they can be transported in the accessible environment. If the porosity, and hence permeability, in the disposal environment were reduced to negligible levels, transport could not occur. Who is better qualified than a sedimentary geologist or geochemist to comment on conditions that could cause selective precipitation in a contaminated unit? I find it interesting that few people dealing with hazardous waste sites think of this obvious alternative.

The Department of Energy is responsible for waste management and cleanup of more than 100 contaminated installations in 36 states and territories. The DOE Nuclear Weapons Complex alone, includes facilities and thousands of square miles in 13 states. Numerous opportunities exist, therefore, for geoscientists to become involved with site-specific advisory boards and with education of the local media in these areas. Unfortunately, past experience suggests that in many instances the decisions regarding environmental restoration and waste management at these facilities might be made in the absence of geological input. Perhaps even more unfortunate, the potential value of such input often goes unrecognized. Thus, it is left up to geoscientists to take the initiative. The IEE Public Outreach Program for Geology and the Environment provides one avenue for involvement. Objectives of the program are to heighten public understanding of geoscience and the geological approach to inquiry, to increase the effectiveness of disseminating geoscience information, and to enhance environmental decision making with relevant geoscience.

Later this month IEE will sponsor a day-long symposium at the Cordilleran Section meeting in San Bernardino on *Earth Science in the Public Arena: Strengthening Environmental Decisions with the Geological Approach to Inquiry.* Keynote speakers will include George E. Brown of the U.S. House of Representatives and Assistant Secretary of the Interior Elizabeth Riecke. In addition, Craig Schiffries will address science policy in the post–Cold War era, David Stephenson will speak on science in the public arena, James Davis will provide a California perspective on the role of earth sciences in strengthening environmental decisions, Gordon Gastil will comment on reinventing the contribution of earth scientists to government, Pat Abbott will address earth scientist involvement in the community, and Dottie Stout will speak on popularizing geology for the masses. In the afternoon session, Lucile Jones will speak on communicating earthquake probabilities to the public, Vic Baker will discuss geological reasoning for understanding the environment, Steve Wells will comment on the role of geomorphology and Quaternary geology in environmental issues of the American Southwest, and Carol Creasey will speak on reducing uncertainty in cleanup design at ground-water contamination sites. The afternoon will end with a session organized by Gary Ernst on reform of the 1872 mining law, with 10-minute talks by William Anell, Kathleen Benedetto, John Livermore, Glen Miller, Elysa Rosen, and Debra Struhsecker.

The San Bernardino symposium, and other such efforts to heighten media and public awareness of the role of geoscience in environmental issues, will help geoscientists capitalize on the opportunity that exists for them to demonstrate leadership in solving the complex issues of today and the future. If you are interested in participating in the IEE Public Outreach Program on Geology and the Environment, or simply would like more information, please mail or fax your name and address to IEE Network, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, fax 303-447-1133. ■

Cordilleran Section Meeting Travel Alert

Collapse of some freeway overpasses in the Northridge, California, earthquake on January 17 may affect your route to the GSA Cordilleran Section Meeting in San Bernardino. The routes affected include I-5 (Golden State Freeway) and State Route 14 (Antelope Freeway) just north of the San Fernando Valley, State Route 118 (Simi Valley Freeway) east of Granada Hills, and parts of westbound I-10 (Santa Monica Freeway) between I-405 and Culver City. If you are coming in from the north, come into San Bernardino on I-15 to I-215, to avoid these areas.

About People

The American Geological Institute's 1994 president is GSA Fellow **John J. Amoruso,** Amoruso Petroleum Co., Houston; Fellow **Samuel S. Adams,** Lincoln New Hampshire, is president-elect; Fellow **Maria Luisa B. Crawford,** Bryn Mawr (Pennsylvania) College, is treasurer; Fellow **Holmes A. Semken, Jr.,** University of Iowa, is secretary; Fellow **Stephen H. Stow,** Oak Ridge (Tennessee) National Laboratory, is member at large; and Fellow **Donald C. Haney,** Kentucky Geological Survey, Lexington, is past president.

Fellow **Donald L. Baars,** Kansas Geological Survey, Lawrence, has been elected vice chairman of the North American Commission on Stratigraphic Nomenclature.

Member **Donald DePaolo,** University of California, Berkeley, has been elected to the National Academy of Sciences.

Fellow **Gerald M. Friedman,** Northeastern Science Foundation, Troy, New York, is the 1993 winner of the Association of Earth Science Editors Award for Outstanding Editing or Publishing Contributions as well as the recipient of the John T. Galey Award from the Eastern Section of the American Association of Petroleum Geologists.

The National Geographic Society has honored GSA Fellow **David M. Hopkins** with its Franklin L. Burr Award. Fellow **Frank C. Whitmore,** U.S. Geological Survey (Washington, D.C.) scientist emeritus, received the Arnold Guyot Memorial Award.

Member **Diane Murbach,** Murbach Geotechnical, San Diego, California, has been selected as the 1994 Professional Fellow in Earthquake Hazard Reduction by the Earthquake Engineering Research Institute.

Fellow **Irwin Remson,** Stanford University (California), has received the National Ground Water Association's M. King Hubbert Award; Fellow **William Guyton,** Austin, Texas, received a Life Member Award from the association.

Fellow **Robert C. Whisonant,** Radford University (Virginia), received the 1993 Neil Miner Award from the National Association of Geology Teachers.

Member **Sarah Stoll,** Sheboygan, Wisconsin, has been re-elected editor of *Gaea,* the journal of the Association for Women Geoscientists.

GSA Welcomes AASG as an Associated Society

The Association of American State Geologists (AASG) became GSA's fourteenth associated society on October 27, 1993, when the associated status was approved by the GSA Council.

The AASG represents the state geological surveys in all 50 states and Puerto Rico. Formed to advance the science and practical application of geology and related earth sciences, objectives of the AASG include the exchange of ideas pertaining to programs, techniques, and application to the needs of the changing economy and other state geological survey matters; the dissemination of information to public, private, and governmental and civic organizations; and the coordination and correlation of work in similar or related fields between federal and associated state agencies.

AASG officers for 1994 are President Donald A. Hull, Oregon Department of Geology and Mineral Industries, Portland, Oregon; President-Elect Donald M. Hoskins, Bureau of Topographic and Geologic Survey, Harrisburg, Pennsylvania; Vice-President Norman C. Hester, Indiana Geological Survey, Bloomington, Indiana; and Secretary-Treasurer Walter Schmidt, Florida Geological Survey, Tallahassee, Florida.

GSA's Associated Societies

The Paleontological Society was the first to affiliate with GSA in this way, in 1909. The Mineralogical Society of America and the Society of Economic Geologists became associated societies in 1920, the Society of Vertebrate Paleontology in 1941, the Geochemical Society in 1956, the National Association of Geology Teachers in 1960, the Geoscience Information Society in 1967, the Cushman Foundation in 1975, and Sigma Gamma Epsilon in 1987. In 1988, the Association for Women Geoscientists, the National Earth Science Teachers Association, and the Association of Geoscientists for International Development became GSA Associated Societies, followed in 1993 by the National Association of Black Geologists and Geophysicists.

The bylaws of GSA provide for associated status for "any national or international society that has aims consistent with those of The Geological Society of America, that is, the advancement of the science of geology." On approval by the GSA Council, societies become associated with GSA "for the purpose of cooperation in annual, sectional, or divisional meetings, in publications, or in other appropriate ways." The GSA Council considers scientific and disciplinary orientation, status as a nonprofit organization, intention to participate in GSA annual meetings on a regular basis, and size of membership. Association of a society with GSA involves no financial obligation. It encourages joint ventures such as symposia, field trips, and publications. ■

GSAF UPDATE

Robert L. Fuchs

Bruce Reed Fund to Support Alaska Research

Family and friends of Bruce L. "Biff" Reed have established the Reed Scholarship Fund to provide research grants to graduate students pursuing studies in Alaska. The primary aim of the fund is to support graduate research in the tectonic and magmatic evolution of Alaska and its mineral deposits. Other geological studies in the northernmost and largest state can also be funded. Award recipients will be selected by the GSA Committee on Research Grants, which meets in early April 1994.

Biff Reed was a 30-year employee of the USGS, working in the Anchorage, Alaska, office. He played a significant role in the 1971 establishment of this regional USGS office. Prior to 1971 he was headquartered in Menlo Park, California, but spent his summers conducting geologic investigations in the vast unmapped areas of Alaska. He was considered an authority on the geology of Alaska and also a leading expert on the economic geology of tin deposits. He wrote or was coauthor of numerous papers on Alaskan geology. As the Survey's tin commodity geologist, his expertise was recognized worldwide, and he served on numerous international committees and project teams that dealt with this metal.

Born in Maine in 1934, Biff Reed began his career with several important firsts, including first graduate of his hometown school system to obtain a Ph.D. and youngest pilot licensed in the state of Maine. Aviation played an important role throughout his life. He owned a float plane for 30 years and used it to support geological field parties in remote areas of Alaska, as well as for pleasure trips to the family camp. Biff's avid interest in geology was matched by his strong interest in the outdoors, particularly the extensive wilderness areas of Alaska.

He graduated from the University of Maine with a bachelor's degree in geology. Subsequently he received the master's degree from Washington State University and a doctorate from Harvard University. He joined GSA in 1960 and was a Fellow at the time of his death in July 1993.

Susan Andrews Reed, his wife, has been instrumental in establishing the Reed Scholarship Fund, assisted by Biff's daughters and other members of the family. Initial gifts include a matching contribution from the ARCO Foundation. In presenting the funds to the Foundation, Susan Reed noted, "This Fund in memory of Biff is the most appropriate way to remember him and his love for geology and Alaska. The understanding of this state that he and his colleagues developed over many years will continue to be expanded in the future through these research grants."

Contributions to the Reed Scholarship Fund from friends and colleagues can be sent directly to the GSA Foundation. Please note the designation on your check or use the coupon accompanying this article. The Reed Fund joins the Foundation's Dillon Fund, which, since its establishment in 1988, has funded five graduate student research grants in Alaskan geology.

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SAGE REMARKS

Edward E. "Dr. Ed" Geary, Educational Programs Coordinator

1993 Educational Programs Summary

The SAGE program continues to grow and expand. In 1993 SAGE handled 805 requests for information and materials, a substantial increase from the 529 requests received in 1992. In 1993 we also (1) planned and convened three national earth science education conferences, (2) watched the Partners for Excellence Program grow from 500 to 737 members, (3) developed an internal GSA communications network on education, (4) helped with the formation of two earth science education coalitions, one state (CESSEN) and one national (CESE), (5) made several awards to outstanding K–12 earth science teachers, (6) began development of several projects and products, and (7) submitted a number of funding requests to national and regional foundations to fund these projects.

We are pleased to report that more than 300 K–12 teachers participated in 1993 GSA meeting activities. As in previous years, hundreds of GSA members volunteered their time, expertise, and energy to make these and other SAGE activities possible. The year was also marked by the addition of Barbara Mieras, Ph.D., to the SAGE staff on a part-time basis. In 1994, contingent upon funding from non-GSA sources, we anticipate continued, moderate expansion of SAGE programs, staff, and products.

1993 Education Conferences

GSA Presidential Conference

"Earth Science Education: Crossing the College-K–12 Barrier" was the subject of the first GSA Presidential Conference, proposed by 1992 President E-an Zen. Fifty-three participants from across the country attended the conference. Participants included university presidents, state and district science supervisors, elementary and secondary teachers, and deans and professors of science education, earth science, and education, as well as members of the National Science Standards working groups, and educators from several professional organizations. The conference was supported by NSF and the Johnson Foundation.

During the conference, participants discussed and developed regional plans to address key issues that currently limit the effectiveness of earth science teaching. The two primary focus issues were (1) imbalances in the promotion and tenure systems at colleges and universities, and (2) the perception that earth science is generally less well regarded as a science than biology, chemistry, or physics. This perception is held by a large number of students, teachers, administrators, and general public. Professional development issues were also discussed with regard to strengthening the training, support, and encouragement of good earth science teaching in elementary, secondary, and college classrooms.

Conference To Create the Coalition for Earth Science Education (CESE)

This conference brought together 45 representatives of organizations involved in K–16 earth science education. All earth and space science disciplines were included in this effort, as were a variety of science teacher organizations and individual K–12 teachers. Participants discussed the vision, mission, and goals of CESE, shared information, and developed ideas for collaboration during the next year. By meeting's end all individual participants agreed to go back to their councils and management boards to explain the benefits to their organization of belonging to CESE. This conference was partially supported by the Johnson Foundation.

Conference To Create Centers for Earth Science Excellence

The initial focus of this effort was to plan a program to create regional centers for earth science education excellence. As envisioned, each center would have addressed the needs of earth science teachers in a given geographic region. Centers would offer numerous professional development opportunities in earth science and serve as earth science resource, partnering, and information clearinghouses. However, at the May 1993 meeting, participants suggested that central control over these centers was not politically feasible or logistically desirable. Participants suggested that GSA act less in a director's role and more as a catalyst to create centers for excellence.

In response to these suggestions, GSA initiated Project Earth S.E.E.D. (Science Education Enhancement and Dissemination), a program designed to catalyze the development of new teacher enhancement programs in all parts of the country. GSA has submitted a preliminary proposal to NSF for support of this project. In addition, we are working on a *Guidebook for Creating*

SAGE *continued on p. 87*

GSAF Update *continued*

Life Insurance— A Versatile Financial Tool

Just about everyone has contact with life insurance over the course of a lifetime. Heads of families purchase insurance to provide financial security for spouses and children in the event of death. Employers provide life insurance to employees as a job benefit. Parents use life insurance policies to fund college educations. Retirees may derive income from policies put in place many years before. Contributors to charitable organizations often leverage gifts with life insurance policies or proceeds.

There are two basic forms of life insurance, term insurance and cash value insurance. Term is pure life insurance protection and may be considered as a way to spread the risk of death. Since the chances of death increase with age, term insurance premiums increase with the age of the insured. For example, the chance of death at age 35 is 2.51 per 1000, whereas at age 75 it is 73.37 per 1000. Therefore, the 75-year-old person must pay a much higher premium than the 35 year old.

Cash value insurance comes in many forms and represents a complex spreading of the risk of death. The premium may be well in excess of the mortality risk for many years, building up a cash reserve that generates earnings for the policy. This cash value may be recovered by the policyholder or beneficiary, or left in place to provide extended death benefits. Some of the types of cash value insurance are whole life, universal life, variable life, endowment, and single premium.

There are many features of cash value life insurance that can be used to one's financial advantage:

- The life insurance policy is a source of money. The policyholder can easily and quickly borrow at low interest rates against the cash value.
- Beneficiaries of life insurance policies receive the money free of income tax.
- With proper design, life insurance proceeds can pass from one's estate without being subject to estate taxes.
- Life insurance can be used in business arrangements such as for a buyout in a closely held company.
- Life insurance can be converted to an annuity that will provide retirement income.
- A life insurance policy can be the method of making a very meaningful contribution to the GSA Foundation.

Life insurance is an excellent and popular charitable device. A substantial gift can result from a series of modest premium payments during the donor's lifetime. By making the Foundation the owner or beneficiary of the policy, at the donor's death, a gift of a definite amount passes to the Foundation. Further, the gift bypasses probate and is not tied up in estate administration. If the Foundation is made the owner of the policy through a gift of the policy during the donor's lifetime, premiums paid subsequent to the date of the gift are tax deductible. Also, there is a charitable deduction in the year of the gift equal to the cash value of the policy at that time.

One of GSA's members has made the Foundation the beneficiary of his universal life policy. Under the terms of his policy, which has a face amount of $25,000 and carries annual premiums of $720, the accumulated cash value belongs to the insurance company, so as time passes the earnings on this cash value increase and the insured's premiums actually decrease. Should the member cease paying premiums now, the policy would remain in full force until 2004, because of this cash value.

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from the average orogenic carbonate rock bulk composition of Ronov et al. (1990). For this bulk composition, we assume that all MgO (4.10 wt%) and Al_2O_3 (3.44 wt%) are assigned to tremolite and zoisite, respectively, in the greenschist facies, whereas these components are assigned to diopside and grossular, respectively, in the amphibolite facies. Model reactions to form these phases are

5 dolomite + 8 quartz + H_2O
= tremolite + 3 calcite + $7CO_2$,

3 anorthite + calcite + H_2O
= 2 zoisite + CO_2

for the greenschist facies, and

dolomite + 2 quartz
= diopside + $2CO_2$

anorthite + 2 calcite + quartz
= grossular + $2CO_2$

for the amphibolite facies. Coupling these reactions with the average orogenic carbonate bulk rock composition given by Ronov et al. (1990), approximately 7% (by weight) of CO_2 would be lost in forming a (fictive) low-grade (greenschist facies) tremolite-zoisite assemblage, whereas ~12 wt% CO_2 would be evolved in metamorphism to a (fictive) diopside-grossular assemblage in the amphibolite facies. We stress that these reactions are utilized for mass balance calculations, and are not intended to represent the actual reactions that formed calc-silicate assemblages in metacarbonate rocks. Nevertheless, the calc-silicates formed by the above reactions are typical of those in metacarbonate rocks of the greenschist facies and amphibolite facies. Our approach is similar to that of Symmes and Ferry (1991), who quantified the reaction progress of pelitic schists using an average bulk composition of shale.

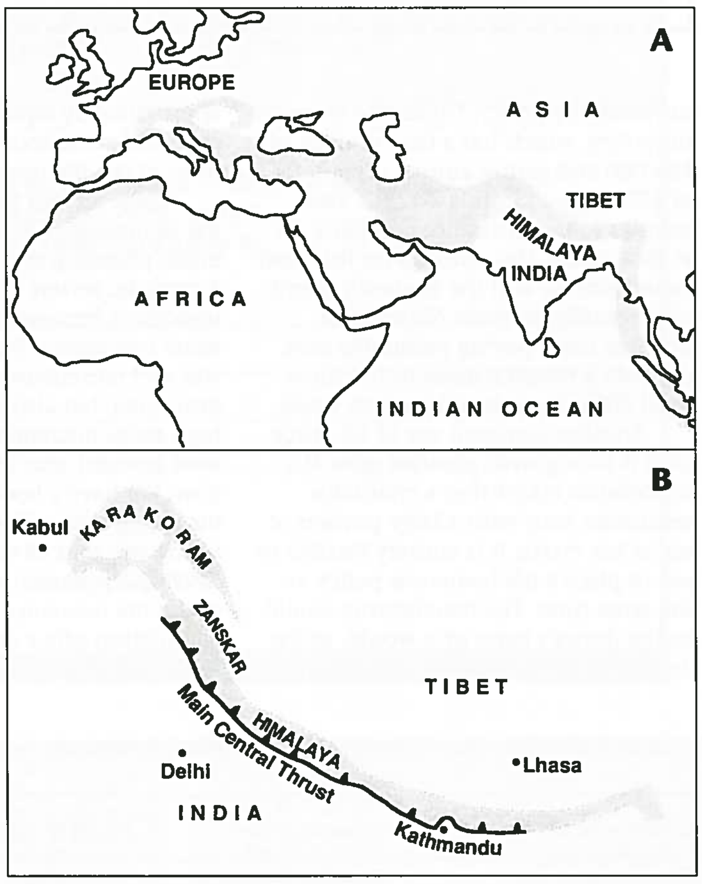

Figure. 2. A: The Tethyan Mesozoic-Cenozoic orogenic belt (shaded); modified from Spencer (1974). B: The Himalayan orogen, showing Searle's (1991) depiction of the 2500-km-long area affected by Barrovian regional metamorphism (shaded).

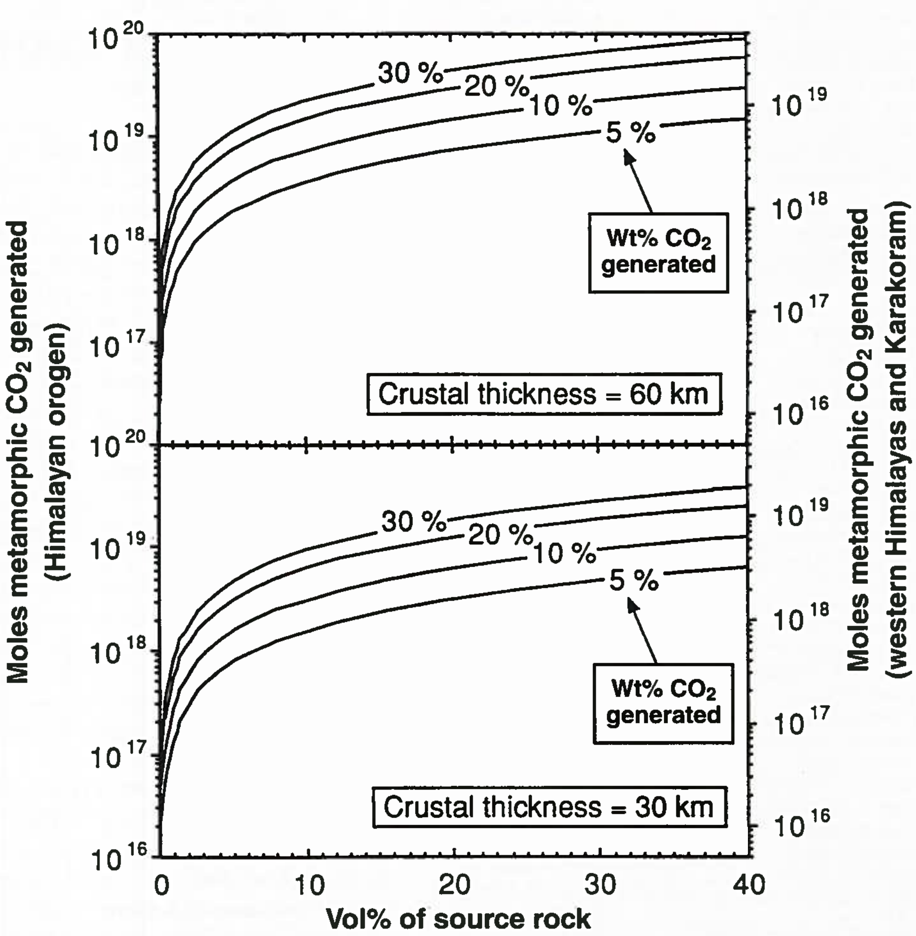

Figure 3. Computed total metamorphic CO_2 production for the Himalayan orogen as a function of the volumetric percentage of metamorphic CO_2 source rocks. The isopleths represent selected values of the weight % CO_2 produced by metamorphic decarbonation. The ordinate on the right represents the northwestern part of the Himalayan orogen; the ordinate on the left refers to the entire Himalayan orogen (see text for discussion).

On average, pelitic sediments (shales) have ~5 wt% CO_2 (Symmes and Ferry, 1991). Following Ferry (1983), we assume that this CO_2 is largely released upon metamorphism in the lower greenschist facies.

Volumetric Proportions of CO_2 Source Rocks

The literature provides surprisingly little quantitative information on the volumetric proportions of metamorphic CO_2 source rocks within the area affected by the Eocene metamorphism. Thus, we used volumetric estimates of metacarbonate and metapelitic rocks that were obtained through communication with several experts in Himalaya geology (see Acknowledgments). Based on their estimates, we suggest that the western half of the Himalaya orogen (i.e., Zanskar and west) contains ~20–30 vol% metacarbonate, and 5%–10% metapelites, whereas the central and eastern parts of the orogen contain approximately 10%–20% metacarbonates and 20%–30% metapelites.

Total Volume of the Himalayan Metamorphic Belt

Computation of the total CO_2 released requires an estimate of the total volume of the orogen that underwent postcollisional metamorphism. This volume was derived from the area of exposed metamorphic rock (Fig. 2B) and the assumption that metamorphism extended to a depth of 60 km (Searle, 1991).

Computed Metamorphic CO_2 Production

Our computed metamorphic CO_2 production from the Himalayan orogen is given in Figure 3. If, as discussed above, we assume that the western half of the orogen contains 20–30 vol% metacarbonate rocks, and that metacarbonates release 10–15 wt%, this lithology would have yielded $>10^{19}$ mol of CO_2. Assuming pelitic rocks constitute 5–10 vol% of the western half of the orogen, and that pelites release ~5 wt% during metamorphism, pelites would have contributed ~10^{18} moles.

On the basis of the volumetric estimates of metacarbonate and metapelitic rocks in the central and eastern part of the orogen, we estimate that ~10^{19} mol of CO_2 were produced. Assuming that prograde metamorphism lasted 10 m.y. in this part of the orogen, we estimate that approximately 10^{18} mol of CO_2 were released over a 1 m.y. period. Combining this with the estimated CO_2 production from the western part of the orogen, we conclude that for the entire Himalayan orogen a total CO_2 of well above 10^{18} mol/m.y. could have been produced at depth. This CO_2 far exceeds the present atmospheric CO_2 reservoir (~6 x 10^{16} mol) and is larger than the present combined ocean-atmosphere inorganic carbon reservoir (~3 x 10^{18} mol).

Our computations assumed that CO_2 was linearly released during a 10 m.y. period of prograde metamorphism. However, for impure carbonate rocks (Ferry, 1983; Labotka et al., 1988), CO_2 release is not a linear function of metamorphic grade; rather, much of the CO_2 is lost at the lowest metamorphic grades. Accordingly, there would be a significant loss of CO_2 during the early, low-grade (greenschist facies) period of prograde metamorphism. Consequently, the time period for release of substantial metamorphic CO_2 in the Himalayan orogen would be compressed in comparison with the model of linear release of CO_2 with metamorphic grade. Considering a linear heating rate over a 10 m.y. period with the assumption that much of the CO_2 is released during progradation through lower greenschist facies metamorphic conditions (~350–450 °C), the bulk of CO_2 release during the Himalayan metamorphism could have occurred over a few million years. This would yield CO_2 production rates that are two to four times larger than the values computed with a model of linear production of CO_2 over a 10 m.y. period.

CO_2 Transport to the Surface

On the basis of the above calculations, we conclude that the amount and production rate of metamorphic CO_2 generated during the Eocene Himalayan metamorphism could have significantly perturbed the atmospheric CO_2 concentration. However, this conclusion hinges on adequate flux of the CO_2 to Earth's surface.

Thompson and Connolly (1992) concluded that significant advective flux of metamorphic fluids occurs by focused fluid flow along lithological contacts, faults, and shear zones. There appears to be a correlation between fluid motion in fault zones and earthquake activity (Sibson, 1992); thus, focused expulsion of metamorphic CO_2 would be aided by seismic activity in orogens. Transient seismicity should yield enhanced, short-term expulsion of volatiles, thereby having a potentially important short-term climatic effect. The very large fluid/rock ratios of ~10^4 for mineralized fractures (Thompson and Connolly, 1992) attest to the efficacy of fluid flow along fractures in metamorphic rocks. Expulsion of advecting volatiles is favored by hydrofracturing resulting from the thermal expansion of volatiles that occurs during advection to shallow depths (Norris and Henley, 1976). As speculated by Oliver (1986), expulsion of significant amounts of metamorphic volatiles from major shear zones may account for the near-surface concentration of natural gas and anthracite coal deposits. The lowest grade rocks, which are considered to have been a major source for metamorphic CO_2 (as discussed above) are in the shallower parts of the Himalayan orogen (see Searle, 1991, Fig. 14.1). In addition to comparatively short distances of transport of volatiles to Earth's surface, shallow depths would facilitate brittle deformation (fracturing and faulting) that would provide channelways for escape of volatiles to the surface (Thompson and Connolly, 1992).

Support for the discharge of significant quantities of metamorphic CO_2 to the atmosphere is provided by Barnes et al. (1978, 1984), who carried out a comprehensive study of the correlation between the present-day global distribution of major zones of seismicity and CO_2 discharged from hot springs. Using ^{13}C stable isotope data of gases, coupled with the spatial correlation between areas of CO_2 discharge, zones of seismicity, and areas with high heat flow, they concluded that CO_2 discharged from seismically active regions of Europe and Asia and from the circum-Pacific belt is largely derived from contemporary metamorphism of carbonates.

Numerous studies suggest that significant focused fluid flux occurred along the extensive (>2000 km long) Main Central thrust (Fig. 2B). Copeland et al. (1991) concluded that a large flux of hydrothermal fluid occurred along

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the thrust during a 1 m.y. period in the Pliocene and that "CO_2 may make up a significant fraction" of the fluid. A significant flux of metamorphic CO_2 in the Main Central thrust zone is supported by the fluid inclusion studies of Pêcher (1979) and Craw (1990). As noted by Craw (1990), hot springs near the thrust zone attest to contemporary focused flow of hydrothermal fluids, and the CO_2-rich compositions of the effluents (Grimaud et al., 1985; Absar et al., 1991) support the hypothesis that the Main Central thrust and/or similar shear zones could have provided a conduit for the escape to Earth's surface of significant quantities of metamorphic CO_2 generated during the Eocene Himalayan metamorphism.

CO_2 FROM EARLY CENOZOIC METAMORPHISM IN OTHER OROGENIC BELTS

To derive a global flux of atmospheric CO_2 produced from early Cenozoic metamorphism, we must consider the integrated flux from all orogens undergoing simultaneous regional metamorphism.

In addition to the Himalaya sector, the Mediterranean Tethys (Fig. 4) contains a large area of rocks that underwent early Cenozoic regional metamorphism (Papanikolaou, 1984; Okrusch and Bröcker, 1990). Marble and calc-silicate rocks are abundant in the Hellenides and Cyclades of Greece and the Menderez massif in western Turkey (Fig. 4); however, the proportion and bulk compositions of CO_2 source rocks cannot be estimated with certainty (M. J. Bickle and A. I. Okay, personal commun.). Provisionally assuming that the proportions of carbonate lithologies in the Mediterranean Tethys are the same as in the Himalayas, the Mediterranean Tethys would produce ~10^{18} mol of CO_2/m.y.

Within the circum-Pacific orogenic belt, Eocene metamorphism has been documented for New Caledonia (Brothers and Yokoyama, 1982), the Hidaka Belt of Japan (Osani et al., 1992), and the Cordilleran belt of western North America (Greenwood et al., 1991). The Eocene metamorphic belt in western North America may considerably exceed the size of the Eocene Himalayan metamorphic belt (L. S. Hollister, personal commun.). We are pursuing further study of present and past metamorphic CO_2 evolution in the circum-Pacific orogen.

In light of the integrated metamorphic flux from the Tethys and circum-Pacific orogens, the early Cenozoic global production of metamorphic CO_2 could have been 10^{18}–10^{19} mol/m.y. If a significant portion of the metamorphic CO_2 produced at depth escaped to Earth's surface, the flux could have been $\geq 10^{18}$ mol/m.y., thereby significantly affecting the Eocene paleoatmosphere (see discussion below).

FYFE'S ANALYSIS

In a brief but illuminating analysis of the significance of metamorphic decarbonation as a source of atmospheric CO_2, Fyfe (1986) concluded that "a significant perturbation of global CO_2 could result from a Himalayan [orogenic] event," and that "major continental collisions and minor overthrust events associated with transform faults can lead to massive [CO_2] degassing." However, Fyfe's analysis involved the metamorphism of an idealized 1-km-thick carbonate slab of uniform composition, and included no attempt to model explicitly the impact of the degassed CO_2 on atmospheric CO_2 content or climate. Fyfe computed a total CO_2 production from the Himalayan metamorphism of 10^{18} mol. However, using Fyfe's assumptions and correcting for an apparent error in his computation, we obtain instead a total CO_2 production of 4.5 x 10^{19} mol. In addition to the Himalayan orogenic belt, Fyfe's (1986) computations assumed that metamorphism encompassed the Tibetan plateau. In contrast, our estimate of the total volume of crust undergoing metamorphism was based only on the exposed area of metamorphic rocks within the Himalayan orogen (Fig. 2B). The India-Asia collision may have resulted in the transfer of large volumes of crust below the Tibetan plateau (Le Pichon et al., 1992). Le Pichon et al. (1992) estimated that ~5 x 10^7 km^3 of crust could have been involved in this underthrusting. No conclusions can be reached regarding the possible role of the sub-Tibetan crust in the Himalayan metamorphism. However, it is notable that Le Pichon et al.'s (1992) estimate of the volume of crust that was underthrust beneath the Tibetan plateau considerably exceeds our estimate of 1.2 x 10^7 km^3 for the volume of crust subjected to Himalayan metamorphism. If some of the sub-Tibetan crust were involved in the postcollisional metamorphism, this could have contributed to additional release of metamorphic volatiles, such that our estimates of CO_2 production based on the exposed area of Barrovian metamorphism (Fig. 2B) would provide a minimum estimate of metamorphic CO_2 production.

EFFECT OF METAMORPHIC CO_2 DEGASSING ON EARLY CENOZOIC PALEOCLIMATE

To estimate the impact of CO_2 releases over periods of 10^5 yr and longer, we must consider the effect of CO_2 consumption by silicate weathering and subsequent carbonate sedimentation (Walker et al., 1981). Silicate weathering can be schematically represented (Berner et al., 1983) by

$$CaSiO_3 + 2CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO_3^- + SiO_2, \quad (1)$$

and carbonate sedimentation in marine

environments can be represented by

$$Ca^{2+} + 2HCO_3^- \rightarrow CaCO_3 + CO_2 + H_2O. \quad (2)$$

Thus, the net silicate-weathering—carbonate sedimentation reaction may be written

$$CaSiO_3 + CO_2 \rightarrow CaCO_3 + SiO_2, \quad (3)$$

whereby atmospheric CO_2 is eventually sequestered in carbonate sediments.

To estimate the change in atmospheric CO_2 content due to a specified global flux of metamorphic CO_2, we need to know the amount and timing of CO_2 emission and the rate at which this CO_2 is sequestered by silicate weathering and subsequent carbonate accumulation. Volk (1987) pointed out that on time scales >10^6 yr, the impact of enhanced CO_2 degassing on atmospheric CO_2 content can be calculated without explicitly resolving ocean carbon reservoirs. Calculating by the method described by Volk (1987), a rough estimate of the long-term atmospheric CO_2 increase from early Cenozoic metamorphism in orogenic belts can be made using Berner's (1990) silicate-weathering rate formulation and his estimate of today's background metamorphic plus mantle CO_2 flux (~6.7 x 10^{12} mol/yr). By this means, we estimate that a metamorphic CO_2 flux of ~2 x 10^{18} mol/m.y. could have doubled the atmospheric CO_2 content (yielding ~1.5 to 5 °C warming), and ~10^{18} mol/m.y. could have increased atmospheric CO_2 concentration by 40% (~0.75 to 2.5 °C warming). Enhanced CO_2 degassing associated with possible seafloor generation rate increases could have contributed additional CO_2 to the atmosphere.

EARLY CENOZOIC CLIMATE AND ATMOSPHERIC CO_2

Several lines of evidence indicate that the early Eocene (50–55 Ma) was the warmest period in the Cenozoic (Crowley and North, 1991). A warming trend began in the late Paleocene and culminated in the early Eocene (Shackleton and Kennett, 1975; Savin, 1977; Miller et al., 1987). Evidence of tropical flora indicates that tropical climates extended to ~45°N paleolatitude (Wolfe, 1980; Hubbard and Boulter, 1983), and early Eocene alligator fossils have been found on Ellesmere Island (Dawson et al., 1976) at a paleolatitude of ~78°N (McKenna, 1980). Laterite soil horizons, interpreted as indicative of warm climates with seasonal rainfall, developed to ~45° latitude in both hemispheres (Frakes, 1979); however, these horizons may not be diagnostic of tropical climates (Taylor et al., 1992). Tropical planktonic nannofloral assemblages extended to ~55°N in the North Atlantic, farther north than in any other period in the Cenozoic (Haq et al., 1977). Oxygen isotopes from planktonic foraminifera have been used to infer a greatly reduced equator-to-pole temperature gradient (Shackleton and Boersma, 1981); however, some of this signal may be the result of diagenetic alteration (Schrag et al., 1992). Oxygen isotopes from benthic foraminifera indicate that ocean bottom water was warmer during the early Eocene than at any other time during the Cenozoic (Fig. 1).

Two major processes may have contributed to the Eocene warmth: (1) enhanced ocean heat transport and (2) elevated atmospheric CO_2 content. Ocean equator-to-pole heat transport may have been greater in the Eocene (Rind and Chandler, 1991). This increased heat transport may have been sufficient to prevent the formation of extensive sea ice. Because sea water has a lower albedo than sea ice, this would result in enhanced absorption of solar radiation and, thus, global

Paleoclimate *continued on p. 64*

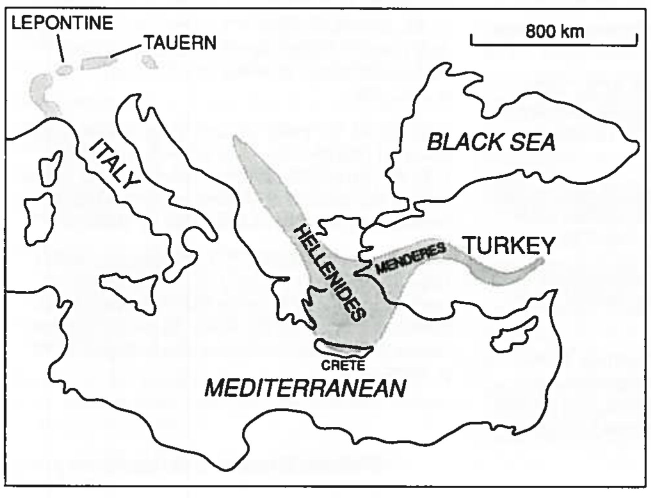

Figure 4. Map of the Mediterranean Tethys showing the area affected by Eocene regional metamorphism (shaded). Note that an extensive area of the Greek Archipelago (north of Crete) has been affected by this metamorphism. (From Ricou et al., 1986, Fig. 1.)

Paleoclimate *continued from p. 63*

warming. Several studies (Freeman and Hayes, 1992; Arthur et al., 1991; Berner et al., 1983) have indicated enhanced atmospheric CO_2 content during the Eocene.

Eocene warming may have resulted from enhanced fluxes of CO_2 to the atmosphere associated with enhanced rates of mid-ocean ridge spreading (Berner et al., 1983). Enhanced CO_2 fluxes to the atmosphere would result in elevated atmospheric CO_2 concentrations, thereby leading to greenhouse warming. Berner et al. (1983) proposed that metamorphic CO_2 degassing is roughly proportional to seafloor generation-subduction rates, and most subsequent long-term carbon cycle models have incorporated this proposal. Studies of seafloor generation-subduction rates have shown little (Engebretson et al., 1992) or no (Kominz, 1984) increase in the Eocene. As India collided with Asia, the Indian plate slowed (Klootwijk et al., 1992); thus, maximum plate velocities preceded regional metamorphism in the Himalayan orogenic belt. Consequently, Eocene metamorphic CO_2 fluxes to the atmosphere may not have been directly proportional to seafloor generation rates. This proportionality has also been challenged by data and calculations indicating that the flux of carbonate transported to metamorphic environments in subduction zones increased through the Cenozoic (Caldeira, 1992). Regardless of whether seafloor generation rates were higher in the Eocene, there is ample reason to believe that widespread Eocene regional metamorphism produced a CO_2 flux to the atmosphere that was in excess of that estimated from seafloor generation rates alone.

PRIMARY UNCERTAINTIES

The accuracy of our computed CO_2 production from the Himalayan orogen, and consequent paleoclimatic implications, are contingent upon several variables (e.g., timing of collision, duration of metamorphism, and the volumetric proportions and compositions of the CO_2 source rocks). Unfortunately, there is considerable uncertainty in quantification of these variables. However, even if our calculated production is excessive by a factor of two, metamorphic CO_2 released from the Himalayan and other Tethyan or circum-Pacific metamorphic belts may have played an important, and heretofore neglected, role in Eocene climate evolution.

DISCUSSION AND CONCLUSIONS

Barron (1987 and personal commun.) estimated Eocene global warming to be in the range of 1–4 °C, with the preferred value of 2 °C. Our analysis indicates that a 2 °C warming could be produced by an enhanced metamorphic flux of ~2×10^{18} mol/m.y., which is half the CO_2 generated at depth computed for the Himalayan orogen alone. Earth generally remained warm throughout the Eocene (Crowley and North, 1991). Even if prograde metamorphism postdated late Paleocene warming, enhanced degassing of metamorphic CO_2 could have nevertheless contributed to sustaining Eocene warmth. Furthermore, CO_2 degassing from regional metamorphism in the central and eastern Himalayas during the Miocene (Treloar et al., 1989; Searle, 1991; Sorkhabi and Stump, 1993) may have contributed to global warming during that epoch (Fig. 1). Thus, even with the uncertainty in the geologic data, it is clear that metamorphic CO_2 released from the Himalayan and other Tethyan or circum-Pacific metamorphic belts may have played an important, and heretofore neglected, role in Cenozoic climate evolution.

In their provocative (Caldeira, 1992; Caldeira et al., 1993) studies, Raymo and coworkers (Raymo et al., 1988; Raymo and Ruddiman, 1992) proposed that the Himalayan orogenesis could have provided an important sink for atmospheric CO_2 by enhancing the weatherability of silicate rock, thereby producing a middle to late Cenozoic cooling trend. Metamorphic degassing of CO_2 from carbonate rocks during Eocene collisional orogenesis would have preceded the uplift-induced cooling proposed by Raymo et al. (1988); thus, Himalayan orogenesis may have been largely responsible for both the warm Eocene and subsequent global cooling.

Our provisional computations suggest that elevated early Cenozoic paleoatmospheric CO_2 levels could have resulted from CO_2 released during regional metamorphism that affected extensive segments of the Tethys orogenic belt. Total world-wide CO_2 produced at depth may have been 10^{18}–10^{19} mol/m.y. Our calculations of atmospheric CO_2 consumption by silicate weathering show that metamorphic CO_2 releases of ~10^{18} mol/m.y. could readily account for the Eocene warming. If a significant fraction of metamorphic CO_2 escaped to Earth's surface, there would have been significant paleoclimatic consequences.

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Paleoclimate *continued on p. 65*

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.

NSTC and PCAST—Yes; FCCSET—No More!

> ***Science and technology are essential tools for achieving this Administration's goals: for strengthening the economy, creating high-quality jobs, protecting the environment, improving our health care and education systems, and maintaining our national security. This country must sustain world leadership in science, mathematics, and engineering if we are to meet the challenges of today ... and of tomorrow.***
>
> **—President Bill Clinton, November 23, 1993**

By executive order, as part of the continuing effort to reinvent government, President Bill Clinton established a new cabinet-level council to oversee and coordinate science, technology, and space policy for the entire federal government. The National Science and Technology Council (NSTC), created in late November 1993, supersedes the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), which was discussed in several 1993 Washington Reports. Also being superseded are the National Space Council and the National Critical Materials Council.

The executive order states that the principal functions of the Council are: "(1) to coordinate the science and technology policy-making process; (2) to ensure science and technology policy decisions and programs are consistent with the President's stated goals; (3) to help integrate the President's science and technology policy agenda across the federal government; (4) to ensure science and technology are considered in development and implementation of Federal policies and programs; and (5) to further international cooperation in science and technology."

The President stated that the "principal purposes of the NSTC will be to establish clear national goals for Federal science and technology investments and to ensure that science, space, and technology policies and programs are developed and implemented to effectively contribute to those national goals." The President further stated that "Our most important measure of success will be the ability to make a difference in the lives of the American people. We must use this new council to harness science and technology to improve our quality of life and the long-term economic strength."

The executive order defines the membership of the NSTC. Specifically identified as members are the President, who will serve as the chair; the Vice-President; the Assistants to the President for Science and Technology, Domestic Policy, and Economic Policy; the Secretaries of Commerce, Defense, Energy, Health and Human Services, Interior, and State; the Administrators of the Environmental Protection Agency and the National Aeronautics and Space Administration; the Directors of the National Science Foundation and the Office of Management and Budget; and the National Security Advisor.

The President stated that completing an across-the-board review of federal spending, focused on research and development, will be one of the most critical tasks that he expects the NSTC to begin. Specifically identified as disciplines within which the NSTC will prepare coordinated research and development are "budget recommendations for accomplishing national objectives in areas ranging from information technologies to health research, from improving transportation to strengthening fundamental research and international science and technology programs."

A "fact sheet" accompanying the President's executive order identifies nine specific research and development coordinating committees that will be established to "prepare coordinated R&D strategies and budget recommendations for accomplishing national goals." These are the committees for health, safety, and food research and development (R&D); fundamental science and engineering research; information and communication R&D; environment and natural resources research; civilian industrial technology R&D; education and training R&D; transportation R&D; national security R&D; and international science, engineering, and technology R&D. As needed, ad hoc working groups will be established to "review and coordinate specific policies and initiatives." Among the existing committees being replaced is the Committee on Earth and Environmental Sciences, which administers the Subcommittee on Global Change Research (SGCR), the home of the U.S. Global Change Research Program (USGCRP). What place the USGCRP will have in the new NSTC is as yet not clear.

Additionally, by executive order, the President established the President's Committee of Advisors on Science and Technology (PCAST). The PCAST will serve as a nongovernmental oversight group for the President and for the NSTC. The PCAST will consist of "16 members, one of whom shall be the Assistant to the President for Science and Technology," and "15 of whom shall be distinguished individuals from the non-Federal sector appointed by the President" including representatives from industry, academia, research institutions, nongovernmental organizations, and state and local government. John H. Gibbons, Assistant to the President for Science and Technology, was named by President Clinton as co-chair of the PCAST. An as yet unnamed private-sector representative will be the other co-chair.

In his executive order, President Clinton stated that the "PCAST will advise the President on science and technology issues and assist the NSTC in securing private sector involvement in its activities." PCAST members will serve without any compensation for their work on the PCAST, other than travel expenses and per diem.

Legislation to establish the NSTC is now moving through both houses of Congress. ■

Paleoclimate *continued from p. 64*

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GEOLOGICAL SOCIETY OF AMERICA

PRESIDENTIAL ADDRESS and MEDALS AND AWARDS FOR 1993

1993 PRESIDENTIAL ADDRESS by ROBERT D. HATCHER, JR.

It is quite an honor for me to have served as your president for the past year. One benefit that the president receives is the short time to indulge the group assembled, at the Presidential Address and Awards Ceremony at the Annual Meeting, with some of his or her ideas, prejudices, and recommendations about anything he or she wishes, all without the benefits and constraints of peer review, but keeping in mind that the purpose of that assembly is primarily to honor that year's medalists. This process occurs every year as the GSA president becomes past president and the vice president becomes president—a kind of transition week. In the words of Larry Sloss, the transition marks the change "from lame duck to dead duck." This forum and transition also serve to relieve the Society of the need to attach disclaimers to the published version of the Presidential Address. To avoid any suspense, I should mention here that this address is intended to build on the theme of the address last year by President E-an Zen on the "Citizen Geologist" (Zen, 1993), and will include several related issues that I consider important.

There probably has been no other time in the history of the Geological Society of America when there have been greater changes that have affected both the Society and all of geological science. Changes occurred during the early history of the Society as petroleum exploration and production became the dominant employer of geoscientists. Other changes have taken place during the 1930s, in times of economic hardship and in the 1960s, when GSA headquarters moved from New York to Boulder (1967). Each placed a different kind of burden on the GSA.

ROLE AND FUTURE OF GSA

The stated purposes of GSA are to advance our science, the scientific growth and development of its members, and the application of geology to the wise use of planet Earth. Three basic roles of the Society can be broadly defined: communication and transfer of information, increased access through member participation and Society outreach, and greater facility through the first two. These roles have remained unaltered through the continuity of Annual and Section meetings, Penrose Conferences, Division activities, support for research, and publications. GSA has steadfastly maintained commitments to these roles, and broadened them into several new initiatives in education, greater public outreach, and addressing environmental problems. A new wing to the headquarters building in Boulder will be dedicated this spring. It is being constructed to provide more space for existing programs—e.g., publications, GSA Foundation, and meetings—and space for new programs.

Today the traditional roles of scientific societies, state and federal surveys, geology departments, and many earth science–related industries are being challenged and debated. Much of the challenge is derived from a major change in emphasis in both perceived needs in training and the real opportunities for employment. As a result, the roles of each will probably evolve, and each of us as geoscience professionals can influence this change by participating—or not—in the processes driving this evolution. I will discuss some of these changes, ask each of us to reexamine the past history of our profession and try, if possible, to map out a strategy for the future. Note that I have not said try to predict our future path, because most of us recall only too well the boom years of the early 1980s in the petroleum industry that were immediately followed by the bust years of the middle and late 1980s, followed by additional, in their terms, "downsizing" of companies and "outsourcing" of many of the traditionally internal means the industry has had of acquiring certain kinds of information, such as paleontological and geophysical data. A by-product of this process is the potential loss of much of the geologic and geophysical data that have been archived for many years, but no longer used, by the petroleum companies. This too was an economic, not a scientific, decision. An effort is underway through the American Geological Institute, sponsored by the U.S. Department of Energy, to recover as much of these data as possible and to create a repository to make the data available for general use by the scientific community and the public.

GEOSCIENTISTS AND THE LIFE-SUPPORT SYSTEM

We live on part of a planet where the life-supporting environment and, consequently, almost all life is restricted to a few kilometers of the surface. As earth scientists we should be able to appreciate this as well as, if not better than, anyone who inhabits the planet. Several issues that have a direct bearing on our daily lives also are quite ably addressed by geoscientists.

Environmental Factors

Is Global Warming Real? There is no question that temperatures have been increasing for the past two centuries. We have also documented the marked increase in CO_2, ozone, chlorinated fluorocarbons, and other gases in the atmosphere. We do not yet know if some natural or anthropogenic event, or events, will change this trend.

Resource Depletion. For both the present and past, we can show that the problem of nonrenewable resources is more one of distribution than of shortage. This will change to real shortages as more underdeveloped countries become consumers.

Fossil Fuel–Related Atmospheric Degradation. Atmospheric degradation by burning fossil fuels has been documented many times over. If we seek alternative forms of energy, as the Clinton Administration advocates—e.g., electric cars—what power source will be used? Solar? Wind? Nuclear?

Poisoning the Environment. We are adding poisons to the environment in the form of organic and inorganic compounds, metals, and radionuclides. In addition, we are having to deal with monotonically increasing volumes of municipal waste—solid, liquid, and gaseous. We are only now learning about the extent and nature of ground- and surface-water contamination, and we are faced with the task of deciding whether cleanup is both wise and cost effective, or if the problems can be mitigated by isolation of the contaminated areas. For example, the only way to totally clean up a ground-water resource involving dense (or light) nonaqueous phase liquids (DNAPLS or LNAPLS) in a fractured reservoir might be to mine out the contaminated zone, a clearly impractical and most costly solution, but it may be relatively easy to isolate the contaminated zone so that it is prohibited from moving with the uncontaminated ground water or independent of it.

Waste Disposal vs. Environmental and Political Considerations

Solutions to many of the problems related to waste disposal and environmental degradation have, unfortunately, for a number of reasons become political issues that prevent our technical capabilities from being utilized. Best known are the seemingly endless problems with siting radioactive waste repositories. We could have had a major repository today in Kansas, and possibly others elsewhere, if the U.S. Atomic Energy Commission in the 1960s had agreed to pay the state a small fee for each canister of waste brought for storage and had agreed to choose an alternative site in Kansas (the site originally chosen, in Permian salt, was in an area of extensive drilling for hydrocarbon exploration and production). The federal government refused and, in the ensuing years, we have spent (probably wasted) billions of dollars making decisions and then reversing them about sites because of public outcry, summarized in the acronyms NIMBY, not in my back yard, and NIMTO, not in my term of office. We cannot even agree on a site for temporary storage of high-level power plant and other nuclear waste (Multiple Retrievable Storage, MRS), so today we have a number of temporary de facto MRS facilities at every nuclear power plant in the United States, and this remains our present, albeit not the best, solution to the storage problem.

Changes in the "traditional" areas of employment of geoscientists—from the petroleum industry, government surveys, academia, and the mining industry to environmental, engineering, and water resources—have justifiably caused many academic departments to reexamine their roles in educating future professionals. Paralleling these changes has been a greater public awareness of continued worldwide environmental degradation and depletion of many resources that, left unchecked, portend a mid–21st century world that may not permit today's developed-country living standards for any of Earth's inhabitants. Moreover, considering the present reality that the developed countries (mainly the U.S.) consume 75% of the world's energy and a proportionally large amount of the world's raw-material production, we in the developed countries must learn to live with less, and more efficiently. Population increases in the underdeveloped world inhibit these countries from achieving U.S., Canadian, and Western European living standards, a goal obviously unattainable for the entire world with the present technology.

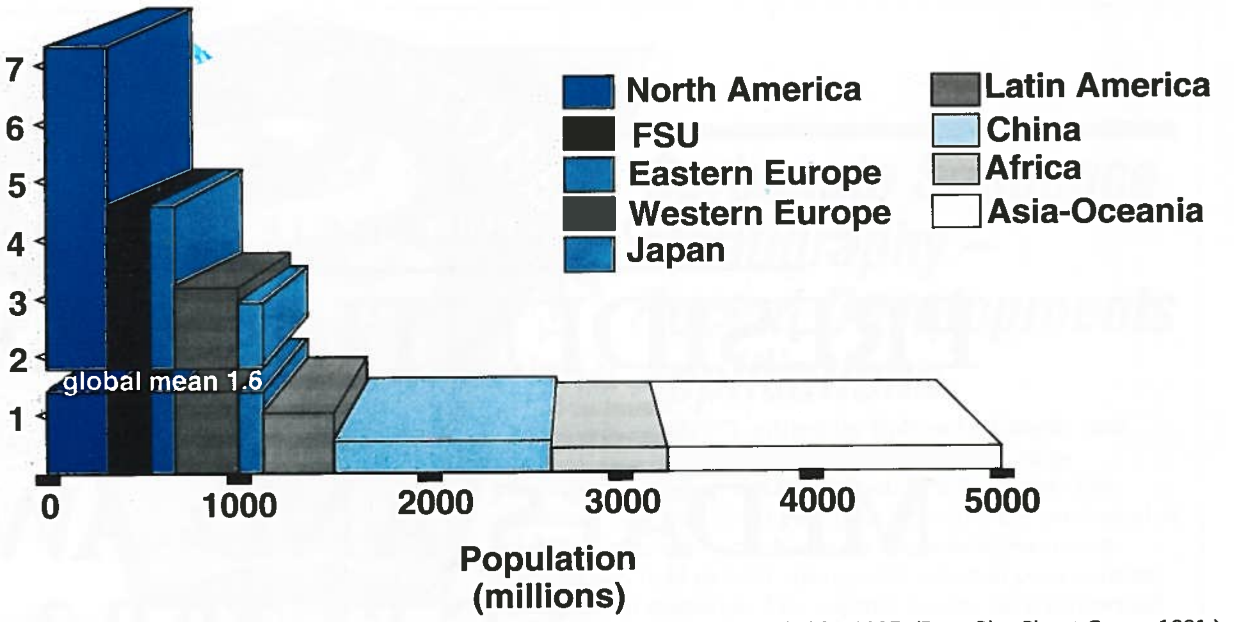


Figure 1. Per capita energy consumption (in kilowatt years) vs. population, compiled for 1987. (From Blue Planet Group, 1991.)

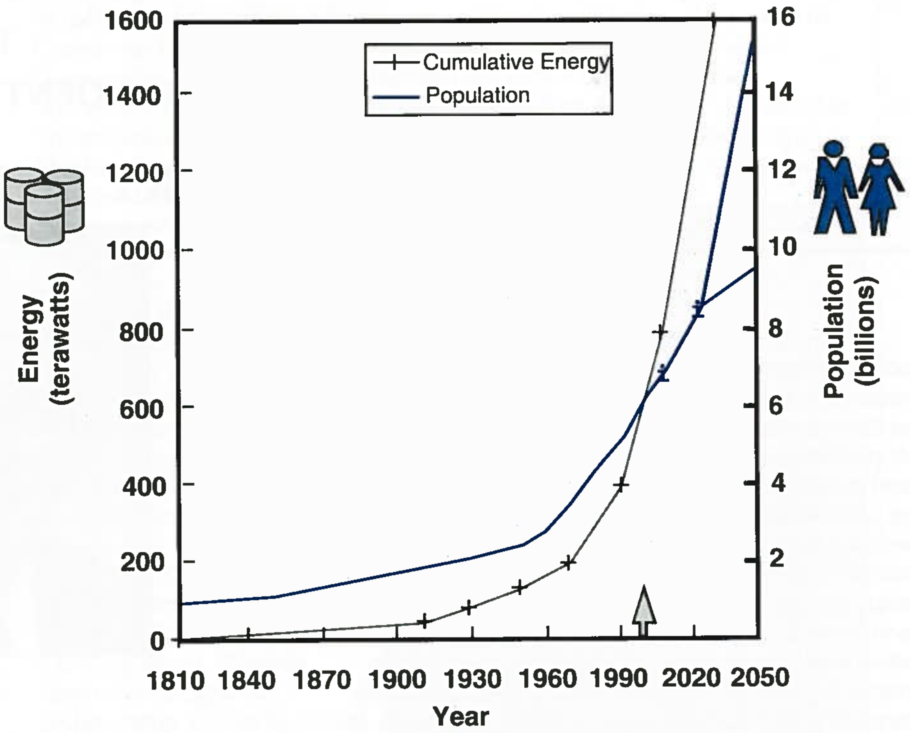
Realities

Easily identified problems exist that, if they are permitted to continue unsolved, will produce untold damage to the life-support system on Earth, if they have not already. The developed countries, particularly the U.S. and western Europe, are responsible for consumption of most of the energy and raw materials produced in the world today (Fig. 1). Underdeveloped countries that produce most of the raw materials we consume are commonly identified with unchecked population growth. We need to recognize that unchecked consumption of energy and raw materials is at least as detrimental to the environment as unchecked population growth. A useful exercise to demonstrate this would be to consider consequences and impact on energy and other resources of providing a uniform high living standard, like that enjoyed at present in Sweden, for the 2 billion population of China! Carrying the analogy another step forward, if we now have problems with 5.4 billion people on Earth, this planet cannot support 10 or 20 billion, as projected for the first half of the 21st century. The analogy is also easily applied to the consequences of continued sustainable development in the developed countries in the context of resource availability, utilization, and consumption (Paty, 1993). Possible consequences, both short- and long-term, include markedly decreased quality of life for all inhabitants of the developed countries and few improvements for inhabitants of underdeveloped countries. Both geoscience professionals and the public must recognize that man is a geologic agent capable, through our activities, of permanently altering the life-support system of the Earth and that we have been in the process of doing so for some time. An outstanding example of this lies in the pressure for real-estate development along the U.S. eastern seaboard that has resulted in attempts to influence the natural dynamic system by engineering that does not recognize the variables in the entire system. Unfortunately, increased demands by an expanding population, coupled with unchecked resource consumption, and unwise development (real estate, energy, mining) that envisions only short-term gain without consideration of long-term environmental damage will ultimately prove disastrous for a much larger area than that originally affected by the development.

Obvious solutions include decreased consumption of goods and energy, decreased economic growth to a steady state in the developed countries, and better means of checking population growth in all countries (Fig. 2). New nonpolluting energy sources would help, but it may take another half century for sources like fusion energy to be in widespread use. Geoscientists have an opportunity—really an obligation—to play a greater role in the solution of these problems. We have already become important participants in solving water resources, waste remediation and disposal, natural hazards, and other environmental problems, in addition to our traditional applied roles in mineral and energy resources, but we can and should do more.

Recall the systems analysis approach by a group called the Club of Rome to the world problems of population growth, environmental degradation (pollution), food supply, resource depletion, industrial output, and life expectancy portrayed in the curves that resulted in the 1972 book, *Limits to Growth* (Meadows et al., 1972). These curves (Fig. 3), plotted without bias by a computer, mostly portrayed a world that offered little hope for survival of life as we know it today in the developed countries, but they also assumed in one model that by the 1990s we would have already depleted many of our metallic resources (Cu, Au, Ag, Sn, and Zn), along with hydrocarbons. More recent scenarios summarized by Hayes (1993) employ essentially the same approach, change the variables slightly to reflect less drastic rates of change, and take into account more positive indications that resources may last somewhat longer, that the effects of pollution on agricultural yields worldwide may not be as severe initially, and other variables that reflect industrial productivity (e.g., goods and services, availability of labor, multiple new technologies). Even so, the newer models are not much changed from the originals (Fig. 4), because they still require that consumption of energy and other resources and population growth must still be sharply curtailed for survival of the life-support system on Earth. If similar models were computed employing the same variables, but computed separately for the dominantly consuming developed countries and the dominantly producing underdeveloped countries, and then compared with the world models, we would perhaps be better prepared to make recommendations for the survival of future generations.

Figure 2. Population increase and energy consumption vs. time. (From Blue Planet Group, 1991.)



COLLEGE AND UNIVERSITY EDUCATION OF GEOSCIENTISTS

Traditional geological education has provided a basic education in geology, with minimal training in the allied sciences, in order to meet the needs of the mining and petroleum industries, and government surveys. Present and future training of geologists and other geoscientists must continue to provide a broad base of geoscience education, along with increased skills in allied sciences, mathematics, and engineering.

Geoscientists are perhaps the best qualified of all scientists to address and solve complex multidisciplinary environmental problems because of our strong tradition of training scientists in the ability to focus on large and complex problems, and achieve viable solutions with incomplete data sets. Today's education of qualified geoscientists must, because of the nature of what we are and what we do, follow a path different from that followed by the other sciences. This is because, unlike other scientists, we must gain in-depth skills in several allied sciences and engineering. The spectrum extends from the mathematician who only needs to know mathematics to a biologist who needs to know biology, chemistry, and, more commonly today, like geologists, physics and mathematics. There also has been in the other sciences a greater tendency toward specialization (and overspecialization!) in recent years, perhaps to avoid the additional effort needed for multidisciplinary diversification; for example, in many graduate programs, a Ph.D. student in organic or inorganic chemistry can minor in physical, analytical, or another chemistry subdiscipline. Ironically, geoscientists, by virtue of the very complex and inaccessible nature of earth processes, require knowledge of the other sciences and engineering more than any other discipline. Partly because of this, many of us see both the need and the opportunity to become more broadly educated than ever before at all levels because of the greater emphasis on multidisciplinary—particularly environmental—problems and the means to solve them.

The strong suit of geoscience has traditionally been in the diversity of the education we receive and in the almost unique ability to assimilate and solve complex problems with minimal amounts of data. We have been severely chastised—more likely misunderstood—by other scientists for not addressing all of our problems quantitatively and deductively, but this element of the training of geologists and the practice of our profession may be our greatest strength and should not be abandoned. For example, with the increased emphasis on laboratory training, more and more "geologists" cannot critically evaluate geologic maps, the most quantitative basic data sets in our science, although most make use of them for sample collection and other purposes.

The following quote from the recent article in *Geotimes* by AGI President and 1992 Campbell medalist Donald C. Haney stated the problem quite well:

> Colleges and universities must critically examine their roles in educating future earth scientists.... If geology is to survive, it must become interdisciplinary, as well as provide the type of training that is sorely needed by our society. If not, geology will become a service area for other disciplines that have the vision needed for the 21st century. (Haney, 1993).

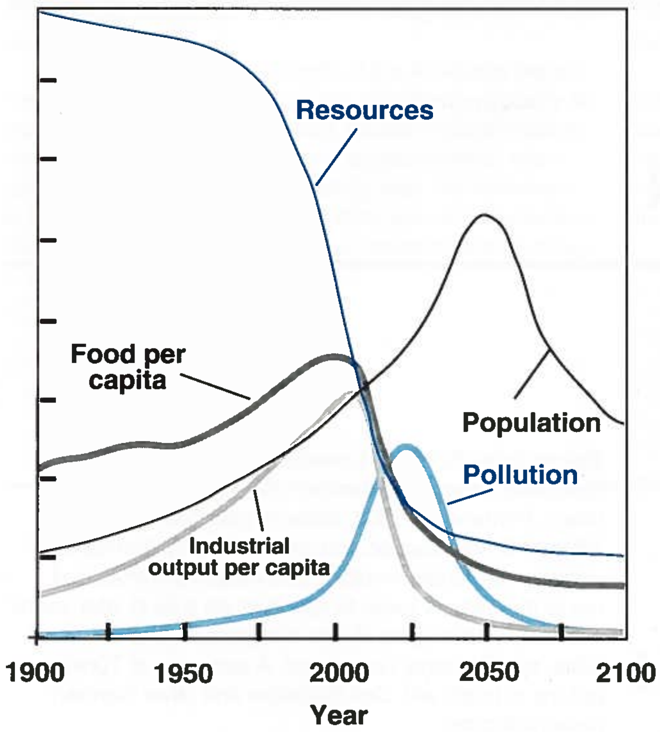


Figure 3. World standard model system. Food supplies, population, and industrial output undergo exponential growth until resources are depleted and industrial production is curtailed. Both population and pollution continue to increase for a time after resource depletion occurs, but the population decreases soon because of diminished food supply and other factors, such as decreased medical services. (From Meadows et al., 1972.)

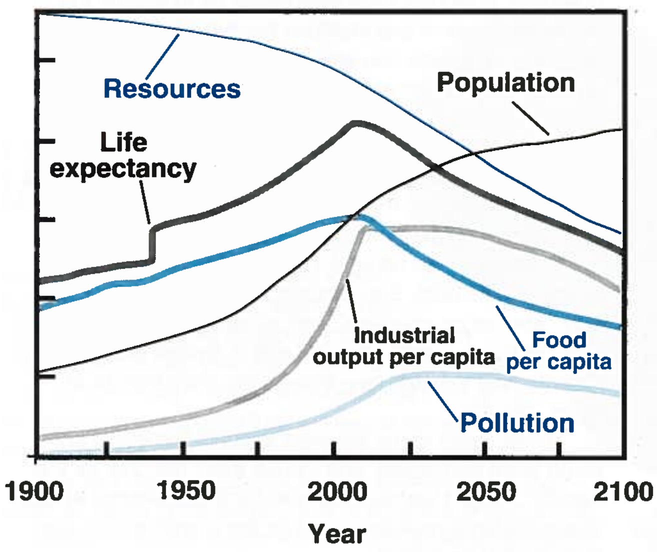


Figure 4. Model, based on increased spending, that predicts greater stability by 2100 despite steadily diminishing resources. (From Hayes [1993], and D. H. Meadows et al. [1992].)

The university in the 21st century *should not change* its primary role of producing educated people—training minds to think. Universities, colleges, and geoscience programs *should change* to reward quality teaching, revamp introductory geology courses (do students really need to memorize 30 minerals and 25 rocks?), and encourage faculty to engage in true scholarly research—not just yield to administrative pressures to generate grant money and overhead. There should be greater early involvement of undergraduate majors in research, basic and applied. Enlightened college and university administrators should respect the three essential elements of a college or university—students, faculty, and a library; lessen their dependence on grant overhead; and increase involvement of faculties in management of universities—employ less "command and control" and more "interactive" management—thereby decreasing micromanagement of faculties; this interactive management philosophy is being adopted by more and more forward-looking corporations.

Should Geological Science Programs be Accredited?

Accreditation of the professional degree in geoscience has the advantage of establishing a quality baseline for programs that will facilitate national comparisons, providing better recognition for existing high-quality programs, and gaining additional options and possible leverage for geoscience programs that are restricted administratively, and a means to upgrade others. Flexibility must be considered a cornerstone of any accreditation program, so that departments that have established excellence in geoscience education should find such an accreditation program a means of achieving additional recognition. Such an accreditation program must contain enough flexibility to permit the programs that have for decades been recognized for turning out high-quality graduates to qualify, and yet have criteria that will enable aspiring programs to be identified and modified to attain accreditation. Although some baccalaureate degree–granting geoscience programs enjoy considerable success in placing their graduates in professional careers, most geologists consider the M.S. to be the entry-level professional degree. Accreditation of professional degree programs regardless of whether they are baccalaureate or M.S. programs may be the best means to approach the problem. Focus on the professional degree in the accreditation process thus adds a dimension to the process that may be unique to the geosciences.

Many of us recognize that geology programs in a number of colleges and universities are restricted by internal requirements that make the baccalaureate geology degree much less rigorous than that in corresponding programs in chemistry, physics, and engineering. While most baccalaureate programs probably do a good job with the basic geology courses (mineralogy, petrology, structural geology, stratigraphy, and paleontology), broad variability exists among individual programs in the requirements for field courses, senior research, and elective courses. The same amount of variability no doubt exists among graduate departments. A major problem with baccalaureate geoscience curricula may be that undergraduates have no latitude to take more than the usual one year of calculus—few enter graduate school with any background in intermediate calculus, differential equations, or linear algebra—and gain greater depth in another of the allied sciences, engineering, a foreign language, economics, or other subjects. A few programs have solved the problem by offering both a B.A. and a B.S. degree, the latter being earmarked as a professional degree. Unfortunately, a number of colleges and universities will *not* permit geology departments to offer two baccalaureate degrees in geology, but *do* permit the chemists this opportunity because of their accreditation program through the American Chemical Society.

The American Institute of Professional Geologists (AIPG) has established an evaluation program for geology departments, but it is intended to stop short of an accreditation review. The focus of their program is on preparation of geologists for professional engineering geology and environmental geology careers, although it is easily adapted to a more general focus. The evaluation consists of a two-day site visit, for which the expenses are borne by the program being evaluated. The course standards considered in the evaluation involve those formulated by the AIPG curriculum committee (American Institute of Professional Geologists, 1991). The results of these evaluations have had a very constructive impact on all of the departments that have requested evaluations, particularly where problems have been identified that can be resolved with minor increased support from the administration. Other programs meeting all criteria have found that the evaluation becomes a "feather in the cap" of the program. Once the evaluation criteria are met, a certificate is issued to the department by AIPG. Some modification of the AIPG recommended curriculum and evaluation program could form the basis for an accreditation program in the geosciences.

RECOMMENDATIONS

Public Involvement

More and more, geoscientists, like other scientists, have been relegated the role of providers of information to the so-called "decision policy makers." This is at least partly because of the common perception that scientists are hopelessly focused on the gathering of data, laboratory experiments, and solving esoteric or narrow applied problems. It is clearly easier for most of us to function only in the realm of pure or applied research, present the results of our research at professional meetings and in journals, or solve applied problems and write reports for our employers. Health professionals have probably done the best job in educating the public and Congress of the importance of their discipline. Physicists and engineers have probably done the next best job of communicating to the public the importance of what they do. Geoscientists have probably done the worst job.

Particularly because of the strong interdisciplinary education of geoscientists, we should play a greater rather than a lesser role in decision and policy making, and we also must make a greater effort to educate the public on the everyday importance of geologic processes and materials, as well as the justification for geoscientists to function in the policy arena. We must become part of the decision-making process in the policy arena, not just providers of data. Education of the public in how Earth is put together and why we think so, and how this affects our everyday lives, is very important—in resources, environmental quality, and siting and construction of everything from houses and highways to dams and nuclear power plants—not just when a natural disaster occurs.

Responsibilities

Our responsibilities as professional geoscientists include: (1) training geoscientists who are literate both in geology and the allied sciences and who have the ability to address complex problems—we should not produce overspecialized technicians; (2) working toward achieving equality with the other sciences; (3) attaining a level of importance of geoscience with the public; and (4) greater direct involvement in the decision-making processes related to environmental issues, and resource planning and management.

Is Our Past the Key to Our Future?

We can identify the problems in light of our past and readily see that our future will not be uniformitarian; we, as geoscientists, may never have a better opportunity than from now through the next decade to make our case and become part of the solution. The opportunities are also here to gain an equal or greater footing with the other sciences and engineering in addressing environmental problems, with the public, and in the decision- and policy-making arena. I recommend the following:

1. Maintain strong university programs in basic geoscience, but broaden them to include emphasis in multidisciplinary and applied disciplines.
2. Become more involved in convincing the public of the everyday importance of our science.
3. Work to become an integral part of the policy- and decision-making process on environmental, engineering, and resources issues.

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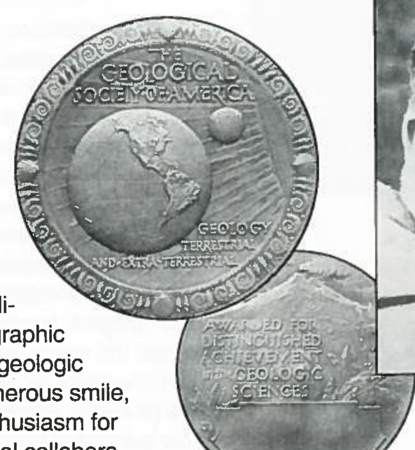
Presentation of the PENROSE MEDAL to ALFRED G. FISCHER



Citation by LISA M. PRATT

Vigilant observer of natural patterns, Alfred Fischer recognized the climatic pacemaker embedded in stratigraphic rhythms and laid a foundation for the geologic discipline of cyclostratigraphy. His generous smile, broad shoulders, and unflappable enthusiasm for field work led to numerous international collaborations and a truly global perspective on long-term climatic oscillations. He has been honored by scientific medals from geological associations in Belgium, England, Germany, Italy, and the United States. He has been elected to the Academia Nazionale dei Lincei, Rome. His widely cited papers span a fifty-year record of peer-reviewed publication. An interdisciplinary thinker throughout his career, Al has integrated geobiological, geochemical, and geophysical data in a series of scholarly publications on the evolution of the Earth system.

His formative childhood years were spent in the alpine village of Berchtesgaden, Germany, where he ventured alone in exploration of meadows, forests, and mountains. He is strongly anchored by vivid memories from this period in his life, such as the pungent smell of summer marigolds and the tranquil sight of deer emerging to feed at dusk. During the mid-1930s, when political conditions in Germany became threatening, his family returned to Wisconsin, where his father had been raised. Although only 14 years old, Al entered a small Lutheran college as his introduction to the U.S. educational system. He later completed a B.A. (1939) and an M.S. with honors (1940) in geology at the University of Wisconsin, under the direction of paleontologist Norman Newell (Penrose Medalist, 1990). Winnie Varney, a student in geography at Wisconsin, married and embarked on a life-long adventure with Al. In the fall of 1941, he accepted a teaching position in a two-man geology department at Virginia Polytechnic Institute. He joined Stanolind Oil and Gas Company (now Amoco) in 1943 as the U.S. plunged into World War II and Virginia Polytechnic was fully converted to military training. Fatherhood, myopia, and the demand for petroleum kept him from military induction. He resumed his studies at Columbia University and obtained a Ph.D. in 1950 under the guidance of Professors Marshall Kay (Penrose Medalist, 1971), Norman Newell (Penrose Medalist, 1990), and Walter Bucher (Penrose Medalist, 1960). The classic reference book on invertebrate fossils by Moore, Lalicker, and Fischer (1952) as well as the benchmark study on Permian reef paleoecology in the Guadalupe Mountains (Newell et al., 1952) were completed during the three years that Al was on the faculty at the University of Kansas. Desperate financial straits, however, drove him to accept a position as senior geologist with the International Petroleum Company, Ltd., an Esso subsidiary. Al, Winnie, and their three young children relocated to Peru. The family flourished in Lima while Al's work on the western flanks of the Andes brought the special joy of geologic discovery in the company of international friends.

He accepted a position on the faculty of Princeton University in the fall of 1956, where he was surrounded by colleagues active in the development of the plate tectonic theory. Al began to systematically unravel patterns of sedimentological and biological response to the Wilson tectonic cycle. He was an early advocate of using remnant magnetism for both paleogeographic and magnetostratigraphic reconstructions. Al's paper in 1961 on the stratigraphic record of transgressing seas recorded by Tertiary coastal sedimentation in New Jersey remains a cornerstone in the building of sequence stratigraphic concepts. His publications on three-dimensional stratigraphic relationships preceded by 20 years the current thinking along this line. In 1977, he published with Michael Arthur a remarkable paper entitled "Secular Variations in the Pelagic Realm." This article fundamentally changed mainstream geological thinking by recognizing the greenhouse and icehouse extremes in Earth's long-period climatic cycle. Through the 1980s, Al's vision was focused increasingly on pre-Pleistocene Milankovitch cycles. He and his students published numerous detailed studies on rhythmic strata from deep-sea and epicontinental sites ranging in age from Early Cretaceous to Eocene. With his characteristically brief titles and lyrical text, Al defined the emerging field of cyclostratigraphy.

The pull of the west lured Al and Winnie from Princeton to the University of Southern California in 1984 for a phased retirement. Ten years later, there is no sign of a decrease in publication or field work. Al was one of four conveners of an international workshop on testing cyclostratigraphic and event stratigraphic concepts at Perugia, Italy, in 1992. This meeting brought together a widely interdisciplinary group of scientists to discuss high-resolution studies of tectonic and climatic processes in the Early Cretaceous (ALBICORE and APTICORE).

Al continues to explore remote outcrops in search of Milankovitch hierarchies and superimposed extraordinary events of impact and volcanism. He is internationally praised for his scientific contributions, but his exceptional gifts as a teacher make him universally adored. Time and time again, Alfred Fischer has recognized critical issues and broken away from established interpretations. His career stands as a model of intellectual leadership in the geological sciences.

Response by ALFRED G. FISCHER

You see me here somewhat dazed on election to the ranks of people long venerated. Medals are not something one works for or expects; they seem to drop out of the sky, and they turn one pensive. What are the human ingredients of a life in science?

Our *parents* encourage curiosity and imagination—in my case, at the expense of putting up with toads and salamanders getting loose in the house, of endless jars of green water, of infusions in varying stages of decomposition, of patching rock-torn pockets.

True *teachers* carry on. Far more than passing on information, they spur curiosity into channels, exercise our imagination, and help us through our teething pains. Norman Newell, my first laboratory instructor in geology, did just that. He has remained a friend and mentor throughout my life, and it is a great happiness to be able to join him in the ranks of Penrose Medalists. Two other teachers, both Penrose Medalists, also played a special role in my life—Walter Bucher and Marshall Kay.

Colleagues continue where teachers leave off. A few memories will have to do: Roy Holden at Virginia Polytechnic Institute, the colorful prototype of a small-college teacher, guru of the region's mineral industries, and a source of countless anecdotes, left me with an abiding love for Appalachian landscapes and geology. Ray Moore at the University of Kansas was just getting the treatise started in the years 1948–1950. He was a wise and delightful, generous colleague of enormous gifts. Peruvian years with Exxon brought contact with Axel Olsson, whose *modus vivendi* was to alternate field work for petroleum companies with monographing the fossil faunas collected: a superb systematist, and a wonderful all-round naturalist. Life at Princeton was notable for Harry Hess, another Penrose Medalist, then putting together his famous "geopoetical thoughts" that launched plate tectonics; for Hollis Hedberg's stratigraphy seminars that regularly outlasted my bedtime; for introduction to the marvels of geochemistry by the young Dick Holland and David Crerar; for teaching biogeography with Robert MacArthur. Return to the Northern Limestone Alps, land of my childhood, brought contact with Bruno Sander of Innsbruck, Penrose Medalist, father of petrofabrics; with Walther Schwarzacher, and with the young German and Austrian carbonate workers. John Maxwell introduced me to Italy, where I was to spend much time in later years with Italian colleagues Bruno d'Argenio, Isabella Premoli-Silva, and Giovanni Napoleone. A semester at Tübingen put me in touch with Dolf Seilacher and other German paleontologists.

The role of students, both undergraduate and graduate, is crucial. Who else forces us to rethink the whole structure of assumptions normally taken for granted? Who else can ask questions that, naive at first glance, turn vital on reflection? Who else matches students in readiness to throw curiosity and intellect at the problem at hand? And who else eventually recognizes so clearly our feet of clay as Science moves on? Without naming individuals, my debt to them is large, and my pride in them may be pardonable.

A *spouse* can be vital. I met Winnie over a cave in Wisconsin in 1938. She brought me three wonderful children, shared my students, and, when at the divergence of two roads in a wood, she was and is always ready to take the one less traveled by—though the shoe leather at times was thin.

Eight years of my life were spent in industry. I enjoyed them immensely and valued them not only for the specific things I learned, but also for the challenge to build theoretical interpretations and for the opportunity to see them tested by drilling.

To me, geology represents the intersection of physics, chemistry, and biology in one small spot in space, the Earth (Fig. 1). Together, physical, chemical, and biological processes produced and evolved, and continue to change the Earth, a unique historical body in space-time. It's that historical character that differentiates geology and its sister, astronomy, from the other sciences. Interaction of the Earth with astronomical force-fields and bodies forms a special part of that history.

Some of us are concerned more with nonhistorical Earth process, others with historical Earth product, but the ball passes back and forth. The products are meaningful only in terms of processes, but many of our processes can only be deduced or comprehended by way of their historical product.

The philosophies and the ways and means of physics, chemistry, and especially biology diverge. Life assemblages are dominated by the unpredictable: the improbable, unique species that comes to the fore, and its phyletic descendants. Such differences may tend to drive

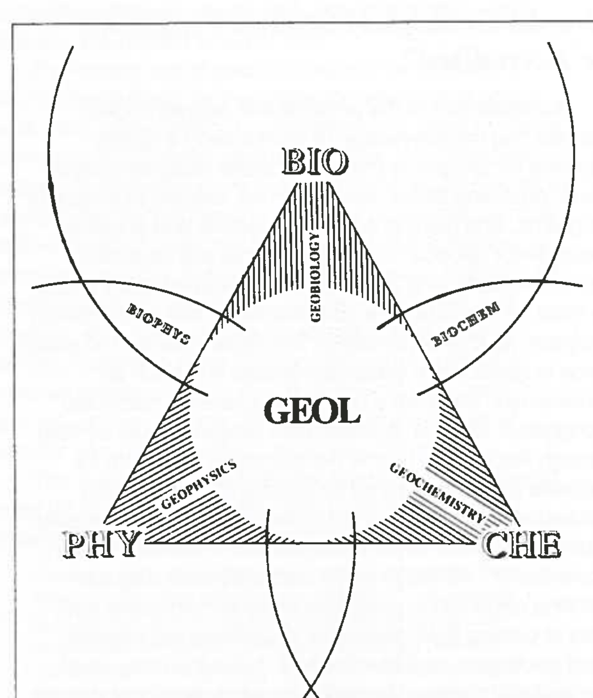


Figure 1.

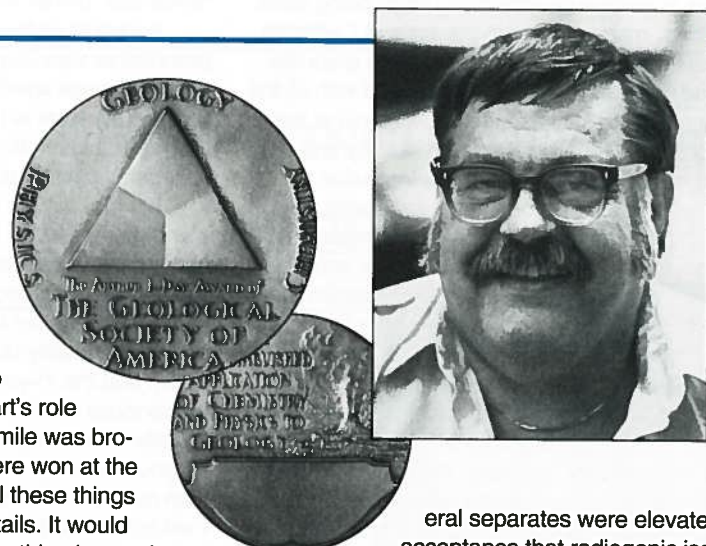
us apart, but the big goal—understanding the Earth—pulls us together.

And therein lies the strength of the American department of geology or whatever it may call itself—typically an organization with a core directed toward regional studies, and three wings—a geophysical, a geochemical, and a geobiological one. When functioning well, the members of such a group, no matter what their specialized interests, insure that the students develop a perspective that recognizes the interdependence of all in the effort to understand our planet—its past, its future, and our role in it.

Concerning that role, geologists spend more time thinking about the historical dimension than any other scientists, and have more appreciation of global change. Yet they have played a rather subdued role in publicly addressing that black cloud of biospheric degradation that hangs over us. Geology, where is your Rachel Carson?

The Geological Society of America has ever been a leading forum for all approaches to the Earth, where geophysicists, geochemists, and geobiologists meet in person and in print. It is the very embodiment of my concept of our profession, as shown in its meetings, its Penrose Conferences, and its publications. And that is why the Penrose Medal means so much to me. Thank you. I am deeply appreciative.

Presentation of the DAY MEDAL to HUGH P. TAYLOR, JR.



Citation by JAMES R. O'NEIL

Hugh Taylor is a legend in his own time. Did you ever want to know the speed of Bob Feller's fastball; who was originally offered Humphrey Bogart's role in Casablanca; the year the 4-minute mile was broken; or how many Victoria Crosses were won at the Battle of Rorke's Drift? Hugh knows all these things and would delight in telling you the details. It would appear that the man seldom forgets anything he reads, sees, or hears in the many fields of knowledge that are of passionate interest to him. His ability to recall an amazing panoply of facts and to focus on a specific area have served him well in his attack on several classical problems of earth science. It is for these outstanding scientific contributions that we honor him today.

Hugh is the ultimate Caltech man. He began his undergraduate career there as a chemistry major but soon developed another all-consuming interest, this time in rocks and minerals, and joined the ranks of the geologists. His undergraduate years at Caltech were marked by a brilliant academic record, legendary feats in dormitory activities, and notable achievements on the gridiron with the famed Caltech football team, now, sadly, defunct. He already knew, long before he completed his B.S. degree, that he wanted to remain at Caltech to work with Samuel Epstein in the burgeoning field of stable isotope geochemistry. As is common practice, however, he was encouraged to broaden his scientific horizons by pursuing his graduate studies elsewhere. He made the trek across country to Harvard, where he particularly enjoyed studying thermodynamics with Jim Thompson and was awarded a master's degree after one year. He bravely endured the rigors of the Cambridge winter without bothering to buy a winter coat because he was determined to return to the womb in the sunny climes of Pasadena. He indeed was welcomed back to Caltech, where he fulfilled his manifest destiny by carefully delineating the stable isotope systematics of igneous and metamorphic rocks and minerals with his prestigious mentor and friend Sam Epstein. After a brief sojourn as assistant professor at Penn State during 1961–1962, Hugh returned once again to his beloved Caltech where he is at the present time the Robert P. Sharp Professor of Geology.

Hugh made a profound impact on petrology and the earth sciences in general by his seminal studies of the stable isotope geochemistry of rocks and fluids in the crust and mantle of the Earth. This impact arose in part from the fact that his scientific approach was primarily that of a geologist in a discipline being developed by laboratory-oriented chemists. His encyclopedic knowledge of rock and mineral systems, geophysical and geochemical principles, and details of the major geologic provinces of the world provided him with extraordinary insights into his choice of research problems and their execution.

One of the most quoted publications in the earth science literature is Hugh Taylor's 1968 landmark paper entitled "The Oxygen Isotope Geochemistry of Igneous Rocks." It was by his systematic classification of source materials, processes, and alteration effects in this work that oxygen isotope analyses of igneous rocks and mineral separates were elevated to the acceptance that radiogenic isotope analyses enjoy as a powerful petrologic tracer. Many later workers established their careers by working out details of the general principles laid out by Taylor in this and related papers on meteorites, lunar materials, mantle rocks, tektites, batholiths, metamorphic suites, ophiolites, ore bodies and even soils. Inasmuch as oxygen is the main element comprising the crust, mantle, and hydrosphere of the Earth, variations in the isotopic ratio of this element take on special significance. Hugh Taylor has spent most of his career placing constraints on and explaining the physical and chemical processes that could have affected the oxygen isotope variations observed in rocks and minerals. And explaining he does very well—with extreme clarity and meticulous attention to detail, both in the text and diagrams. Taylorian trademarks are baroque figures and figure captions that, in normal font, can be as long as a page of text.

Hugh has worked on many and varied petrologic problems over the years, and made several exciting discoveries along the way. In his characteristically scholarly fashion, he resurrected fundamental concepts about the process of assimilation and fractional crystallization formulated by N. L. Bowen in the 1920s and incorporated them into his own AFC model, which predicts the changes in oxygen and strontium isotope ratios that occur in crystallizing magmas. This is just one example of the healthy historical perspective that Hugh maintains in his work and imparts to his students. A contribution that looms in importance is his bringing to the earth science community a heightened awareness of the major role that meteoric water plays in so many diverse processes occurring in and on the Earth. Together with his students and colleagues, he unambiguously demonstrated the conditions under which meteoric-, magmatic-, and marine-hydrothermal systems are established in the crust and the extraordinary dimensions they can assume. The implications of these findings are profound and bear on fundamental issues including the geochemical evolution of the oceans and crust, the thermal structure of the crust, and the formation of ore deposits.

For more than three decades Hugh Taylor has been exploiting the power of stable isotope measurements *as no other practitioner* to the understanding of petrological processes. This world-renowned scientist has worked diligently and well by producing a prodigious amount of excellent science, by nurturing younger colleagues, and by communicating his findings effectively in well-written journal articles and in books he has carefully edited. Hugh is a very popular man whose infectious enthusiasm for science and life in general is well known and appreciated by a vast population in the scientific community. Harmon Craig recently wrote about him, "Hugh Taylor stands like one of his own plutons, heads above the ranks of petrologists and geochemists in the area of the isotope geochemistry of silicate rocks. There is no one like him and there will not be. He is *sui generis.*"

Response by HUGH P. TAYLOR, JR.

I want to thank the Geological Society of America for this recognition, especially because Arthur L. Day was one of my early heroes as a result of his pioneering work on hydrothermal phenomena. Much of my own work on fossil hydrothermal systems has followed in his footsteps. It is indeed a great honor to be singled out for such an award by one's fellow scientists, and a particular pleasure to receive this medal in Boston, where I spent some time as a student at Harvard and later as a visiting professor at M.I.T. I am also glad that all four of the most important people in my professional life are here today: My wife Candi Taylor, who is a marvelous companion, and who has been so supportive of my career; my citationist Jim O'Neil, whom I first got to know in the 1960s when he was a postdoctoral fellow working with me on isotopic fractionations in the feldspar–H_2O system—we have been fast friends and mutual admirers of each other's science ever since; my longtime friend and colleague Lee Silver, who taught me much of the geology that I know, and who has been a coauthor with me on several papers, particularly those dealing with granitic batholiths; and particularly my Ph.D. thesis advisor, scientific father, coworker on countless research projects, and friend for 40 years, Sam Epstein, who is himself a Day Medalist.

I am also very grateful to many other students and postdoctoral fellows who have worked with me and who have contributed so much to the scientific discoveries we have made together—Yuch-Ning Shieh, Bruno Turi, Jim Lawrence, Dave Wenner, Simon Sheppard, Bob Criss, Bob Gregory, Francis Albarède, Richard Forester, Debra Stakes, Terri Bowers, Steve Wickham, Dave Beaty, Emelia Burt, Peter Larson, Cathy Manduca, Diane Clemens Knott, and Cleve Solomon—as well as my present students Carey Gazis, Jean Hsieh, and Greg Holk. I also want to express my thanks to four other scientific collaborators and friends who have been tremendously helpful over the years: Bob Coleman, who first worked with me on blueschists and on a gabbro-granophyre–sheeted dike complex in Saudi Arabia, and who later provided enormous support to Bob Gregory and me in our studies of the Oman ophiolite; Alexander ("Mac") McBirney, with whom I studied the Parícutin volcano in Mexico, and without whose help I would not have been able to carry out field work on the Skaergaard intrusion in 1971; Dick Nielsen, who first worked with me in southeastern Alaska in the 1950s, and who introduced Simon Sheppard and me to the problems of porphyry copper ore deposits; and Denis Norton, who introduced me to computer modeling of hydrothermal systems and who provided me with a much deeper understanding of the time-temperature-hydrological regime of the Skaergaard intrusion. Finally, and with a tinge of sadness on this otherwise happy occasion, I want to mention the late

Robert Hill, who worked with Lee Silver, Bruce Chappell, and me on the Peninsular Ranges batholith, and the late Mordeckai Magaritz, with whom I worked on a number of projects over the past 20 years, including some that are still unfinished. Mordeckai had also planned to be in Boston, in spite of the fact that he was recovering from a heart transplant operation. However, a few weeks ago I was deeply saddened to learn that he had tragically died in Israel of complications from this operation. I shall miss him very much.

I would like to recount some of my interactions with earlier Day Medalists, because it is clear to me that these associations are very much related to why I am today standing in the same place that they did! My scientific career virtually coincides with the period of time over which the Day Medal has been presented. Just a few months after the first medal was presented to George Morey in 1948, I was in the 11th grade and had just won an American Chemical Society scholarship to go to Caltech, which had always been my boyhood dream. Later, when I entered Caltech in the fall of 1950, little did I realize that future Day Medalists Walter Munk and Gene Shoemaker had preceded me as undergraduates there, and that a future Day Medalist—Don Turcotte—was one of my 180 fellow freshman classmates. In 1952, I switched to a geology major as a result of taking a terrific course from Bob Sharp and from interacting with some of the outstanding faculty at Caltech at that time such as Dick Jahns, Lloyd Pray, Ian Campbell, and James Noble. Incidentally, as part of Bob Sharp's course, I attended a series of lectures on groundwater hydrology by Day Medalist King Hubbert. During this period, Caltech embarked on a major program in geochemistry, at which time Sam Epstein came with a group of other scientists from the University of Chicago to begin his remarkable program of stable isotope studies in geochemistry, geobiology, glaciology, meteorology, and cosmochemistry. Even though I was only an undergraduate, I was encouraged to take part in these programs. I became an early convert, and in 1954 I became the first geochemistry student to graduate at Caltech.

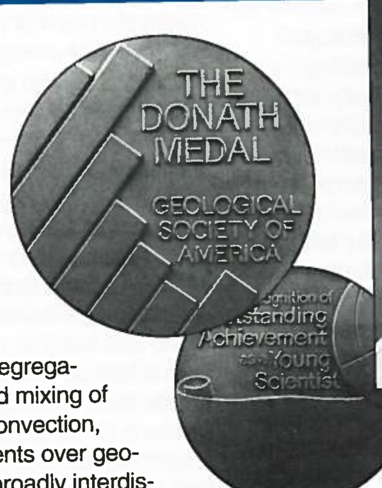
At that time Caltech discouraged its students from staying on, so I went off to Harvard for graduate study. There, one of my fellow graduate students was future Day Medalist E-an Zen, and there I took two remarkable courses, one from Day Medalist Francis Birch and a year's course from future Day Medalist Jim Thompson. Thompson's petrology and thermodynamics course made a tremendous impact on me, one that remains to this day. In fact, later on when future astronaut Harrison Schmitt followed me from Caltech to Harvard, I kept pestering him to get me a copy of his notes of Thompson's course, because I knew that they would be a lot different, and would supplement the notes of the course that I had taken. However, because I had remained enamored of the climate of southern California and the possibilities of the new science of stable isotope geochemistry, I had by that time returned to Caltech to work on my Ph.D. with Sam Epstein, a choice I have never regretted. Interestingly, when I took my Ph.D. oral exam, three members of the committee were future Day Medalists: Hugo Benioff, Jerry Wasserburg, and of course, Sam. Future medalist Frank Press was on the Caltech faculty, and future medalist Don Anderson soon joined me as a fellow graduate student. In addition, future Day Medalist Hat Yoder was a visiting professor at Caltech at that time.

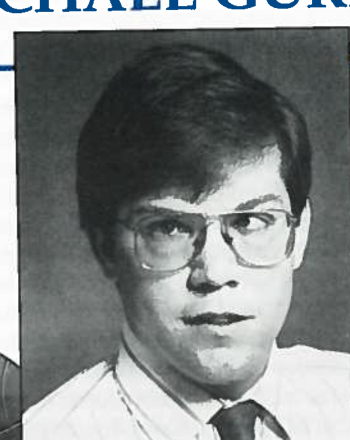
I was very lucky to be around when some of the pioneering studies in isotope geochemistry were being done back in the 1950s, many of them in the state of California. I remember well that Sam made sure that as a graduate student I visited the laboratories and interacted with all the active isotope geochemists in southern California at that time, including future Day Medalists Harold Urey and Harmon Craig, who were then at Scripps Institution of Oceanography. In fact, that is one of the hallmarks of geology at Caltech, bringing in numerous scientists as visiting scholars for the benefit of both students and faculty. Over the years a large number of Day Medalists have visited or taught courses at Caltech, and I have been fortunate to be able to interact with many of them, such as Hans Eugster, E-an Zen, Ted Ringwood, Harry Thode, Wally Broecker, Jim Thompson, Claude Allègre, and Ian Carmichael, among others. Even when I went off to Penn State as a young assistant professor, the person who was largely responsible for hiring me was future Day Medalist Frank Tuttle. Although I accepted the position at Penn State and stayed there for a year and a half, I had previously also interviewed for a job at UCLA with Day Medalist Willard Libby. Later on, after I had returned to Caltech, future Day Medalists Gene Shoemaker and Sue Kieffer came to Pasadena as professor and graduate student, respectively. Also, a little over ten years ago I was asked by another Day Medalist, the late Allan Cox, to come to Stanford University for six months as a visiting professor. My wife Candi and I have some wonderful remembrances of that visit and of our many interactions with Allan Cox, particularly because at that time Jim O'Neil was then with the USGS at Menlo Park, so we got to see a lot of Jim as well. Over the years, one of my warmest friends has been Hal Helgeson, whose Ph.D. mentor at Harvard was Day Medalist Bob Garrels. Through this association with Hal I also became very friendly with Bob, whom I learned to respect enormously, and from whom I learned a great deal. I was also privileged to have gotten to know the late Hans Eugster quite well during several field trips and conferences in the Alps and in other parts of Europe. A few years ago I was invited to be a visiting scholar at Johns Hopkins for several weeks while Hans was chairman of the geology department there. My family and I have very fond memories of that visit, particularly of an outstanding "three-star" dinner at the Eugster farm in Maryland.

Added to all the above is the fact that my scientific grandfather was Day Medalist Harold Urey, and the inventor of the mass spectrometer that I have used over the years in my work is Day Medalist Al Nier, and you can see that a lot of "osmotic intellectual exchange" has occurred between myself and the earlier medalists.

It is clear to me that one of the main reasons I am standing here today is because of the superb environment created by Caltech as a place to flower intellectually, particularly in our Division of Geological and Planetary Sciences as it was put together by a series of outstanding chairmen, notably during the 16-year tenure of Robert P. Sharp and the 11-year tenure of Barclay Kamb. I owe a tremendous debt to Caltech and to all of the remarkable scientists with whom I have interacted over the years. As you can see, I am just the latest in a long line of Caltech recipients of the Day Medal, and I feel very certain I will not be the last.

Presentation of the YOUNG SCIENTIST AWARD (DONATH MEDAL) to MICHAEL GURNIS





Citation by HENRY N. POLLACK

Michael Gurnis's research has centered on the large-scale dynamics and chemical/thermal evolution of the Earth. His early work addressed the segregation of the Earth's core, the stirring and mixing of chemical heterogeneities by mantle convection, and the growth and mobility of continents over geologic time. His scholarship has been broadly interdisciplinary, embracing geology, physics, chemistry, and computational fluid dynamics.

The research that Mike is currently pursuing with his characteristic vigor and enthusiasm, and for which recognition by the GSA is so appropriate, employs the Phanerozoic sedimentary record as a constraint on models of the internal dynamics of the Earth. Thermal convection within the mantle causes uplift and subsidence of the Earth's surface, and this "dynamic topography" from time to time leads to the submergence of continents and the deposition of marine sediments. The preserved sedimentary record thus can provide bounds on the spatial and temporal scales of convective motions in the interior, which in turn provide information on the viscosity, heat transfer characteristics, and thermal evolution of the Earth. Mike has brilliantly conceptualized and carefully quantified the link between large-scale geodynamic processes within the Earth and the distribution of sedimentary rocks in time and space. He has provided a dramatic demonstration that the Earth indeed functions as an integrated dynamic system.

Enthusiasm also characterizes his teaching. At a time when the general citizenry misunderstands and is detached from science, Mike has plunged enthusiastically into the task of conveying science to students at a level of the curriculum that many faculty eschew: the introductory courses. Whether in large lectures or small freshman seminars, Mike has brought the excitement, rigor, and relevance of earth science to many undergraduates with diverse backgrounds.

Michael Gurnis is a most worthy recipient of GSA's Young Scientist Award and Donath Medal. He is not cut from ordinary cloth. He has a different vision; he hears a different drummer. His research is strikingly unorthodox and already displays uncommon maturity and scientific perspective. It is truly remarkable that a scientist at his career stage has developed such a broad array of insights into major problems of Earth history. His accomplishments represent only the beginning of a distinguished academic career.

Response by MICHAEL GURNIS

I need to thank those individuals who have shaped my career in special ways. But first, thank you, Dr. and Mrs. Donath—I am truly honored to receive this medal. Moreover, I think that it is only appropriate to thank the many geologists I've encountered over the last few years who have motivated me to continue my current avenue of work. You see, my background is firmly rooted in geophysics (theoretical geophysics, for that matter), but when I first went to Michigan as a new assistant professor, I decided to attack one of the last unexplained mysteries of classical geology: continental epeirogeny and long-term sea-level change. Stratigraphers had long recognized that mantle processes must play a dominant role in moving continents vertically; Larry Sloss is obviously one of the most famous of those stratigraphers. When explaining my new-found research plans to geodynamics colleagues and competitors, I never saw so many eyes roll over backward. But on many field trips, Michigan field camp, and visits to many geology departments around the country, I never meet a more receptive audience of supporters than those soft-rock geologists who knew what the rocks were saying!

Many individuals can be thanked for shaping my career. I would like to thank my parents, in particular—they played a key role in supporting my education over many years.

There are two individuals whom I want to specially mention. Both are geodynamists; both allowed me to understand that mantle convection is strongly displayed in the geological world around us. The first is Geoff Davies, who was my graduate advisor at the Australian National University in Canberra. Much of my work on sea-level change follows directly from the ground-breaking work by Geoff on the role of the lithosphere in mantle convection. Geoff is a clear and logical thinker, almost dedicated to Occam's razor. He was a tough advisor, but also one of the most pleasant and humble persons I have known. He is a deeply creative scientist. I owe Geoff a lot.

After ANU, I was extremely lucky to have a postdoc at Caltech's Seismo Lab, working with Brad Hager. Brad has incredible insight into how to make dynamic models useful for the rest of geophysics; he helped me develop insight into how to make dynamic models useful for geology. Although Hager allowed me to pursue my own interests with complete freedom, he turned out to be a fierce devil's advocate, and this continuously forced me to do better.

There are also a number of others who deserve mention. From my time at ANU's world-renowned Research School of Earth Sciences, I must acknowledge the influence of Ross Griffiths, for sharing his deep understanding of fluid mechanics. I must also mention my fellow ANU graduate students Herb McQueen and Bill McDonough. It was at ANU that I first met Mark Richards, who has since turned into a spirited colleague; like Davies and Hager, Mark is one of a few geodynamists who are trying to make the connection between Earth dynamics and geology. From my time at Caltech, the influence of Don Anderson cannot be overlooked. He spent long hours forcing me to question everything Geoff Davies and Brad Hager had taught me! Scott King and Arthur Raefsky also played influential roles in introducing me to the world of finite elements. I'm not sure where geodynamics would be without the influence of Raefsky. At Michigan, I've had the privilege of working with a fine group of stimulating young scientists, including Mark Russell, Stuart Weinstein, and Shijie Zhong.

I end by giving a special thank you to my many friends at the University of Michigan. The last five years have been among the most wonderful and rewarding of my life. I have many delightful and stimulating colleagues in Ann Arbor, including Kacey Lohmann, Bruce Wilkinson, Rob Van der Voo, Henry Pollack, Larry Ruff, and Youxue Zhang. I thank them all and many others.

Presentation of the GSA DISTINGUISHED SERVICE AWARD to MICHEL T. HALBOUTY

Citation by L. L. SLOSS

Mike Halbouty is clearly overqualified for the Society's Distinguished Service Award as an active and enthusiastic supporter of GSA for more than 35 years, most recently as an early champion of the goals and attainments of the DNAG program. Further, he has served as a long-term, continuing link joining the sometimes disparate intellectual aspirations of industry and academia, not just in Texas or North America but on a global scale. Here, Mike's initiative and drive are well exemplified by his sponsorship, direction, and support of the repeated Circum-Pacific Conferences on Energy and Minerals. Many will agree that beyond these accomplishments and beyond six decades of publications on salt domes, subtle hydrocarbon traps, and the application of remote sensing to energy exploration, those words spoken and written in support of a sound energy policy for the U.S. will be identified as Mike Halbouty's most distinguished, if commonly disregarded, acts of service to his profession and to his country.

Mike and I resonate to somewhat different wavelengths of the political spectrum; yet many among the scientists of this Society (to whom Mike would assign a shade of pastel pink) join me in admiration of his words and deeds in what he calls "The War Without End" to make the U.S. independent of foreign oil cartels. As far back as the first Eisenhower administration, when both the appearance of a glut and the low price of oil on the North American market were created and maintained by imports, Mike made himself the Cassandra of oil policy, forecasting with uncanny precision the embargo of 1973 and its sequelae. The Halbouty agenda calls for vastly increased levels of domestic exploration (and accelerated development of alternative fuels) supported by higher prices and import taxes—anathema (then and now) to government and the multinational Seven Sisters.

To me, the importance of this issue and Mike's continuing devotion to the cause transcends his other intellectual contributions and his many acts of beneficence. Individual members might have placed emphasis elsewhere, but we can all agree that in Mike Halbouty we have the archetype of distinguished servants of GSA, of earth science, and of the citizens of the Americas.

Response by MICHEL T. HALBOUTY

Not everyone would be lucky enough to have someone like Larry Sloss say all those kind, generous, and mixed-up things about them. Of course, he left out the things I wanted him to say which he said were "insignificant."

One of the proudest moments in my career was the day I became a part of the Geological Society of America membership, and even more so when I was elected a Fellow. Through the years it has broadened the horizons of my profession. The GSA is one of the most respected geoscience organizations in the world, and its recognition started with its inception. On the 27th day of December 1888, a formal organizational meeting of the Geological Society of America was held at Cornell University. The Society was founded for the purpose of "the promotion of the science of geology by the issuance of scholarly publications, the holding of meetings, the provision of assistance to research, and other appropriate means."

It is remarkable to note that during the 105-plus years of the existence of the Society the purpose as originally stated has remained unchanged. The phrase "and other appropriate means" safeguarded the objectives of the Society, as the phrase gave it the authority to delve into whatever is necessary to enhance the science of geology.

To partake in the activities and contributions of the Geological Society of America is to also become involved in a continuous educational experience because its publications and meetings are structured to add to the knowledge and the heritage of the science of geology. The strength of any society is the support of its members and one of GSA's greatest assets is its ongoing member-supported Foundation, which has added greatly to the financial resources of the Society and provided for new projects, such as the DNAG publications.

Almost two decades ago during my tenure as a member of the Committee on Investments (1975–1977), I became keenly aware of the acute financial problems of the Society and pondered how they could best be resolved. I reflected on the tremendous success of the American Association of Petroleum Geologists (AAPG) Foundation which I established during my presidency of AAPG in 1967. This prompted me to recommend to Larry Sloss and the GSA Council, during his administration, that the GSA consider organizing a similar foundation with its prime objective of enhancing the financial stability of the Society. Without any hesitation whatsoever, the Council approved the Foundation, and with its establishment and success the objective was accomplished.

It was an honor for me to have served as one of the founding trustees of the Foundation for nine years, during which I had the pleasure of witnessing its successful growth.

Although I have served the GSA in many other capacities, I feel that my involvement in the organization of the Foundation initiated my receiving this award, for which I thank the officers and members of the Society.

Presentation of the

RIP RAPP ARCHAEOLOGICAL GEOLOGY AWARD

to

DONALD L. JOHNSON

Citation by DANIEL R. MUHS

It is a pleasure and a privilege to present this award to Don Johnson for his achievements in archaeological geology. I am particularly honored to present this award because it was from Don that I took my first course in earth science, entitled "Earth's Physical Systems," in 1972. Don's nature as a true interdisciplinarian was evident even in that introductory course, and it inspired me to follow the career that I have.

Don was born in southern California and grew up on the coast and in the deserts of that state and in Arizona and Nevada. His natural curiosity and observational skills in this diverse landscape led to numerous youthful adventures in the deserts, mountains, and coasts of California and Mexico, but did not lead immediately to a career in the earth sciences. In fact, Don did not enter the esteemed halls of higher education until somewhat later in life, after having established a highly successful plastering business in the Los Angeles area. For whatever reason, at some point in his late twenties, a time when most people are already loath to make major life changes, Don decided money wasn't everything, gave up his plastering business in Los Angeles, and started college.

True motivation toward learning is a mark of the older beginning student, and Don was no exception. He excelled in studies at UCLA and won a fellowship to the University of Kansas, where he completed his Ph.D. in 1972. Don started out his studies at KU with the idea of being a regional specialist in Latin American geography. However, a term paper on calcrete genesis on the California Channel Islands, written for visiting professor James Thorp, one of the most esteemed soil scientists in the United States, proved to be the important turning point for Don, and Latin American regional geography was pushed to the back burner. From the beginning, Don was learning soils from one of the best minds in American earth science, and Thorp ingrained in him a sense of the integrated approach to the study of the earth that is so much a part of Don's approach to this day.

From his base of operations at the University of Illinois (in fall, winter, and spring) and UCSB (in every summer that he can get away), Don has made important contributions to the discipline of archaeological geology. His background in soils, geomorphology, and Quaternary stratigraphy has led him to be a part of the studies at a number of key archaeological sites, including the pygmy mammoth sites and infamous "fire areas" of the California Channel Islands, the Kimmswick Clovis-Mastodon site in eastern Missouri (with coworkers Russ Graham, Vance Haynes, and Marvin Kay), and the Paleolithic and Neolithic sites at Wadi Tushka and the Selima sand sheet in the eastern Sahara (also with Vance Haynes). At these important archaeological sites, Don provided the expertise in soil-forming processes that is critical to interpretation of the sequence of events and reconstruction of paleoenvironments.

Don's studies on the northern Channel Islands in California led him to test the time-honored theory that mammoths had migrated to those islands via a hypothesized land bridge. He showed that there is little or no geologic evidence for a former land bridge, and that another mechanism must be invoked. Studies of the behavior of modern elephants led to Don's proposal that mammoths in fact *swam* to the Channel Islands from the mainland during glacioeustatically lowered sea levels of the Pleistocene. This effort not only answered long-standing questions in both island zoogeography and structural geology, but also led Don to further studies of elephant behavior. His investigations of elephant behavior resulted in a paper on the strategies of Clovis people for hunting mammoth. Don and coworkers explored the human motivations for hunting mammoth during Clovis time, the possible hunting methods employed, and how behavior patterns of mammoths were probably exploited by Clovis hunters.

One of the issues still unresolved in Quaternary studies is the mechanism by which the Rancholabrean megafauna became extinct near the close of the Pleistocene. Some workers, such as Paul Martin, argued that the Clovis hunters alone could have accomplished the job; other workers argue that the shift from a glacial to interglacial climate was the forcing mechanism. Still others, such as Vance Haynes, have suggested that it may have been a combination of animals under climatic stress that were successfully hunted by Clovis people. Don's field studies on the U.S. West Coast led to a series of papers on a reconstruction of the full-glacial paleoclimate of the California coast. In these studies, he assembled an extensive array of radiocarbon ages in key stratigraphic sections, along with geologic, pedologic, paleobotanic, and palynologic data to show that the full-glacial climate in coastal California had a basically Mediterranean character, similar to the present climate. Although Don documented southward shifts in vegetation zones during full-glacial time, he was able to show that dramatic changes of climate, such as those experienced in the continental interior, did not occur on the coast. The implication of this work is that extinction of the Rancholabrean megafauna on the California coast cannot be explained by climatic change by itself, because little climate change occurred. The important conclusion of Don's work is that human predators had to be at least in part responsible for extinction along the California coast, even if they were not the key factor in other localities.

Since 1972, Don has published over twenty papers on the subject of disturbance of archaeological sites by pedologic, geomorphic, and biologic processes. Inspired by Charles Darwin's 1837 studies of the burial of 2000-year-old Roman artifacts on the English landscape by earthworm casts, Don has conducted extensive field and laboratory studies of the effects of naturally occurring earth-surface processes on artifact mixing and site disturbance. His studies have demonstrated that frost heaving, swelling clays in Vertisols, tree throw, and biomantle production by earthworms, ants, termites, gophers, and other fauna not only have tremendous implications for soil profile development and landscape evolution, but also artifact context and relative-age relations at archaeological sites. Don has supported his models with field studies from California, the Midwest, Australia, and Africa, and his work shows that artifact assemblages exposed in a trench can have an extremely complex history and highly disturbed stratigraphy.

Don is fortunate to have had his wife, Diana, as an astute field observer, critical editor and coauthor, and energetic field assistant throughout his career. Don and Diana have explored many of the field sites together, each contributing observations and insights.

Don's approach to archaeological geology has been that of a true interdisciplinarian, combining theories and techniques from the fields of archaeology, geology, pedology, geography, and biology, in the tradition of the 19th century naturalist Charles Darwin, who is one of his role models. In that tradition, Don has grounded his studies in careful field observations, a key part of archaeological geology. This approach, combined with an excellent sense of humor and a never-ending sense of wonder and curiosity, has made Don a most worthy recipient of this year's Archaeological Geology Award.

Response by DONALD L. JOHNSON

Everything had a name and each name gave birth to a new thought.

—*Helen Keller*

I thank the Archaeological Geology Division of the GSA for choosing me as the recipient of the Rip Rapp Award for 1993. I must admit, however, to a bit of guilt in receiving it, because I know for a fact that there are many other people within and outside the Division, in fact in this room, that are far more deserving. Nevertheless, I am truly humbled and touched by the honor, especially as it comes from my peers and is presented by my first graduate student and good friend, Dan Muhs.

In accepting this award I would like to share the honor with two institutions and several people who indelibly affected my life and early career. I would then like to honor them, and the Archaeological Geology Division, by offering a brief essay based partly on how truth and new discoveries in geoarchaeology can be sidetracked for want of language to describe them and a theoretical framework to convey their relative importance.

The institutions are El Camino College and Los Angeles Valley College in Torrance and San Fernando Valley, California. At both I was introduced to the fun and excitement of science by some very able and inspirational professors, notably Joan Baldwin, Bernard Pipkin, and Wally Ford of El Camino, and Bob Coony and Jim Slosson of Valley College. Thanks for helping me get out of plastering and into academia, even though construction paid a hell of a lot better.

Other individuals are Bette Wahl, Diana Johnson, Charles Darwin, Nathanial S. Shaler, J. P. Watson, and Francis Hole. Bette Wahl is my sister who, along with her then-husband Don Tolley, put me up (and put up with me) during that economically lean period when I attended Valley College. Diana Johnson, my wife, I met in Pipkin's Historical Geology class at El Camino; she has put up with me too, lots. Thank you, Bette and Don, for your early encouragement; thanks, Barney, for having attractive and smart coeds in your class; and thanks, Diana, for your effusive encouragement and for making my life enjoyable and productive.

Darwin, Shaler, Watson, and Hole impacted my career largely through their published works, a point that will become obvious in the essay which follows.

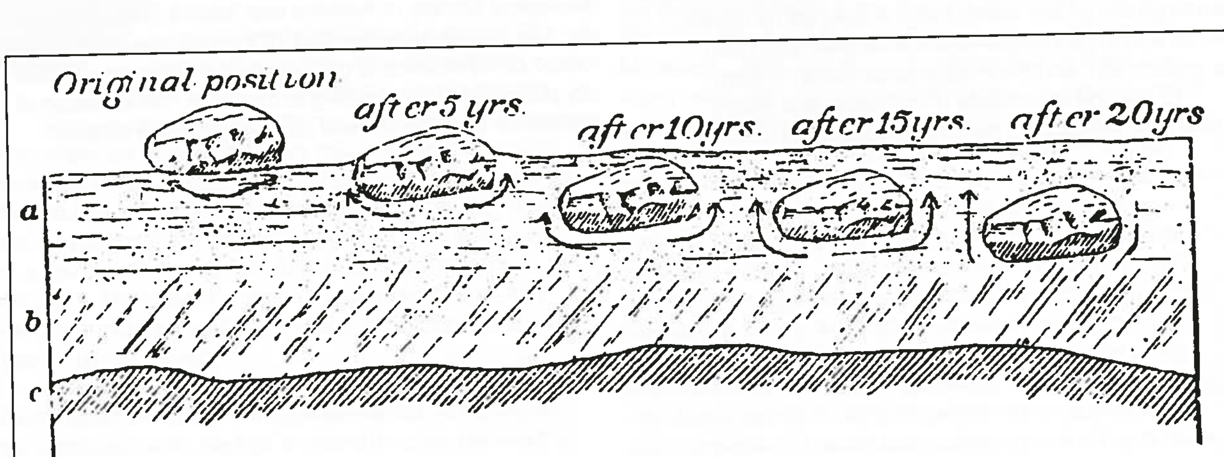


Figure 1. Original diagram from Shaler (1891), showing how *biomechanical processes,* specifically *faunalturbation,* can form a *biomantle* and concomitantly cause stones to be lowered to the base of the dominant zone of *bioturbation* (note that Shaler did not use the genetic language shown in italics; such terms did not then exist).

I'll start with Darwin, and end with all of them, and a quote by Alexander Graham Bell.

In 1881, the year before he died, Darwin produced a book entitled *On the Origin of Vegetable Mould through the Action of Worms.* In it Darwin showed how one animal, the lowly earthworm, can biomechanically form the upper two layers of three-layered soil systems, systems that typify the epidermis of landforms on our planet. His little book quantified the process, and was based on observations that spanned 44 years. It should have had a profound and lasting impact on the then-evolving, or soon to evolve, theoretical frameworks in archaeology, ecology, forestry, geomorphology, pedology, and soil science. But it didn't, and why it didn't is partly what this essay is about.

For a short time Darwin's book did have an immediate impact on the earth and biological sciences. It prompted a plethora of studies where biomechanical processes were recognized as fundamental in the evolution of landscapes. In 1891 N. S. Shaler conceptually modeled the process (Fig. 1). But after the turn of the 20th century, Darwin's message and Shaler's model were largely ignored by earth and life scientists, in fact for some 60 years, until 1961. In that year two papers were published that espoused Darwin's biomechanical message, but more important, they conveyed the message in new conceptual frameworks. One was "A Classification of Pedoturbations and Some Other Processes and Factors of Soil Formation in Relation to Isotropism and Anisotropism" by Francis Hole, published in *Soil Science.* The other was "Some Observations on Soil Horizons and Insect Activity in Granite Soils" by J. P. Watson, published in Rhodesia (now Zimbabwe) in *Proceedings of the First Federal Science Congress, 1960.* Both are watershed papers insofar as they were among the first after Shaler to convey Darwin's biomechanical message in conceptual vehicles.

In his paper, Hole coined various terms to capture both general and specific pedogenetic (and geoarchaeologic) processes and concepts. A general one now in wide use was "pedoturbation," a term that embodies the biomechanical message that Darwin promulgated. Hole also coined the terms "floralpedoturbation" and "faunalpedoturbation," of which the latter specifically captures Darwin's observations (this was later shortened to "faunalturbation"). Not only did Hole provide a language to articulate the processes about which Darwin had written and Shaler had modeled, he also linked them to pedogenetically induced isotropism and anisotropism. He thereby laid the conceptual cornerstone for soil evolution theory, biomantle theory, dynamic pedogenesis, and dynamic denudation, all recent frameworks in which biomechanical processes are accorded high geomorphogenetic and pedogenetic rank. What is interesting is that insofar as Hole did not cite Darwin's work, he apparently came to his ideas more or less independently.

Watson, on the other hand, who did acknowledge Darwin's work, attributed the upper two of three-layered soils that are found throughout the tropics, subtropics, and mid-latitudes to the biomechanical activity of insects. Watson defined the three layers as the "mineral," "stone," and "weathered rock" horizons, and gave them M, S, and W horizon designations. Watson's principal contribution was to show that biomechanical processes play dominant roles in producing the upper horizons of soil profiles.

In sum, Hole provided a language for the pedogenetic processes that Darwin had observed and Shaler had modeled, whereas Watson gave visibility and conceptual identity to the products of the processes.

Now we return to the question posed. Why did Darwin's observations, and Shaler's conceptualization of them, not have a profound and lasting impact on the then-evolving, or soon to evolve, theoretical frameworks in the various fields indicated, especially archaeology, geomorphology, and pedology? I submit that the answer is linked to several reasons that point up the sometimes stochastic and stumbling nature of scientific progress.

One is that neither Darwin nor his contemporaries developed a genetic language to articulate the basic process, as did Hole, nor did they give names and appropriate designations to the horizons produced by the biomechanical process, as did Watson. Neither did they create a theoretical framework to effectively convey their findings. Because of Hole, and a term borrowed from sedimentology, three useful pedogenetic terms are now available, pedoturbation, bioturbation, and faunalturbation, from the general to the specific.[1] Because of Watson, three useful horizon names and designations are now available, the mineral (M), stone (S), and weathered rock (W) horizons. (I have elsewhere shown that these horizons are the genetic equivalents to the conventional A, E, and B-C horizons used in the northern hemisphere mid-latitudes).

The lesson here is that science is retarded in the absence of an evolving and constantly updated essential lexicon of key terms that define the basic processes observed by practitioners. Science is also retarded in the absence of names and notations to identify products of the processes. Scientific jargon may be our bane, but the timely coinage of conceptually sound and logically consistent terms is fundamental to the advancement of science.

A second reason that Darwin's observations and Shaler's model had no lasting impact turns on the inherent structure and nature of the two principal soil and earth science theories that were being formulated toward the end of the 19th century. These were the soil formation-factorial theory of V. V. Dokuchaev and his Russian disciples, and the geographical cycle theory of William Morris Davis and his American colleagues. The structure and direction of both frameworks were such that they could give only minimal conceptual visibility and significance to the biomechanical observations of Darwin and his contemporaries. Both theories have dominated the fields of geomorphology, pedology, and soil science for most of this century, certainly the first half of it. As indicated, four new useful structures which provide visibility and significance to Darwin's observations are soil evolution theory, biomantle theory, dynamic pedogenesis theory, and dynamic denudation theory. The lesson here is that science is retarded when existing theoretical structures cannot convey the importance of key processes that are operating, or do not give visibility to the results of those processes, or do not—or cannot—encourage important new questions to be asked. New theoretical structures must then be advanced.

A third reason, in my judgment, that Darwin's observation and Shaler's model languished was an inherent inability on the part of many, though not all, late-19th-century soil scientists and geomorphologists to recognize the importance of biomechanical processes on the landscape. At that time soil science was dominated by agricultural chemists whose focus was on biochemical processes and their results, and whose questions must surely have been asked within the contexts of biochemical and increased yield frameworks. Geomorphology, on the other hand, was a field growingly concerned, if not obsessed, with megascale landscape-evolution frameworks from which biota were essentially omitted. Ironically, it is biotic agents that make Earth surface processes fundamentally different from those on other planet-like celestial bodies; that they would be omitted from any Earth-centered generalized explanatory framework is sobering. The fact that the small-scale, seemingly insignificant biomechanical observations of Darwin and Shaler and their contemporaries were—and still are—virtually ignored in the writings of most soil scientists and geomorphologists validates this judgment.

As a counterpoint I call attention to a growing field of science that underscores the theme of Darwin's 1881 book, Shaler's 1891 model, Hole's 1961 lexicon, and Watson's 1961 horizon designations. It is the science of ichnology, and is supported by a new journal, *Ichnos.* Its underlying theme parallels one present in most of Darwin's work, which is the other basis for this essay and underscores a third lesson—that given enough time, small and seemingly insignificant biotic processes will produce significant effects on landscapes.

Finally, the perspicacity and wisdom of Darwin, Shaler, Hole, and Watson are reflected in words by Alexander Graham Bell, who noted, "Discoveries and innovations arise from the observation of little things."

[1]The term "bioturbation" was coined by Rudolf Richter, a sedimentologist, in 1952 to describe biotically caused displacements in soils and sediments. It appeared several decades later in the literature of pedology and geomorphology as a general substitute for "faunalpedoturbation" and "floralpedoturbation."

Presentation of the

GILBERT H. CADY AWARD

to

MARLIES TEICHMÜLLER

Citation by PAUL C. LYONS

Marlies Teichmüller's distinguished 55-year career, mainly with the Geologisches Landesamt Nordrhein-Westfalen (Krefeld, Germany), includes publishing about 164 papers comprising both fundamental and pioneering works in coal petrology and coal geology. She studied under Erich Stach of Germany, who pioneered reflected-light coal microscopy, and Reinhardt Thiessen of the United States, who pioneered transmitted-light coal microscopy. Her Ph.D. dissertation (1941, University of Berlin) entitled "The Microscopic Structure of American Coals in Polished Sections and Thin Sections—A Comparison of Microscopic Methodologies" dealt—inter alia—with a Kentucky coal. Her dissertation was started in January 1938, under Thiessen's guidance at the U.S. Bureau of Mines, Pittsburgh, Pennsylvania, when Marlies was a German exchange student in the United States. It was completed in Germany under Stach, her dissertation advisor.

Her coal petrologic research led to the establishment of the reflected-light method of coal petrography as the international standard. Marlies' genetic approach to coal petrology was greatly influenced by Thiessen, the pioneer in genetic coal petrology. She used coal-ball plants and botanical analogs in peats and soft brown coals to study the genesis of coal constituents. The application of fluorescence methods led to her recognition of new liptinite macerals (exsudatinite, bituminite, and fluorinite) and their origin. She also clarified the origin of inertinite macerals such as micrinite. One of her latest publications, "The Genesis of Coal from the Viewpoint of Coal Petrology" (1989, *International Journal of Coal Geology*), an 87-page summary of work in the field of genetic coal petrology, has become one of her most widely read publications.

Marlies pioneered transmission-electron microscopy (TEM) studies of coal, fluorescence studies of macerals, and the use of vitrinite reflectance to map coalification in the Ruhr, Saar, Upper Silesian, and other coal basins of Europe. Her meticulous research has resulted in an understanding of the relationship among vitrinite reflectance, paleotemperature, petroleum generation, and coal chemical composition. Her coalification curves are used world-wide. With her husband, Rolf Teichmüller, she related degree of coalification to tectonics, geothermal history, and hydrocarbon exploration and made many outstanding contributions to regional analysis of the German coal basins and other basins of Europe. Rolf, a structural geologist, was the major guiding force behind many of her early coalification studies, and their collaborative publications are models of excellence in coal geology. Her study of the large Rhenish brown-coal deposit in the Lower Rhine basin of Germany resulted in her well-known reconstructions of Miocene coal swamps. Marlies' wide range of studies includes graptolite reflectance as a coalification indicator and the application of coal petrology to archeology.

As a founding member of the International Committee for Coal and Organic Petrology (ICCP), she has contributed to international definitions, standards, and procedures in coal petrology. Marlies played an important role as a member of the editorial staff for the *International Handbook of Coal Petrology* (1965, 1971, 1975) of the ICCP. She is the coauthor of *Stach's Textbook of Coal Petrology* (2nd [1975] and 3rd [1982] editions), still the fundamental textbook in the field.

Many of us who are privileged to know Marlies have been greatly influenced by her incisive reviews, her high professional standards, and her leadership in promoting research in organic petrology and coal geology. Her encyclopedic knowledge of these fields and her own outstanding contributions to them are without parallel. Combining such professional qualities with her friendliness, warm smile, and encouraging manner have endeared her to friends and colleagues alike.

Marlies has received many awards, including the Hans Stille Medal of the German Geological Society (1969, jointly received with Rolf Teichmüller), the Reinhardt Thiessen Medal of the ICCP (1971), the Carl Engler Medal of the German Society for Petroleum Science and Coal Chemistry (1978), the Distinguished Service Medal of Germany (1979), and the Van Waterschoot van der Gracht Medal of the Royal Geological and Mining Society of The Netherlands (1987).

Marlies' papers have greatly influenced our understanding of coals worldwide and have promoted the fields of coal petrology and coal geology in North America. She is the first coal geologist outside of North America to receive the Gilbert H. Cady Award for her leadership and pioneering studies in these fields.

Response by MARLIES TEICHMÜLLER

I thank Heinz Damberger for his kind linguistic revision of this response and for reading it at the Boston meeting, because I could not personally go to Boston to accept this award. I am also very grateful to Paul Lyons for his kind citation. My sincerest thanks to the Coal Division of the Geological Society of America for the great honor to receive the Cady Award and to be the first recipient from outside North America. This makes me very proud, and I regard the award as an honor also to my late husband, Rolf Teichmüller, with whom I worked together for more than 30 years.

We met at the Humboldt University of Berlin in 1937 at the Geological Institute of Professor Hans Stille, an internationally well known geologist. Rolf had already finished his studies and was Stille's assistant, supervising Ph.D. theses on the Mediterranean region. I had come from the University of Freiburg, where I had begun to study geography. I wanted to fulfill my dreams to "discover the world." This was in 1935 when conditions were difficult in Germany. Among other things, it was almost impossible to leave Germany because of an embargo on foreign exchange. The 10-marks-per-month limit everybody was permitted to exchange was spent in France or Switzerland, where we could go with bicycles, heavily loaded with food and blankets.

In Berlin, I soon became much impressed by Stille's excellent lectures on structural geology, and by the immense times, spaces, and forces that are so characteristic of geology. I asked Stille to let me change my major from geography to geology and become one of his students, but it was quite uncommon then for a woman to study geology. I had to wait for some time before Stille agreed.

When I asked Stille for a doctoral thesis topic, my admired teacher proposed a paleontological topic that was not at all to my liking. In response, I went "next door" to the Invalindenstrasse, where the paleobotanist Professor W. Gothan, and the coal petrologist Dr. Stach, worked at the Prussian Geological Survey. Stach was a young lecturer at Humboldt University, too, and willingly accepted me as a Ph.D. candidate.

To satisfy my desire to see foreign countries, I applied to be an exchange student in the United States. After a generous acceptance of my limited school English by a kind English university lecturer, I received support from the Deutsche Akademische Austauschdienst (German Academic Exchange Service) to visit first Clark University in Worcester, Massachusetts, and thereafter Reinhardt Thiessen, the famous, internationally known coal petrologist, at the U.S. Bureau of Mines in Pittsburgh, Pennsylvania. The four months I spent in Pittsburgh in 1938 were decisive to my professional life.

At that time, in contrast to most coal petrographers in Western Europe who studied coals under the microscope using polished sections, Thiessen and other American coal petrologists worked with thin sections. These different methods had led to different coal microscopic nomenclatures and analytical results. Thus, it seemed reasonable to compare and correlate the two different systems. This was the main reason I went to Pittsburgh, in January 1938. Although I was able to stay there through April, my expectations were badly shattered when on January 30, just three weeks after my arrival, Reinhardt Thiessen died of an unexpected heart attack. He was only 70 years old. Up to then this was the greatest disappointment in my life.

The major result of my stay in Pittsburgh was my doctoral thesis on American bituminous coals, which I studied both in transmitted and reflected light. In part, I used polished thin sections that allowed the use of both methods on the same specimen. The study of polished thin sections demonstrated that translucent constituents are underemphasized, and opaque—i.e., highly reflecting constituents in polished sections—are overemphasized in transmitted light. These results, later strengthened through a cooperative study with Bryan Parks from the U.S. Bureau of Mines, finally led to the general international acceptance of the maceral classification based on the reflected light method.

During the three weeks I worked with Thiessen, I got to know his great personality and his unique methodology as a researcher. Thiessen was very broad minded. This was, at least in part, a reflection of his academic training in several disciplines, including botany, chemistry, geology, and astronomy. Unlike most coal petrographers, Thiessen was familiar with the conditions prevailing in mires and peat deposits. His thin section method offers notable advantages for botanical and genetic investigations, although the method was applicable mainly to lower rank coals, including high-volatile and some medium-volatile bituminous coals.

Thiessen's ideas and his last publication, "What Is Coal?" (posthumous, 1947), became a guide for my later work on the genesis of coal and its constituents.

Another main field of interest was coalification, its causes and relations to geothermal history, tectonics, and oil and gas maturation. This was a hobby that I often worked on with my husband Rolf, who was responsible for the geological and structural background of these studies. Our work was appreciated and supported by the presidents of the Geological Survey of North Rhine–Westphalia in Krefeld, and we received much help from our colleagues and coworkers. I am especially grateful to the late presidents, Professor H. Karrenberg and Mr. E. Reiche, and to my colleagues and co-workers, the late Professor W. Schmidt, the late Dr. G. Stadler, Dr. C. D. Clausen, the late Mr. H. Hinz, Mr. K. Ottenjann and Mrs. M. L. Schlösser. Many scientists from other institutions helped to clarify geological questions on the basis of coalification measurements. I would especially like to thank here the physicochemists Dr. J. Karweil and Professor H. Jüntgen (both Essen), the late geologists Professor K. Patteisky (Bochum) and Professor G. Kneuper (Saarbrücken), geologists Dr. H. Damberger (Saarbrücken, today Champaign, Illinois), Dr. R. Bartenstein (Celle), Professor K. J. Reutter (Berlin), Professor K. Weber (Göttingen), geophysicist Dr. G. Buntebarth (Clausthal), mineralogist Professor M. Frey (Basel), and organic chemists Dr. M. Radke and Professor D. Leythaeuser (both Jülich).

But let me tell you more of the stimulating visits and discussions with colleagues of North America. First of all, there is Dr. Cady! I first met him in Europe where he came as representative of the United States in 1953 for the first meeting of the International Committee for Coal Petrology (ICCP) in Geleen, organized by Professor van Krevelen. He was strongly interested in an international coal classification. This resulted in 114 letters between us during the years 1951 to 1964, as Jack Simon kindly pointed out to me, after a search through Cady's files at the Illinois Geological Survey. Dr. Cady knew German very well. He had translated part of Stutzer's book *Kohle* (Leipzig, 1923; *Geology of Coal*, University of Chicago Press, 1940, translated by Adolph C. Noé [Cady completed the translations and saw the book through to publication after Noé's death in 1939]), and also some of our papers dealing with geological applications of coal petrology. Dr. Cady's last visit to Europe was in 1963 when he was awarded the Reinhardt Thiessen Medal of the ICCP in Paris. After the ICCP meetings, we commonly enjoyed some sightseeing together.

Personally, I remember Dr. Cady as a distinguished senior gentleman, always very friendly and helpful. Once in Liège, we had agreed to take an early morning stroll. I waited a fairly long time, but Dr. Cady did not appear. So, I went to his hotel to ask if he had gone out. The answer was no. Nobody had seen him for breakfast yet. We became concerned that something bad might have happened to him. The hotel people knocked on his door, but there was no answer and the door was locked from the inside. Finally somebody succeeded in entering the room through a window and found Dr. Cady still asleep. Obviously, he had not heard his alarm clock. In just a few minutes he appeared in the hall, correctly dressed, and unwilling to have his breakfast before we started. This was the gentleman, Dr. Cady!

The same kindness as Dr. Cady's was extended by Jack Simon of the Illinois State Geological Survey. He provided us with American literature shortly after World War II when we were hungry for it, but could not get it in Germany. Jack was the first of more than 30 American colleagues who visited us in Krefeld, according to our guest book. This was after the Heerlen Conference in 1951. In 1964 Jack kindly invited me to visit Urbana for several informative and pleasant days. There I met John Harrison and Drs. Gluskoter, Hopkins, W. H. Smith, and White. The coal samples we took at the Harmattan Mine in eastern Illinois provided the first microscopic evidence of oil formation in coal; additional coal samples from Illinois that Dr. Damberger sent us later provided more evidence.

Most visits to North America also took me to Penn State University, where Bill Spackman, in particular, made me feel at home in the United States. His field excursions to the Everglades and to the Okefenokee Swamp in 1964 and 1967 were unforgettable. They satisfied my personal interest in the genesis of coal, especially as to comparisons with Miocene soft brown coals of Germany. These excursions under Bill's excellent leadership, together with his students Walter Riegel, Art Cohen, Gil Smith, and Phil Dolson, were highlights of my life. I will never forget our boat trips through the quiet and peaceful waters of the swamps, in the cypress forests of the Okefenokee Swamp where our boat was sometimes shaken when it struck the hidden root of a *Taxodium* tree. Another unforgettable image I have is Bill standing in water up to his stomach to take mud samples.

In 1967 Peter Given was with us in the Everglades. I learned from him and his students much about the chemistry of peats and coals. He also was a good cook; he prepared breakfast, with fried eggs, for the students, while the young men were still lying in their beds. This somehow struck me as odd and I asked a student why they did not help. The answer was "because he likes to fry eggs and prepare breakfast." Also, Bill Spackman acted as cook on the big boat of the Pennsylvania State University on which we went out into the Gulf to visit mangrove islands. Apart from the hundreds of mosquitoes we had to fend off, that part of Florida was like a paradise for a most curious coal petrologist from Germany, who learned also that in the United States, friendship more than authority characterizes the relationship between professors and their students.

At Penn State I had the chance to visit the best equipped coal petrological laboratories that I had ever seen. We discussed the results on Florida peats that Art Cohen had obtained by using his thin-section method, the bacteriological studies of Professor Casida, and the chemical studies of Peter Given and his coworkers. Dr. Neavel had just finished his Ph.D. thesis, a fundamental study on sulfur in coal; and Professor Vastola demonstrated his first results on coal pyrolysis with the laser mass spectrometer. Later, when Alan Davis became the director at Penn State, the main topics for demonstrations and discussions were related to our mutual interest in geological applications of coal petrology, and in the fluorescence properties of coal macerals, their causes and significance for bituminization and coking behavior.

My first visit to Penn State was in 1964. Peter Given had organized the first Coal Science Conference. At that time, the idea of David White and T. M. Stadnichenko that pressure is the main cause for coalification was still the prevailing one in North America. My lecture, "Geological Causes of Coalification," based on coalification studies of vitrites in Germany, was strongly opposed because we had concluded that rock temperature was the main cause for rank increase. I think this has been confirmed and accepted in North America by the excellent coalification studies of C. Barker, N. Bostick, R. M. Bustin, H. Damberger, P. A. Hacquebard, A. G. Harris, and W. Kalkreuth. Pressure certainly may influence physical properties of coal, such as porosity and the alignment of aromatic clusters, and therewith the anisotropy of vitrinites. Heinz Damberger has shown that overburden pressure influenced the porosity of Illinois coals; and Alan Davis, Jim Hower, and Jeff Levine demonstrated that vitrinites from coals in the folded Appalachians show biaxial optics that indicate former stress regimes. Their studies are an excellent example of what can be done with coal petrological methods to clarify geological questions.

In 1964 I visited many other colleagues in the United States. In Columbus, Ohio, Jim Schopf was very interested in our studies of coalification and tonsteins. He showed me contact-metamorphic coals from Antarctica that he had discovered recently, and an Ohio oil shale that contained very large *Tasmanites* algae, 2 to 3 mm in diameter, of yellow color on weathered surfaces. At Harvard University, I visited Elso Barghoorn, whom I had met earlier in Krefeld in 1957 when he kindly provided advice on our reconstructions of the brown coal mires of Germany. I saw the rich collections of fossil plants, coals, and coal thin sections of the late Dr. E. C. Jeffrey, and the famous glass reconstructions of living plants. Barghoorn was a famous paleobotanist who was much interested in the genesis of coal, and particularly in organic substances from Precambrian rocks. Together with William Schopf, he had recently isolated porphyrins from the Precambrian flints of Lake Michigan. We discussed bacterial life in marine peats, and I learned that the marine Spartina peats of Massachusetts reached a thickness of 10 m within only 5000 years.

At the Woods Hole Oceanographic Institute, I met the late Dr. Degens, a German organic geochemist who later became a professor at the University of Hamburg. In 1964, there were only a few organic geochemists in our country, in contrast to the United States. We discussed humification and peat formation, the different kinds of humic acids, and the role of organic substances as geologic thermometers.

At the U.S. Geological Survey in Washington, D.C., Irving Breger discussed his research with me on the Upper Devonian Chattanooga oil shale, and on the chemical differences he had found between marine and terrestrial deposits. Dr. P. Zubovic demonstrated the strong influence that erosion in the vicinity of ancient peat deposits has on the type and concentration of trace elements found in coals. He also was an expert on uranium in coals, which at the time was a hot subject. Dr. R. O. Fournier kindly shared his findings on the formation temperature of pyrophyllite, which we had found in anthracites in the Bramsche Massif of Germany.

Also, in 1964, Shell Research in Houston invited me to talk on the relationship between coalification and oil formation. Chris Gutjahr, who was still in Houston at the time, had visited us in Krefeld in 1960 to study our methods of rank determination and to calibrate his spore translucency method with the rank parameters we used. For the first time I heard about a marked decrease of spore translucency, which was caused by heat damming and increased heating at the margins of salt domes, due to the much higher thermal conductivity of salt.

I am certainly very grateful for the invitations to two Gordon Conferences on coal science (in 1967 and 1973), and to one on organic geochemistry (in 1978). They were held at young men's prep schools or colleges in New Hampshire, during vacation time, when there was room for about 100 invited experts. Lectures and discussions took place in the morning and late evening up to midnight. The afternoons were free for private discussion, sports, or excursions. No one was allowed to publish results except one's own, which permitted researchers from private industry to report on their work. I think that is a practical and typically American great idea!

During my visits to the United States and Canada, 1978 became the year of "coalification and hydrocarbon generation." At the Gordon Conference, I had reported on first petrographic indications of oil formation in coals. In Denver, I met Neely Bostick, Charles Barker, and Claudia Wadell to discuss mainly reflectance measurements in rocks other than coal. In Calgary, I met Alex Cameron and his group, as well as many oil geologists like Staplin, Creaney, Gunther, and others who were estimating the maturity of organic materials by microscopic methods. I was especially impressed by the studies of Mrs. Masran of Imperial Oil, who had subjected marine and terrestrial plants to chemical and biological breakdown in order to clarify the genesis of certain organic constituents in oil source rocks. Alex Cameron invited me for an unforgettable trip into the Canadian Rockies. I ended that trip by visiting John Grayson in Tulsa to discuss maturity parameters, like translucency and fluorescence of liptinites. He had just gotten his license to fly an airplane when he took me in a little Cessna low over Tulsa and the Arkansas River. It was a thrilling end to that trip to North America.

One of my latest visits to the United States was combined with the International Geological Congress in Washington, D.C., in 1989, where the superorganizer Paul Lyons had succeeded in preparing and conducting a symposium on "Peat and Coal: Origin, Facies and Coalification." The 47 papers had just been published prior to the Congress in two thick special issues of the *International Journal of Coal Geology.* Another volume with discussion and other selected papers of this symposium appeared in 1990. An admirable performance!

The last trip to the United States was again to Penn State University, in 1992. Alan Davis and his students had organized the annual meeting of the International Committee for Coal and Organic Petrology, followed by the meeting of The Society for Organic Petrology (TSOP). I especially enjoyed the relaxed American style of discussions within TSOP and the very well prepared excursion to an anthracite field in the Appalachians. At the U.S. Geological Survey in Reston, Ron Stanton showed me his excellent work on the etching of polished coal surfaces, and Paul Lyons discussed his results on tonsteins and coal balls.

Thank you very much, my American colleagues, for all your kindness and help, which I have always experienced in your country!

Those mentioned here and others, last but not least my colleagues and coworkers at the Geological Survey of North Rhine–Westphalia in Krefeld, have certainly contributed to my being recognized with this award. I accept it with my sincerest gratitude.

Presentation of the

E. B. BURWELL, JR., AWARD

to

RICHARD W. GALSTER

Citation by RICHARD E. GRAY

The E. B. Burwell, Jr. Award is presented for a published work of distinction which advances knowledge concerning principles or practice of engineering geology and memorializes E. B. Burwell, Jr., who was an early leader in the practice of modern engineering geology and first chief geologist of the U.S. Army Corps of Engineers.

Engineering Geology in Washington (Richard W. Galster, Chairman, Centennial Volume Committee, Washington State Section, Association of Engineering Geologists, Bulletin 78, Washington Division of Geology and Earth Sciences, 1989) is a two-volume, 1234-page publication containing 13 chapters with 127 papers by over 100 authors. These volumes commemorate the 100th anniversary of Washington statehood (1889–1989) and were prepared to provide a reference on the practice of engineering geology in the state and a compendium of case histories relating geology to significant engineered projects in the state. The publication is dedicated to Howard A. Coombs, who served as chairman of GSA's Engineering Geology Division in 1971. Richard Galster was editor or co-editor of four chapters and was author or coauthor of 21 papers. *Engineering Geology in Washington* is clearly a publication of distinction which advances knowledge concerning the principles and practice of engineering geology. This publication and its principal editor and author, Richard W. Galster, are most deserving of the E. B. Burwell, Jr. Award.

Richard W. Galster has had a distinguished career in engineering geology as a practitioner, a leader, and an author of numerous publications. A native of Seattle, he earned B.S. and M.S. degrees in geology from the University of Washington. In 1955 he joined the Seattle District, Corps of Engineers; as staff geologist and later as lead geologist he participated in engineering geological investigations, the design and construction of Howard Hanson, Lower Monumental, and Wynochee Dams in Washington, and Libby Dam, Montana. Projects included extensive highway and railroad relocations, including the 7-mile-long Flathead Tunnel and pioneering use of rock slope instrumentation for the Libby Project. He was involved with a variety of military projects including site evaluation for the first group of Minutemen ICBMs in Montana.

In 1973, Mr. Galster became district geologist and chief of the Seattle District Geology Section, a position he remained in until his retirement from government service in 1985. During this period he supervised seismic safety evaluations for 18 major dams in Washington, Oregon, Montana, California, and Idaho; provided construction advice for completion of the Libby Project, and directed geological investigations, excavation plans, and specifications for Libby Reregulation Dam. He directed investigations and provided contract and construction input for modification of Chief Joseph Dam on the Columbia River, including highly controlled demolition of concrete structures. Feasibility studies for several on-stream hydropower and pumped-storage sites in the Pacific Northwest and coastal projects were carried out under his direction.

In 1980 he was sent to China on special assignment as the geologist member of an eleven-man Corps design-review team for Longtan Hydropower Project. From 1981 to 1985 he represented the Corps of Engineers on the U.S Nuclear Regulatory Commission advisory group for a proposed high-level nuclear waste repository at Hanford, Washington. In 1985 he was awarded the Department of the Army Decoration for Meritorious Civilian Service. Since leaving government service in 1985 he has been a consultant to the U.S. Nuclear Regulatory Commission Center for Nuclear Waste Regulatory Analysis—Southwest Research Institute, Lawrence Livermore National Laboratory, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, and numerous engineering firms. He is currently an adjunct faculty member in the civil engineering department at the University of Washington, where he teaches a graduate level class in engineering geology.

Mr. Galster is a member and past president (1982–1983) of the Association of Engineering Geologists, a Fellow of the Geological Society of America, and chairman (in 1978) of the GSA Engineering Geology Division. He is a member of the U.S. Committee, International Commission on Large Dams, currently a member of the U.S. Executive Committee for the International Association of Engineering Geology, and American Arbitration Association. Between 1986 and 1989 he was a member of the U.S. National Committee for Rock Mechanics, National Research Council. He has received awards from the Association of Engineering Geologists recognizing his publications and service to the profession.

Response by RICHARD W. GALSTER

I am personally most honored to have received this award, but I do so with considerable humility and in the name of the other 15 members of the Centennial Volume Committee of AEG's Washington State Section, who collectively kept the effort moving, and of the 109 authors and coauthors who contributed to the volumes *Engineering Geology in Washington.* The idea for these volumes came about early in 1986 as a result of the anticipated celebration of the centennial of the state of Washington. The strong group of geologists in Washington practicing in the engineering geology and environmental field had been in existence nearly a quarter century working on dams, power plants, coastal projects, nuclear and hazardous waste disposal, water supply, transportation routes, urban geology matters, and geologic hazard mitigation. Very little had been published regarding some of these projects, although scattered, very incomplete documentation could be found by searching a number of journals. Many case histories were in danger of disappearing forever into files or the scrap heap. Some of the actors were leaving the Pacific Northwest; others had retired or died. I believed that the state centennial was an appropriate time to rectify the paucity of accessible information and document the geologic aspects of the many civil engineering projects in our state so that future generations of engineering geologists and the lay public might be aware of some of the geologic problems encountered.

Early on, the committee voted to enlarge upon the historic documentation and include a section relating to the importance of geology to the state and its development and the status of current practice in engineering geology. Thus, the volumes are divided into two sections: Engineering geology and its practice in Washington, and case histories of a wide variety of projects. Within a short period the committee had developed a list of potential authors and working titles and had obtained agreement from the many potential authors to accomplish their assigned tasks. Armed with this I approached Raymond Lasmanis, state geologist, whose office and staff were devoting most of their time to the revised state geologic map project. After due consideration, he agreed to have the Division of Geology and Earth Resources publish the proposed volume as a Bulletin during 1989, the centennial year. This was the coup that has made the volume successful, for it was the expert editorial review of the many papers by Katherine M. Reed and other members of the division staff that kept us practicing engineering geologists and our compatriots in the engineering profession on our toes. We all learned from each other in the process. The volumes were officially introduced in June of 1989. Because the state is prohibited from making a profit on such publications, the 1234-page volumes that include 126 papers are a bargain at [U.S.] $30. Their purpose has indeed been realized.

A surprise vignette was the dedication of the volumes to Howard A. Coombs, dean of northwest engineering geologists. Coombs was professor emeritus of geology at the University of Washington and was well known for his work on dams in many areas of the world. He was chairman of this division in 1971. As a working member of the Centennial Volume Committee, Coombs' insight was most valued. Toward the end of our work he happened to miss a committee meeting and it was then we decided on the dedication of which he was unaware until he received his own copy at a special publication luncheon. The spirit of the honor was dampened by his death nine months after the volumes were published.

I would encourage practicing engineering geologists in other states to make the effort to record the geologic aspects of major, and perhaps not so major, civil projects in published form. Yes, it is a demanding task to coordinate such an effort, given the usual nomadic tendency of many engineering geologists. Perhaps we were fortunate in that we only had to replace a single committee member who moved from the area early during our efforts, and replaced one author; perhaps something of a record knowing the problems other publication coordinators have suffered. However, such an effort is well worthwhile and makes the information readily available to engineering geology groups as well as the general interested public. You owe this to the profession.

I cannot close this response without a word about the namesake of this award. Ed Burwell completed his long career with the Corps of Engineers just two years after I began mine; we never met during this period. However, on a beautiful autumn day in 1963 while I was working a plane table on what would later become the well-known left abutment of Libby Dam in northwestern Montana, Burwell, then a private consultant to the Corps, came across the river to observe firsthand some of the geologic details we were mapping. We chatted for about ten minutes; then he was gone. Yet I was moved by the manner of his questioning, his kind and encouraging words, and the way he listened; this well-known expert to a comparative neophyte. Regretfully, he did not live long enough to see the project come to fruition. Yet I can recall that encounter now as clearly as I could 30 years ago, and I am honored to be the recipient of the award named for him.

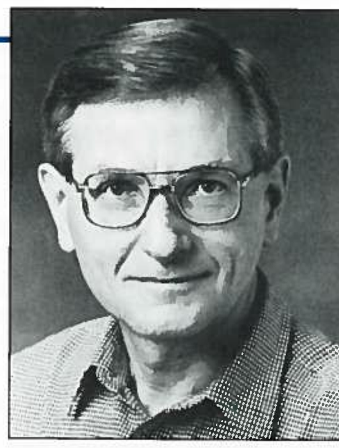
My thanks to the division and to its Burwell Award Committee for your kindness.

Presentation of the

GEORGE P. WOOLLARD AWARD

to

RON M. CLOWES



Citation by G. RANDY KELLER

Most citationists are former students, classmates, longtime research collaborators, or fellow workers of the recipient. Unfortunately, I am none of these to Ron Clowes. However, I have known him for many years and have long admired what he has accomplished and what he represents. Because of what he has accomplished, he now represents LITHOPROBE, which I believe is the embodiment of what the Woollard Award is about. I do not want to suggest in any way that this award is really being given to LITHOPROBE, but I do want to say that under the leadership of Ron Clowes, this program has become a model for efforts to integrate geology and geophysics to answer fundamental questions about the earth. It is also a model of what can be accomplished when government and academic researchers cooperate to attain a common goal. We are seeing more of this in the United States, but could still learn a great deal from our Canadian colleagues.

For those of you who may not be familiar with the LITHOPROBE project, it is Canada's national, collaborative, and multidisciplinary earth science project, which was established to develop a comprehensive understanding of the evolution of the North American continent. Its principal scientific and operational components are built around a series of ten study areas, each of which is aimed at a number of key representative geological targets. These span the country and geologic time from 4 Ga to the present. Scientifically, the project is spearheaded by multichannel reflection seismology, but uses every conceivable geological, geochemical, and geophyscial method in a coordinated fashion to achieve integrated results. One of Ron's contributions relative to the Woollard Award is his leadership in assuring a healthy mix of all of these disciplines in solving geological problems.

Now to focus on the accomplishments of Ron Clowes, I would like to briefly summarize his career. Ron is a western Canadian through and through. He was born in Calgary, Alberta, and received his university-level training in physics and geophysics primarily at the University of Alberta in Edmonton. He received his Ph.D. in geophysics in 1969, and after a postdoctoral experience in Australia, he accepted a faculty appointment in the Department of Geophysics and Astronomy at the University of British Columbia. He has remained at this university while rising through the ranks to appointment as full professor in 1983. In 1987, he became director of LITHOPROBE, but has continued his research and involvement in his department and especially with students.

Ron has conducted research on a variety of topics involving studies both on shore and at sea. There is not time to mention even most of his work, but the features that characterize it are integration, innovative quantitative modeling, and insightful appreciation of geodynamic implications. All of these attributes can be found in the main body of his work, which focuses on Canada's active western margin. During these studies, he has proven to be an unselfish scientific leader who has played a pivotal role in a series of major scientific projects. All of these projects have produced high-quality results in a timely manner.

I am particularly impressed at how soon the quality of Ron's research was recognized. In 1966 while a graduate student, he received the Best Paper Award from the Canadian Society of Exploration Geophysicists; he received this award again in 1981. In 1969, his paper on deep crustal reflections received the Best Paper Award for papers published in *Geophysics,* the journal of the Society of Exploration Geophysicists. In 1987 to 1988, he was offered two important research fellowships that he had to decline because he was beginning his duties as director of LITHOPROBE. Finally, in 1988 he was awarded the prestigious Past President's Medal by the Geological Association of Canada for his research, which was "judged to constitute an outstanding accomplishment in the field." Thus, it seems clear that Ronald M. Clowes is a very worthy recipient of the George P. Woollard Award, which recognizes efforts to apply geophysics to the solution of geological problems.

Response by RON M. CLOWES

I'm highly honored to be a recipient of the George P. Woollard Award, especially so when I see the list of former award winners, including for example, George Thompson (the first recipient in 1983), Drum Matthews, Jack Oliver, Norm Sleep, and most recently, Rob Van der Voo. I sincerely thank the Geological Society of America and its Geophysics Division for this recognition. In passing, I note that I am the first Canadian to be so honored and appreciate that fact on behalf of Canadian geophysics.

For someone who first took pure physics and then subsequently geophysics, without (I now am certainly sorry to confess) so much as a single formal course in geology, this recognition by one's peers, for geophysical contributions to the solution of geological problems, is particularly satisfying. I've had to learn a great deal about the geological sciences and probably have even farther to go along that learning curve. I see this as both a challenge and an opportunity. Perhaps there is a message here to younger scientists: Don't feel constrained by the specific field in which you have studied or worked. Rather, realize that you've already got a good background, can build on it, and expand your horizons accordingly. Future opportunities and societal needs will require this multifaceted base, one of the points that Robert Hatcher made in his presidential address.

In his comments Randy referred to my role in LITHOPROBE. In some ways, there is a serendipitous factor to this role. I seemed to be in the right position scientifically at the right time of my career. I do look upon this award as another strong acknowledgment of the direction we have taken in LITHOPROBE—that of a coordinated, multidisciplinary research project. Geological studies have contributed immeasurably to our understanding of geophysical results; conversely, geophysical studies have provided realistic constraints and new concepts for the fertile imaginations of geologists. From this multidisciplinary earth science mix, we have derived some outstanding results that have been highly recognized both nationally and internationally. To my many close colleagues within LITHOPROBE, and to the hundreds of others who have contributed to our success, I think you all can take much satisfaction, and part of the credit, in my receiving this award.

Throughout one's career, a few individuals seem to emerge as especially influential in the direction of that career. In my case, I would like to mention three of these individuals. First, Ernie Kanasewich, my research supervisor at the University of Alberta, who swayed me from a career in the petroleum industry to carry on a Ph.D., and gave me both the freedom and the guidance to complete it successfully. He remains a source of scientific stimulation, a colleague, and a friend. Second, I would like to acknowledge Bob Ellis, a good friend, colleague, and current head of Geophysics and Astronomy at the University of British Columbia. We have worked together for over 20 years on land-based refraction studies. But particularly when I arrived at UBC and decided to set up a marine seismic program, Bob's support and generosity shone through. I had never been to sea, nor seen anything of marine seismics. Let's just say the teething pains were substantial. However, I was able to maintain a modicum of relevant publications from our joint work on land, something that was essential to retaining a position and moving ahead. Third, Alan Green, formerly of the Geological Survey of Canada in Ottawa and now a professor at ETH Zurich, is a good friend and colleague who always pushed me to take on the challenges that serendipity placed before me. But beyond that, he was extremely supportive, both scientifically and personally, even when the controversial discussions and ideas arose, as they inevitably did. For LITHOPROBE, he held the torch within the GSC, now passed on of course, and his efforts are entwined in the George P. Woollard Award.

In addition to these three individuals, I've had the great pleasure of working with geoscientists from across Canada and internationally. But perhaps my greatest source of personal pride is in those graduate students, and a smattering of postdoctoral fellows and research assistants, who have ably taken on the research challenges posed, and gone well beyond just getting the job done. They have made my research programs work. In addition to the stimulation and controversy that they engendered, I thank them for keeping me young, at least in mind, if not body. Now many of them are forging their own successful careers.

The development of those students and PDFs within my own research programs and the successes we have achieved in applying geophysics to geological problems, partially reflected in this award, and the incredible success of Canada's national earth science research project, LITHOPROBE, which I am fortunate to lead, have derived from the continuous (and hard-won) funding provided by the Natural Sciences and Engineering Research Council of Canada. I recognize its contributions to my personal research and to LITHOPROBE.

Last, but certainly not least, I thank my wife Sheila, for her unstinting support and generous understanding of my position, which takes me away from home for a combined total of many months per year.

Thank you all.

Presentation of the
HISTORY OF GEOLOGY AWARD
to
MARTIN GUNTAU

Citation by URSULA B. MARVIN

I feel very privileged indeed to take part in this presentation of the History of Geology Award to Martin Guntau. Martin, who has earned two doctor's degrees and published more than 100 articles and eight books on the history and philosophy of the earth sciences, deserves this award many times over for the quality of his contributions to our field. I will discuss his writings a little later on. First, since I have had the pleasure of working closely with Martin for the past four years, I want to say something of his approach to his work and to life in general.

I first met Martin Guntau in 1989. That year he was elected president of INHIGEO, the International Commission on the History of Geological Sciences, and I was elected secretary-general. I had been a member of INHIGEO for nine years but never had served on the board, which, according to all reports, had vigorously pursued all of the East Bloc–West Bloc rivalries of the Cold War. With no first hand experience to guide me, I felt I was about to plunge into rigorous on-the-job training in political intrigue.

Martin Guntau was an East German. Not only was he an East German, Martin was an East Prussian! For an American, such a national origin still tends to conjure up images of implacable autocrats modeled on Otto von Bismarck and all those characters played by Eric von Stroheim. How, I wondered, could the two of us, total strangers, communicate across our immense geographical and cultural distances to shape policies for INHIGEO? I had my answer as soon as I was introduced to Martin at the International Geological Congress in Washington. Obviously, here was a man with a sparkling sense of humor, and wherever there is a sense of humor, everything else will be all right.

Martin and I began laying plans for INHIGEO. The following year, 1990, INHIGEO was scheduled to hold a symposium at the China University of Geosciences in Beijing. For 1991 Martin wanted to invite INHIGEO to meet in Dresden, and I seconded that idea with enthusiasm. We sorted out a number of technical details and left for home at the end of the meeting with a cordial and well-functioning working relationship.

Then, only four months later, in November, 1989, some of the people massed in West Berlin reached up and offered flowers to the guards atop the Berlin Wall. The guards accepted the flowers and handed some of them back. These gestures, performed on live television, signaled events that would change the history of Europe and of the world. On November 9, the gates opened and the wall started crumbling, literally and figuratively. Eleven months later the two Germanies underwent formal reunification. That was on October 3, 1990, and so, when Martin and I met in Beijing on October 25, his nation had been merged out of existence. With it had gone Martin's full membership in INHIGEO; thus, technically speaking, INHIGEO had a president from nowhere—one who was totally disenfranchised.

Nothing in the bylaws provided for such a contingency. Indeed, the INHIGEO bylaws stipulated that presidents and all other board members must be elected from among the full members, and there could be only one full member from each country. Wolfhart Langer, of Bonn, was the full member for the Federal Republic of Germany. Now that the Federal Republic embraced the entire country, a logical argument could be made that Professor Langer should occupy the office of president—to which, however, he had not been elected. But Wolfhart Langer would have none of this. Fortunately, he too was at the symposium in Beijing, and together he and Martin plotted to simply finesse the situation to the end of Martin's term. In this, they succeeded.

Martin already had begun searching for funds for the Dresden symposium but, needless to say, the passing of the German Democratic Republic had removed all the old familiar sources of support. Over the next few months, one federal or private organization after another turned him down. Then, in the spring of 1991, with the Dresden Symposium scheduled for September, our communications ceased altogether. Letters were taking up to five weeks. Day after day the fax machine at Martin's university refused to accept messages. At the same time, Martin changed residences and had to wait for a new telephone number.

As the weeks went by I became more and more convinced that the Dresden Symposium would have to be canceled, and I was prepared to send that message to our members around the world. Suddenly, one day my fax spun out a message from Martin. It included his new telephone number, and I could not resist calling him immediately. His first bit of news was that one more organization, upon which he had placed high hopes, had just refused its support. Next, he said that he remained hopeful that all would go very well! Such optimism astonished me. I never could have remained hopeful if my own country had vanished from the face of the Earth. But events showed that Martin was right to be optimistic, and I was wrong to be so pessimistic. In September 1991, INHIGEO held its symposium in Dresden, with three days of lively sessions and two of field excursions thoroughly enjoyed by more than 60 participants from 17 countries.

Since that time I have learned that Martin comes by his optimistic outlook through long and hard experience. Martin was born at Gilgenau in East Prussia. When he was a boy his father was sent to the Russian front and died as a prisoner of war in the Soviet Union. In 1945, with the Russian armies sweeping toward Germany, Martin's mother gathered what they could carry and walked westward with 11-year-old Martin. The Russian front engulfed them at the little city of Grabow in Mecklenberg, where they ended their flight and began a daily struggle for survival. Survive they did, by sheer grit, and after eight years of hard work and hard studying Martin was admitted to the historic Mining Academy of Freiberg, from which he emerged in 1958 with the title of Diplom-Mineralogist. For the next three years he taught mineralogy at Freiberg.

Martin then turned to what has become his true vocation—history. He entered Humboldt University in Berlin as a research fellow for history and philosophy of science. In 1964 he earned his doctor of philosophy degree with a dissertation on uniformitarianism and natural law in the geological sciences. Martin then returned to Freiberg, where he taught history of science and served as curator of the mineralogical museum.

It was in Freiberg that Martin met his radiant future wife, Brigitte, whom he discovered working in a bookstore. The couple now have two children and one 3-year-old grandchild, and Brigitte now holds a position as assistant manager of a large company that sells and distributes books.

In 1976, Martin earned a doctor of philosophy of science degree from Humboldt University with a dissertation on the emergence of geology as a natural science. Thereafter, he began his teaching career at the University at Rostock where he initiated a program on history of science. He became a full professor in 1981 and director of the Department of History in 1986.

The many articles and books Martin published between 1963 and 1993 reflect a lifelong interest in the origins of geology, the principle of actualism, and the relationship between natural science and philosophy. His writings place special emphasis on the intellectual ferment at Freiberg in the 18th century, when mineralogy and geology were developing into new disciplines. Martin has examined the importance of mining practices in the Saxon Erzgebirge on the development of mineralogy at Freiberg and the influence of the Freiberg School on earth scientists in Germany, France, and Sweden. He also has traced a reverse flow of ideas in the 19th century, when Charles Lyell's uniformitarian thought reached Germany.

In 1984 Martin published a book on the life and thought of A. G. Werner (1749–1817), and the controversies generated by his geological ideas. Among the other individual scientists whose contributions he has analyzed are Joachim Jungius (1587–1657), who influenced chemical thought at the turn of the 17th century, Niels Stensen (1638–1686), M. W. Lomonosov (1711–1765), Leopold von Buch (1774–1853), Friedrich August Breithaupt (1791–1873), and Alexander von Humboldt (1769–1859).

In addition to his publications, Martin has played leadership roles in numerous national and international organizations dedicated to the history of geology. To mention only a few, he helped to cofound the German Democratic Republic's group on the history and philosophy of geological sciences, served two terms as secretary-general and one as president of INHIGEO, served as a councilor of the History of Earth Sciences Society, and has been a member of the editorial board of the *International Journal for History and Ethics of Natural Sciences, Technology and Medicine.* With his abiding interest in the international exchange of geological ideas, Martin arranged for an ongoing exchange of students and faculty members, engaged in research on the history of geology, between the universities of Rostock and of Campinas in São Paulo, Brazil.

In the years between 1989 and 1992, mass meetings of students and faculty at Rostock led to a markedly unstable situation wherein the history of science program was abolished and reinstated at least once before it was definitively abolished in 1992, along with Martin's chair. Martin was able to take early retirement, and the next time I heard from him he had been retained by an oil company to do research not as a geologist but as a historian! Where does one find such oil companies?

As one of his first projects, Martin coedited a beautifully illustrated volume, with the text in German and Spanish, tracing the travels of Alexander von Humboldt in South America. With numerous other projects in the planning stages and his unfailingly positive outlook, Martin shows every sign of becoming more and more productive as a historian of geology.

Response by MARTIN GUNTAU

Ursula Marvin was quite friendly and generous in her citation and I would like to extend her a sincere and hearty thank you for her kind words. Yet my real thanks go to the History of Geology Division and the Council of the Geological Society of America for the great acknowledgment they have conferred upon me. I can't begin to tell you how moved I was when I first heard of this completely unexpected and high honor the Geological Society of America had bestowed on me. Occurrences of this kind are full of special meaning. Not only do they give one great pleasure; they also give strength and self-confidence. They strengthen old contacts and open up new possibilities.

The past few years have been times of especially far-reaching changes in the world. The encrusted East-West political stalemate has been broken. This has also affected our community of geology historians. Even with all the advancement of international cooperation in this community in the past decade, I would say—and I'll take the liberty of stating this plainly—that five years ago perhaps it would have hardly been probable that the History of Geology Award of the GSA would have been awarded to a historian of science in the German Democratic Republic. And the East German recipient would have had large problems both in explaining such an award from a scientific society in the USA and in obtaining permission to receive the award.

All of this belongs to the past now, and we all are happy and thankful to be living and working under better international conditions today. I myself am very glad about these fundamental changes and new possibilities, without wanting to or even being able to sever myself from the past in one fell swoop. Four decades are a long time in a person's life, and one cannot treat them carelessly.

Of course, just as one needs to rethink old scientific works, so must we also critically examine earlier political ideas. And when the results prove themselves to be useful even in today's world, then we cannot abandon relevant statements or principles just because an opportunity presents itself. In any case, there is the need for a critical look back with respect to the current changing conditions in my home country. However, what counts is that these doubts become productive, that they don't paralyze us, that they flow in the direction of the slogan, "Don't worry, be active!" Such a maxim will not, of course, protect us from making mistakes or new errors, but it does make each scientific life a life worth living, an interesting, productive, and above all a hopeful one. Even defeats have a deeper moral meaning when you understand their source and stay realistic in life.

As far as I see it, 1993 is the first year that the History of Geology Award of the GSA has been awarded to a German. For the historians of geological sciences in my country this is a great honor, both in the East and in the West. Hans Prescher or Wolf von Engelhardt, Otfried Wagenbreth or Helmut Hölder, Wolfgang Langer or Peter Schmidt—just to name a few—have contributed in exciting and successful ways to various different areas of the history of geological sciences during the last few decades; work that also more and more younger colleagues have done and that has not been without growing resonance overseas. There has been an attempt to make the achievements of such German geoscientists as Georgius Agricola, Abraham Gottlob Werner, Leopold von Buch, Alexander von Humboldt, Alfred Wegener, and others more understandable for the present day.

I find it astonishing that the ideas of A. G. Werner and his Neptunism have met with marked interest, especially in the English-speaking world. Of special importance here is the Mining Academy in Freiberg (Saxony), also my scientific birthplace, as a basis for the spreading of the ideas of Neptunism, which has been widely misunderstood by the learned ever since its beginnings. In spite of an incorrect basic idea, this paradigm has played an indisputably important role in the development of geology as a science, which only goes to prove the productive function of so-called false concepts in the history of science. The obvious occurrence of this phenomenon can be found not only in geology, but also in astronomy and chemistry.

The geologist William Maclure, who was also a convinced utopian socialist, did a good job working with fundamentals of geology in the spirit of Abraham Gottlob Werner right here on the eastern coast of North America at the beginning of the last century. Many of his academic counterparts in other countries of Europe and the Americas sparked on geology on the basis of Neptunism.

It can be seen that the history of geological thought can always be understood as an international phenomenon, as it is with historical research in our time, to an increasing degree. With gratitude I think back to the first personal contacts with colleagues here in the USA almost 30 years ago to the day. At first there was an exchange of ideas by post with Claude C. Albritton in connection with his book *The Fabric of Geology*, which I was allowed to review in Germany. About the same time the relationship with the Werner researcher Alexander M. Ospovat began, out of which a true personal friendship has grown over the years. Cecil J. Schneer, Albert V. and Marguerite Carozzi, Kenneth L. Taylor, and William A. S. Sarjeant (Canada) have become close to me through their scientific work, but also especially through their humanity. Finally, in 1989, a time of highly fruitful and pleasant cooperation began in the INHIGEO Commission with Ursula B. Marvin, although we had never met before. I mention this here because the freely practiced tolerance and the cooperation across borders and through different points of view was of great importance and effectiveness for our work.

I have to thank V. V. Tikhomirov from Moscow for the personal links to the international community of historians of geology. He invited me to the founding meeting of INHIGEO in Jerevan, Armenia, in 1967 and I have him to thank for my participation in the many INHIGEO symposiums in various countries during the '70s and '80s.

The work as secretary general of the INHIGEO Commission was not easy in the late '70s and early '80s; the political East-West opposition had eased a bit, but the Cold War was by no means yet over. All international geological-historical initiatives, if they are to succeed, must be planned, organized, and realized in a balanced climate of honest cooperation. At that time I had a wonderful and, for me, very educational working experience with the one-time INHIGEO President Reijer Hooykaas in Utrecht, the Netherlands, which I look back on with fond memories. The problem back in those days was knowing the possibilities and limits of international scientific work (especially in socialist countries) and using these to the fullest in order to give INHIGEO work productivity and stability.

Between 1976 and 1984 I went to Utrecht and Moscow yearly in order to discuss projects, to clear away reservations or prejudices, and to achieve a secure political balance. This "pendulum diplomacy" was time consuming, but worth it in the end. It was only possible because I enjoyed the trust of elected members of the INHIGEO board, which I am thankful for even today. I was able to practice a successful scientific cooperation that met with approval from all sides.

These experiences were, without question, important and helpful for my own scientific work. Especially in those years I had the chance to initiate studies of the history of natural sciences at the university in Rostock, founded in 1419. After examining a number of biographical papers, we constructed a model of the genesis of scientific disciplines. This entailed detailed studies of the mechanisms of the formation of geology as a science at the end of the 18th century. Also the history of scientific institutions such as geological surveys, societies, or museums was the topic of many research projects. Detailed research was pursued on the exchange of geoscientific ideas between Germany and Russia, France, Sweden, or Latin America in the past.

Of course, the heart of all scientific activities was the substantial research in the historiography of geology. And to find an international resonance a person must have a firm scientific grounding in his own country. Unfortunately, the history of science as an institution at the University of Rostock has come to a de facto (though certainly temporary) end since the political and structural changes in recent years. But the possibility of continuing research in the history of science is present wherever there is a large library nearby and scientific lines of communication are functioning. For me at present these conditions are fulfilled, so there are many possibilities for practical work in the area of the history of geological sciences in my home country as well as overseas.

It is in this situation that not only is the History of Geology Award of the Geological Society of America a reat honor for me, but above all this occasion is a grand encouragement and a stimulus for my further activities. For me, this recognition is an exceptional highlight of my scientific life, for which I would like to thank you again from my heart.

Presentation of the O. E. MEINZER AWARD to L. NIEL PLUMMER

Citation by DONALD C. THORSTENSON

I am particularly pleased to present the O. E. Meinzer Award to L. Niel Plummer because of a personal friendship and professional association with Niel that now spans two decades.

Niel did not inherit an interest in geology. In fact, by birthright and upbringing, he should perhaps be a news commentator. His father was for many years the director of the School of Journalism at the University of Kentucky, and Niel's early interests were in this area. It was from Niel that I learned the reporter's maxim "bad news is good news," to which we will return shortly.

Niel's interest in geoscience began at the University of Kentucky, where he obtained both his bachelor's and master's degrees. His thesis for the latter was on the geochemistry of barite vein host rock with John Thrailkill. He then attended Northwestern University where his geochemical indoctrination continued under Fred Mackenzie, Owen Bricker (who was a visiting profesor at the time), and Hal Helgeson. His Ph.D. thesis was on rates of mineral-aqueous solution reactions, a subject on which he continues to publish to the present time. From Northwestern, Niel moved to an assistant professorship at the State University of New York at Buffalo, where he stayed for two years. In 1974 he accepted an offer to work for the U.S. Geological Survey Water Resources Division as a member of what we refer to as the National Research Program.

I want to come back to the issue of Niel's journalistic background, because I am quite confident that, unlike many of us, Niel *likes* to write. True or not, the fact is that by 1993, without benefit of textbooks, Niel is author or coauthor of about 2500 printed pages, with the number still increasing exponentially. So, let's take a look at the phenomenon of a Plummer paper in some detail. Are we dealing with bad news that's good news, vice versa, or something different entirely?

First of all the work itself is always exacting. "To a gnat's eyebrow …" is a common Plummer expression. Niel and coauthors Ed Busenberg and Vivian Parker have, for example, redefined the value of the standard free energy of the strontium ion. Second, a Plummer paper is complete; all data associated with the work in question are presented, and readers are thus able to draw their own conclusions without having to read a half-dozen preceding papers (or to wait for a half-dozen subsequent ones to be published). Third, a Plummer paper is informative; it presents background on the subject, key references, and pros and cons of hypotheses. So, what Niel writes, in fact, is just plain "good science."

If we look at some of the fields to which Niel has contributed, we find in approximate order of appearance in his career: reaction kinetics of carbonate minerals, development of geochemical-modeling computer codes, the mass balance approach to reaction modeling, the concept of stoichiometric saturation in the theory of solid solutions, isotopic evolution and ground-water dating, thermodynamic studies of carbonates, application of mass balance modeling in the Madison aquifer and other hydrochemical systems, and the analytically elegant use of CFCs in dating young ground waters.

The last two fields contain the papers for which Niel is being honored today. They are two, and one represents an end (or at least a culmination to this time), and the other a beginning. The "end" is the paper on geochemical modeling of the Madison aquifer, with coauthors John Busby, Roger Lee, and Bruce Hanshaw. This paper represents the current state of the art in mass balance reaction modeling, an inverse approach to geochemical modeling that Niel and colleagues developed at the USGS. The approach was pioneered by Niel in a 1977 paper defining reactions and mass transfer in the Floridan aquifer. In its present incarnation, we see chemical mass balance integrated with carbon and sulfur isotopes, redox and organic reactions, and regional hydrology and geology leading to state-of-the-art water age estimates.

The second paper, by Busenberg and Plummer, is about a new and exciting technique in ground-water hydrochemistry, the use of dissolved chlorofluorocarbon compounds as a means of "dating" young ground waters. The technique has already been applied in a variety of ground-water environments and is currently being used to define recharge mechanisms and to estimate rates of gas flow in unsaturated zones.

In addition to his research, Niel has been a major contributor to activities of the USGS. He has recently completed a five-year tenure as research advisor for ground-water chemistry, a position of much responsibility that entails a huge amount of work. He has been on call as needed by the organization; perhaps his most noteworthy accomplishment is the decade that he has spent as coordinator of a two-week annual training course in ground-water chemistry. For his scientific contributions and his efforts within the USGS, Niel has been honored with the Department of the Interior's Meritorious Service Award.

It has been my pleasure and considerable good fortune to work on a variety of studies with Niel over the years at the USGS. In these pursuits, I have been continuously awed by his capacity for work, his bulldog perseverance, and his overall general dedication to the pursuit of excellence in science.

Response by L. NIEL PLUMMER

I am very pleased and honored to accept the O. E. Meinzer Award for 1993.

I am grateful to many who have helped me over the years, but first of all, I must express my gratitude to my parents for supporting me and believing in me from very early on, even in the face of mounting academic evidence to the contrary. Over the past 26 years, my wife, Phyllis, has been a stabilizing influence in my life. She remains also my toughest critic. For example, when I try to tell her details of some technical point that I'm all excited about, she will listen for awhile, and then deliver the big question: "Well, what's that good for anyway?" or she may simply comment, "What a waste of the taxpayer's dollar!" The reality she drives home in me is that scientific advances, eventually—maybe not today, maybe not tomorrow, but eventually—must be good for something. Phyllis still has her doubts about some of my research, but, I must say, receiving the O. E. Meinzer Award has given me a little more credibility at home, and I thank the committee for that.

There isn't space for me to personally thank all my friends and colleagues who have helped me over the years. But to all of you, I am extremely grateful and proud to know you and to have worked with you. There are several, though, to whom I have a deep personal debt.

Irving S. Fisher first caught my interest in geology at the University of Kentucky. Dr. Fisher and John Thrailkill, both now retired from the University of Kentucky, provided an environment where I discovered how exciting independent study and research could be. At the conclusion of the master's degree at Kentucky, these gentlemen sent me on to Northwestern University and on to the course that brought me here today.

At Northwestern University, Harold C. Helgeson drove into and through me the power of chemical thermodynamics in the earth sciences and the advantages of developing computerized geochemical models. Fred T. Mackenzie, Abraham Lerman, and Owen P. Bricker focused my interests on kinetics and thermodynamics of low-temperature geochemical processes, and in particular the carbonates. I am particularly grateful to Fred Mackenzie for his guidance during my doctoral research. Besides, there aren't many graduate students who can boast that their thesis advisor got them to Bermuda four times during their student days.

I am also grateful to Tom Paces, my predecessor at SUNY Buffalo for the strong geochemical foundation he and several other faculty members established at SUNY Buffalo which greatly facilitated my transition from the student to the teacher. I first met Eurybiades (Ed) Busenberg while at SUNY Buffalo. Ed was studying the kinetics of feldspar dissolution for his doctoral dissertation. Four years later I brought Ed into the USGS to study the kinetics of dolomite and calcite dissolution with me. I remember Ed politely telling me that after studying feldspar dissolution, these carbonates would be a piece of cake, or something to that effect. Well, as many of you know, the "simple" carbonates turned out to be rather challenging and occupied much of our efforts for more than a decade.

But before I get ahead of myself, I must tell you of my appreciation to Blair F. Jones. Many of us regard Blair as the father of our geochemical research group in the Water Resources Division. Blair was responsible for recruiting me and a number of others into this group. He was the first research advisor for geochemistry, a position he jokingly referred to as "group janitor"; but in fact it was a position through which he laid the foundation and guidance of our geochemical research. What a joy it has been over the years to go to work with the likes of Blair Jones, Bill Back, Bruce Hanshaw, Ike Winograd, Joe Pearson, Owen Bricker, David Parkhurst, Don Thorstenson, and many others who are now or were formerly with the Reston research group.

If you have ever looked at my bibliography, you will notice right away that there are very few papers where I am sole author. I have benefited greatly from collaboration in my research over the years. The two papers for which I am being recognized today—the geochemical modeling study of the Madison aquifer, and the dating study using chlorofluorocarbons, are examples of these collaborations. The Madison study uses geochemical methodology and modeling concepts developed over a 10-year period with David Parkhurst and Don Thorstenson. I became involved in the Madison study initially as a reviewer of the original investigation that was conducted by John Busby, Roger Lee, and Bruce Hanshaw. After giving these guys a bad time for not quantifying the redox reactions, I volunteered to resample the Madison wells for sulfur-isotope geochemistry to aid in defining extent of sulfate reduction. By flip of a coin (John Busby lost the flip), it was John's job to resample the Madison with this geochemist, who had rarely ventured from the laboratory and computer. I suspect John would have preferred to leave me out in the middle of Montana somewhere, but instead he taught me a wealth of practical lessons in hydrology and hydrogeology.

In the middle of this sampling trip of more than three weeks duration, I had to leave John to have a kidney stone removed. John carried on and I returned a week later and finished the sampling. When we parted in the Denver airport, John said something like, "Well, Plummer, it's been a hell of a trip. I enjoyed working with you, but I hope I never see you again." I naively thought at the time, what a kidder, this John Busby.

When you look at all the precise data tabulated in the Madison paper and the quantitative rigor in computer modeling the paper portrays in combining geochemical mass balances, carbon-13, sulfur-34, and radiocarbon dating, one sometimes loses sight of the reality from which the data originated. Let's have a look at two of the Madison wells. Here's Bruce Hanshaw sampling the Philip, SD well [slide of Hanshaw holding an open bottle to a blast of hot water from an open pipe]. And here I am trying to decide how to obtain a meaningful sample of the Mysse well in south-central Montana [slide of hot water flowing from a broken open well surrounded by deep algal and mineral deposits]. It took us two days to find this well, and there's a group of sheep herders out there that I'm sure still laugh about the time they sent these government guys off in the wrong direction.

Ed Busenberg is the senior author of the second paper I am being recognized for, the paper on chlorofluorocarbon dating. I am especially indebted to Ed for his expertise and skill, particularly in the laboratory, and for development of novel instrumentation approaches both in this study and in many of our earlier laboratory studies with carbonate minerals. [Recent photo of Ed taking a chlorofluorocarbon sample at a municipal supply well in Valdosta, Georgia; photo showing our very first sampling of ground water for chlorofluorocarbons, in May 1989, on the Delmarva Peninsula; editorial comment on this then infant method added by Joe Bachman of the Survey's Towson, Maryland office—roadside billboard sign pointing to a local turkey shoot].

I have been very fortunate to have worked the past 20 years at the USGS where I have had the opportunity to interact with numerous scientists, many of whom I regard as national treasures in the fields of hydrology and geochemistry. I highly value the experiences I have gained through the Research Program of the Water Resources Division, through training classes we teach to division personnel at the National Training Center in Denver, and through field investigations where I have had the opportunity to get to know many of the Survey's hydrologists, geologists, and geochemists.

It's an exciting time for geochemists and hydrologists. We are working closer together than ever before, partly because of research frontiers along the discipline boundaries, such as in modeling the coupled processes of ground-water flow and chemical reactions, and applications of environmental tracers to dating ground water. I am excited about the future of hydrologic research and hope I can continue to contribute to the field. Recently some visitors came through my lab. One inquired if I had worked here at the USGS all my career. I said, "No, not yet." Thank you again for selecting me as recipient of the 1993 O. E. Meinzer Award.

Presentation of the G. K. GILBERT AWARD to MICHAEL H. CARR

Citation by LAURENCE A. SODERBLOM

The recipient of the 1993 G. K. Gilbert Award is someone with whom Gilbert himself would find strong affinity. Like Gilbert, Michael H. Carr possesses tremendous breadth in scientific intellect and capacity—as a geologist, as a physicist, and as a chemist—questioning conventional wisdom, focusing on the scientifically significant. Like Gilbert, Carr also displays breadth in scientific style—as a theorist, as an experimentalist, and as a first-class observer. And, like Gilbert, Carr has been a leader, molding the future direction of scientific exploration on the national scale, promoting cooperation in science on the international scale.

Carr earned his bachelor of science degree from the University of London in 1956 and his masters and doctoral degrees from Yale University in 1957 and 1960. During his student years he worked for the Connecticut Geological and Natural History Survey as a geologist mapping metamorphics in western Connecticut. Upon receipt of his doctorate he became a post-doctoral research associate at the University of Western Ontario, where he studied the behavior of rocks under high pressure. Later this work would lead to research into crater-forming processes, during his early career with the U.S. Geological Survey.

Carr joined the Branch of Astrogeologic Studies in 1962 and for a year continued his work on shock waves in rocks. Soon thereafter he became involved in research on cosmic dust and fallout from nuclear weapons. He established electron microprobe and electron microscope labs in Menlo Park and used these facilities to characterize dust collected in the upper atmosphere and near-Earth space. His work on cosmic dust resulted in major revisions in the estimate of the flux of cosmic dust into Earth's atmosphere and became essential information for understanding the hazards to vehicles orbiting Earth and its moon. Later in the 1960s, Carr became heavily involved in the lunar mapping program. His geologic maps—through which he made important contributions in analyzing Lunar Orbiter data and in planning the Apollo 11 and 15 Missions—set the standards for lunar geological studies.

During the 1970s, Carr turned his substantial energies toward the scientific exploration of Mars. As a member of the Mariner 9 investigation team, he prepared the first preliminary global geologic maps of Mars; these maps led to the first formal geologic map of the red planet, which he compiled with coauthor David H. Scott. During this period, Carr was selected as the team leader of the Viking Orbiter Experiment, which would yield an enormous wealth of raw scientific information that would form the basis for a vibrant research program in planetary geology—a program that has been a core research activity in the Planetary Geology Division of the GSA for nearly two decades.

The yield from this program also became the sustenance for Carr's considerable scientific appetite. The list of research topics on Martian surface processes that he has addressed read like a glossary in terrestrial geology. Just a sampling of these topics includes stream and lake stability, volcanic episodes, climatic history, crustal permeability, megafloods, ice precipitation, early atmospheric evolution, valley-network formation, fluvial history, volcanic collapse, polar processes, and climatic-change thresholds.

Carr has never hesitated to attack the complacency of conventional wisdom. An exceedingly important area in which he has recently focused his attentions is Mars' volatile inventory. This topic has dramatic ramifications not only for understanding the history and evolution of Mars' interior and atmosphere and its climatic history, but also for future, ultimately manned, exploration of the planet. Carr sought to resolve the conflict between various chemical indicators that suggest relatively minor amounts of water at the surface and geologic evidence indicating the presence of abundant water. For example, the high D/H ratio in the Martian atmosphere had been taken as an indicator of little water at the surface. But he concluded that, because the Martian interior is largely isolated from chemical communication with the surface and atmosphere, episodic regional geologic events could repeatedly reset the D/H ratio to the juvenile value, so it was of little use for estimating water inventories. As a result of his work, the community now leans toward models in which Mars' water inventory is substantially greater than isotopic and chemical considerations originally indicated.

Carr extended this line of research to examine the differences between Mars and Earth, demonstrating a scientific point of view that reflects the founding spirit of the Planetary Geology Division of the GSA, placing Earth and the other planets in a common context. Carr explored a model in which the volatile inventories were added late, during accretion, as outer veneers to the planets. The differences in Earth's and Mars' atmospheric evolution and isotopic composition and in mantle water content (suggested from SNC meteorite studies) he attributed to Earth's violent mantle convection and plate tectonics and to Mars' more stable crust.

Carr's scientific contributions and awards testify to his extraordinary productivity. Among his many publications are several books, one of which, *The Surface of Mars,* was recognized by the American Association of Publishers as the Outstanding Scientific Publication of 1981. He has received the Department of the Interior's Meritorious Service and Distinguished Service Awards and NASA's Medal for Scientific Achievement, and he is a Fellow of the American Geophysical Union.

Carr's zest for Martian exploration extends into the future. The national and international committees developing the next missions to Mars on which he has served form a list nearly as long as his repertoire of Martian research topics. The committees that he has chaired include (but are not limited to) Mars Geochemical and Climate Science Working Group, Mars Rover and Sample Return Working Group, U.S./USSR Mars Landing Site Implementation Team, and Mars Science Working Group.

It is clear that if one really wanted to measurably affect the future exploration of Mars, one would have to present convincing arguments to the recipient of the 1993 G. K. Gilbert Award, the near-Martian, Michael H. Carr.

Response by MICHAEL H. CARR

I would first like to say thank you to Larry and to the members of the Planetary Division. An award from one's peers is especially gratifying. They are the people who know best what you have been doing.

Being given an award like this causes you to pause and reflect on how you ended up in your particular career. It also makes you realize that you are no longer the brash young scientist that you feel you are inside, but rather a staid, gray-haired eminence. I became interested in geology as a teenager. Growing up in northern England, I spent much of my leisure time hiking, climbing, and caving in the Pennines and the Lake District, and what could be more satisfying than spending one's whole career as a geologist doing just that? So I applied to the Geology Department at University College, London, and was fortunate to be accepted. I was fortunate also in the choice of University College because of its strong emphasis on field work, under the chairmanship of Professor S.E. Hollingworth. During my undergraduate years there, I did field work in Dorset, South Wales, North Wales, and the Welsh border country, and had a full summer season in northern Norway. I don't think that it is a coincidence that a previous recipient of this award, John Guest, also went to University College.

This was during the l950s and these were austere times in England. Prospects for employment in geology were poor. The British Geological Survey was small, and the various colonial geological surveys, which had traditionally hired many geology graduates, were being disbanded. So I applied to do graduate work in the United States and was accepted at Yale. My main interests were structural and metamorphic geology, and John Rogers persuaded me to work for the Connecticut Geological Survey during the summers, mapping metamorphics in western Connecticut. John Rogers was at that time compiling a state map of Connecticut, and I have fond memories of doing geology at 60 mph while driving around the state in an early 1940s two-seater black coupe. It was my first introduction to remote sensing. But I found field work in the heat and humidity of the Connecticut summers very debilitating, and decided that I did not want to make field work a career. Fortunately, Karl Turekian had just arrived at Yale and I was easily persuaded to do a thesis in geochemistry, the geochemistry of cobalt, which involved neutron activation analysis and emission spectroscopy. So at Yale I had as mentors two of the most stimulating men in our field.

When I finished at Yale I had to leave the country because of the visa I was on. Prospects in England were still poor, so I looked to Canada and found a postdoctoral position at the University of London. However, the position was in geophysics, about which I felt I knew next to nothing. I was specifically hired to develop a technique for determining the behavior of rock materials under high shock pressures. It was a frustrating two years, for I never really was able to develop a reliable technique, and really the task was simply not achievable with the resources that we had available. However, this was the work that got me into lunar and planetary science.

I had read an account of the finding of coesite at Meteor Crater by Ed Chao and Gene Shoemaker, and having learned from Danny Milton at a GSA meeting that Gene had set up a Branch of Astrogeology at Menlo Park and was looking for people, I wrote to him of my shock-wave work. He was on my doorstep within days, armed with a treatise on Meteor Crater, which I still have, and a geologic map of Copernicus. The following September (l962) I arrived at Menlo Park and have been there ever since. In retrospect, the adversity that caused me to change from geology to geochemistry to geophysics was fortunate, for I was pretty well prepared for the interdisciplinary nature of lunar and planetary science. I was fortunate, also, in that my career had already been directly affected by some giants of the geosciences—Hollingworth, Rogers, Turekian, and Shoemaker.

During the 1960s I did a mixed bag of things, and in terms of scientific papers written, they were not very productive years. They were, however, very busy years. I tied off my shock-wave work, and Gene persuaded me to get involved in a project to characterize dust in the upper atmosphere. This work was mostly classified, being concerned with identification and characterization of fallout from nuclear weapons. The work was fascinating. We would identify the fallout particles, analyze them chemically on the microprobe, characterize their morphology with an electron microscope, then ship them off for isotopic analysis. We would have periodic meetings to interpret the data, and it was truly astonishing what could be gleaned from these minute particles. But, of course, there were no science publications. At that time almost all branch members were expected to participate in telescopic mapping of the geology of the moon. In Menlo Park we used the 36-inch refractor at Lick Observatory, a huge 60-ft long telescope built in the l880s, and I spent many a night in the dome with Don Wilhelms, Dick Eggleton, and Jack McCauley, listening to the wind whistling around the dome, peering up at the yellow swirling image of the moon, trying to interpret its geology. I confess that I found the experience somewhat frustrating in that good seeing was so fleeting that you were never quite sure what you actually saw.

In l967 I first got my taste of mission operations. I was at JPL for Lunar Orbiter IV, and I think that was my first time at JPL. The long strips of positive transparent film would come in from the photo lab. We would assemble the strips in a mosaic on light tables, in awe of the exquisite detail we were seeing for the first time of familiar features such as Copernicus, the Aristarchus Plateau, and the Orientale basin. There was lots of dreary work too. We made tens of worthless, high-resolution geologic maps of potential Apollo landing sites, with memorable names such as II-P2 and III-P3. These were dutifully printed by the Survey in full color. Who knows what happened to them? During the Lunar Orbiter mission I first met another whom I consider to be a giant of our field, Tom Young, then of Langley Research Center, later with the Viking Project and now president of Martin-Marietta Corp. Lunar and planetary science owes him an enormous debt of gratitude for his unfailing engineering skill, judgment and plain common sense.

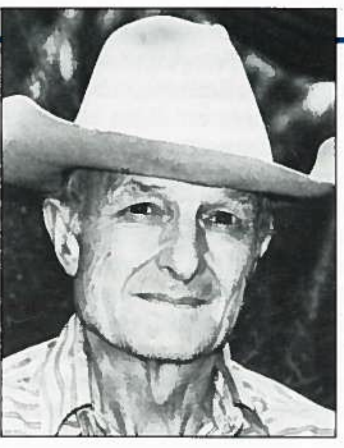
About l969, Hal Masursky, who was leader of the Mariner-9 imaging team, got several branch members involved in the planning of that mission, including Dan Milton, Don Wilhelms, Jack McCauley, and myself. At the same time, I was encouraged, I think by Hal, to submit a proposal for participation in the Viking Orbiter Imaging experiment. These two decisions put me on a path to Mars that I have been on ever since, and I will be forever grateful to Hal for his guidance. Mariner-9 operations were very difficult. A fraction of the available imaging was devoted to systematic mapping of the whole planet, the rest for special purposes. As geologists our concern was getting higher resolution coverage of interesting features that we had seen in the systematic coverage. We were under tremendous pressure all the time, reviewing what we had just acquired, arguing over interpretation, trying to figure out locations (because there was lots of uncertainty), and then projecting ahead to determine on which orbit to do the targeting. That was the first time that I met Larry Soderblom. There was a group from Caltech—Bruce Murray, Jim Cutts, Larry—and they seemed to spend all their time in loud and belligerent arguments with each other, or with anyone else who might get in the way. I now know all these guys pretty well, and they are pretty nice people, but at that time we were all convinced that at Caltech classes in nastiness were a Ph.D. requirement.

Mariner-9 was, of course, followed by Viking. The year 1976, when Viking arrived at Mars, was the most exciting of my life. It seemed that we were on a constant high. First there was the search for landing sites, then the landings, and then the puzzling results of the biology experiments. As leader of the Orbiter Imaging Team, I was particularly concerned about the camera performance, because we had had to make so many compromises along the way. But the cameras turned out to be superb, and we ended up taking about 55,000 pictures of the planet. New products are still being made from these pictures. The Mars Digital Image Model was published last year, and Flagstaff has just produced some spectacular new global color products. The Voyager encounters of Jupiter and Saturn also occurred in the late l970s, and although my participation was relatively minor, I did have fun working on Io.

As we all know, the l980s were lean years for the planetary program. Most of the new data on Mars was provided by the SNC meteorites. Early in the decade, being largely free of mission obligations, I managed to write my Mars book and do some science, focusing primarily on climate change on Mars, and the role of water in its evolution. However, toward the end of the decade I was drawn into a number of very time-consuming advanced planning activities, including Mars Rover Sample Return, the Space Exploration Initiative, and Mars Observer. All these activities have come to naught for different reasons. I am still heavily engaged in planning activities and recently returned from a meeting with representatives of several space agencies in an effort to promote international cooperation in Mars exploration.

Looking back, I could not have wished for a more exciting career. Planetary science, with its mixture of mission planning and pure science suits me temperamentally. There is the give-and-take of mission planning, the satisfaction of seeing one's plans realized, the exposure to other disciplines, the excitement of exploration, and the pleasure of the science itself. I am looking forward to the next few years. Galileo is well on its way to Jupiter, the Russians are to launch an ambitious Mars mission, in 1994, and we have good prospects for starting our recovery from Mars Observer in l996. Again, thank you for this honor. It seems strange to be honored for doing what you most enjoy.

Presentation of the KIRK BRYAN AWARD to WILLIAM B. BULL



Citation by LESLIE D. McFADDEN AND PETER W. BIRKELAND

Owing to the recent development of the "greenhouse warming" hypothesis by climatologists, the subject of the impacts of future changes in climate triggered by global industrial and agricultural activities has become quite popular. It is even fashionable for politicians to demonstrate an informed awareness of this issue, and our present vice president has even highlighted the topic in a recent book. Indeed, how will Earth respond to the predicted climatic changes? Many of the scenarios, some of which are catastrophic in their result, rely on numerical simulations. How can these predictions be critically evaluated? Quaternary scientists would maintain that this can be done by interpreting the record of past impacts of climatic changes, as these have been as large as or even larger than those postulated through greenhouse effects. The subject of the publication *Geomorphic Responses to Climatic Change,* by William B. Bull, is timely because it develops many hypotheses on the responses of landscapes to climate change in diverse environments. Accordingly, the Quaternary Geology and Geomorphology Division of the Geological Society of America honors this publication with the Kirk Bryan Award for 1993.

One gains considerable insights into Bill Bull's intellectual approach to evaluating climate change and landscapes by inspection of the organization of the book. Chapter 1 provides the overall conceptual framework that will be applied to diverse geographic settings. What is described in Chapter 1 is essentially a systems-analysis strategy. Rivers are the key aspect of this system. Fluvial system response to perturbing influences, such as climate change, is interpreted through the recognition that the system response is controlled by independent and dependent system variables. Responses to perturbations and disruption of equilibrium states in the system can be described by process response and relaxation times, complicated by the occurrence of occasional but important system thresholds. One especially important threshold emphasized in the opening chapter is the "threshold of critical power." Ultimately, a key conclusion of this chapter is that two fundamental fluvial land forms can be recognized: aggradational terraces that reflect climatic response and strath terraces that form via tectonic controls. The significance of tectonics is important because virtually all landscapes are influenced in some manner, albeit subtly, by tectonics. The conceptual view of the fluvial system described clearly reveals the strong intellectual influences of Luna Leopold, a close friend and colleague, one of two individuals to whom Bill Bull dedicates this book.

Chapters 2 through 5 illustrate examples of the philosophy of reductionism as used in scientific research. Chapter 2 focuses on the Mojave Desert, an area characterized by landscapes that are arguably geomorphically simple in comparison with other landscapes. Many parts of the Mojave Desert are tectonically inactive, mountain ranges exhibit limited relief, and monolithologic drainage basins are readily located. By constraining the complexity of the system with the selection of a study area, the geomorphic response to climate change can be elucidated. Bull concluded that strikingly different modes of system operation can be recognized: the arid and semiarid mode. These modes switched repeatedly in the Quaternary, profoundly influencing the hillslopes, vegetation, soils, and streams of this region. Two other points regarding this chapter are also worth mentioning. First, this and other chapters show how the application of different tools, including pedology, paleobotany, stratigraphy, paleoclimatology, paleomagnetism, and tectonic-volcanic history, can be used to complement geomorphic research. This multidisciplinary strategy is a recurrent theme throughout the book. Second, the chapter reflects a "how-to" character, providing abundant explanation of the above tools accompanied by tables that enable one to "hit the ground running," so to speak, upon arriving in a field area. Other chapters do the same, but for different environmental settings. For students of geomorphology, this aspect of the book may be, in some respects, the most valuable and enduring.

The remaining chapters each focus on areas in different environmental and tectonic settings. In Chapter 3, which focuses primarily on studies conducted in the Nahal Yael, located in the hot, dry-desert of the Dead Sea Rift in Israel, an additional system variable, lithology, is considered. These studies demonstrate how lithologic variation can strongly influence geomorphic processes on different areas subjected to the same climatic changes. Chapter 4 focuses on research conducted in the Transverse Ranges, California, where a new major system variable, tectonics, could be considered. These landscapes enable evaluation of geomorphic processes operating in a subhumid climate in mountains with far greater relief than those of the Mojave Desert and the Nahal Yael. Yet, on the basis of lessons learned in the latter areas, influences of tectonics could be identified and separated from those of climate. Perhaps the most interesting outcome was the realization that despite significant uplift during the Quaternary, late Quaternary climatic changes resulted in a system response that overwhelmed the tectonic influences. Lessons learned during these studies ultimately enabled recognition of the influences of climatic changes in New Zealand, discussed in Chapter 5, despite lithologically complex, high-relief mountains and the extraordinarily high tectonic uplift rates in this geomorphically complex region. There Bill did some work on marine terraces in order to provide age control for a large area. Remarkably, despite diverse uplift rates, lithologies, and regional climates, all study areas are hypothesized to show the influence of the Milankovitch astronomical clock—not so blatantly obvious as the marine oxygen-isotope record—yet it is observable in the record of fluvial land forms and deposits that at first glance (and to some of us, second and third glance) seemed to defy correlation and explanation.

The book also represents the results and perspective gained over 15 years of research. Prior to this period of time, Bill Bull, trained as a hydrologist and working for the U.S. Geological Survey, began a study of alluvial fans in

California. While he gained a great deal of understanding about alluvial-fan form and processes, this work excited a keen interest in the fundamental question: what are the relative effects of climate and tectonics on the formation of streams and landscapes in general? By the early 1970s, at the University of Arizona, Bill began his studies in the Mojave Desert, and initiated collaboration with Israeli scientists, including Ran Gerson. The Bull-Gerson relationship documents the importance of "feedback" processes, a type of process much emphasized in this book. The feedback was clearly positive, and Bull dedicated the study focusing on lithologic factors to Ran. Productive collaboration with his graduate students also is highly evident throughout the book, testimony to the ideal goal of the research-education mission of academia.

A clear mission, a well-chosen scientific approach, and effective collaboration are certainly necessary and evident in this book; nevertheless, a bit of good luck never hurts. The opportunity to conduct research in the Transverse Ranges, for example, arose in part courtesy of the discovery of the acclaimed Palmdale bulge, presumed by many at the time to be an ominous precursor of a great earthquake on the San Andreas fault. A lot of people live in this part of southern California, so, not surprisingly, federal money flowed to geologists to study this phenomenon. A small part of this ultimately supported the geomorphologic studies in the Transverse Ranges. The Palmdale bulge turned out to be an illusion; the impacts of climatic change on these tectonically active mountains, however, was not!

Sometimes, reading through a 280+ -page technical publication can be somewhat of a chore, given the all too typically dry, almost mechanical nature of academic prose. Reading this book, however, is enjoyable; its prose is such that one can almost hear the author himself speaking. The fine prose is complemented by excellent photographs and figures. One type of figure appears often in the book and demonstrates a favorite technique of the author. This technique, which those of us who have known Bill Bull over the years can immediately recognize, merits further comment. These figures depict process responses as functions of some system variable. Notably, the x and y axes are ungraduated and x-y space lacks data points. A few "geomorphotechnicians," so aptly described by Vic Baker, may find these figures rather schematic. Yet this would be to miss their primary purpose: these diagrams clearly and efficiently illustrate the complex processes described in the text. In our opinion, they are educationally highly effective devices. In some cases, they represent new, innovative hypotheses in symbolic form, hypotheses that provide challenges to a new generation of geomorphogists who will test them through research in new areas utilizing new strategies.

Geomorphic Responses to Climatic Changes reflects Bill Bull's continuing and total commitment to his chosen scientific discipline. Armed with his field tape recorder, shovel, oyster shuckers, and a computer for night-time data reduction, he collects vast amounts of data under highly challenging circumstances, ranging from the 115° heat of the deserts to freezing temperatures and harrowing exposures of the New Zealand Southern Alps. He has sustained over the decades and continues to sustain research even when the extramural funding did not materialize. He simply reached into his pocket and kept going. This demonstrates commitment. We could not end this citation without acknowledging the important role his field companion and best friend, his wife Mary, has played during all the global travels and studies. Even as Bill was trying to discern geomorphic responses to climate in New Zealand, Mary studied New Zealand culture and published a book entitled *Judder Bars and Chilly Bins* that explains some of the more curious Kiwi customs for Yankees who might endeavor to visit a country the Bulls have come to admire greatly.

A long time ago the senior citationist, as a beginning graduate student, signed up for a seminar on climatic geomorphology. The assigned reading included the earliest versions of the first two chapters of the remarkable publication we honor this evening, a book that would ultimately take on a far larger significance. As Bill Bull notes in the final chapter, understanding the past impacts of climatic changes on the environment can be used to assess the impacts of future climatic changes on geomorphic hazards such as floods and landslides, or on agricultural productivity, an impact with far-reaching consequences. Thus, we can only hope that others outside our discipline might read this book, as the lessons learned through this research methodology have implications in the social-political arena. This publication, perhaps as much as any other recent publication in our discipline, demonstrates vividly why the voices of field-oriented Quaternary geologists and geomorphologists studying a wide variety of depositional systems and areas should be heard and respected as the Global Change Program takes center stage in the scientific research agenda of the fast-approaching 21st century.

Response by WILLIAM B. BULL

I thank division chairpersons, members of the Kirk Bryan Award Panel, colleagues, and friends for awarding me the highest honor that a geomorphologist can aspire to. My book is among many essays by fluvial geomorphologists and Quaternary earth scientists seeking to learn more about how climate and climate change affect landscape evolution. I would like to use this opportunity to sketch the chronicle of chaos from which *Geomorphic Responses to Climatic Change* emerged, and to express some candid opinions.

In the 1960s, Luna Leopold encouraged the employees of the Water Resources Division of the U.S. Geological Survey to study geomorphic processes. He proposed that we choose "back-yard research" projects, and suggested that we set our career objectives a little higher than we might otherwise. Luna had a series of books in mind. Not knowing better, the world became my back yard, and my goal of writing this book bordered on fantasy. Indeed, it took 15 years to complete!

But we live in an age of promotions and pay raises based largely on numbers of peer-reviewed journal articles. John Costa referred to this as the age of "salami science." A single coherent package of research results is thinly sliced and distributed to many journals, with appropriate rotation of senior authorship. Success in obtaining research funds also requires a track record, so I had a decision to make. Not all books are successful, so the obvious path with least risk would be to issue a torrent of short, disconnected articles. I decided instead to gradually compose a monograph about a global scientific question that I found particularly challenging. Why? Because the book project seemed to be the best vehicle for my long-term professional growth.

A first step was to outline a book about tectonic and climatic geomorphology of arid regions. How incredibly naive of me to think that both topics could be discussed adequately between the covers of a single book. In order to understand tectonic geomorphology, one first needs to identify and understand many climatic controls on landscape evolution. The challenge was to identify different responses of fluvial systems to tectonic and climatic perturbations, and to describe their relative importance. Clearly, key explanations of interactions between geomorphic processes would have to be elucidated by studies of tectonically active and inactive fluvial systems in both humid and arid regions. Fortunately, major climatic perturbations overwhelm fluvial systems, even in tectonically deforming mountain ranges.

My 15-year odyssey took me from the arid Sinai Peninsula to humid New Zealand, and to many intermediate climatic and tectonic settings. Collection of essential data at key field sites provided the basis for a more global viewpoint. Soils descriptions and mapping of Quaternary alluvium allowed reflections on the genesis of alluvial fans and stream terraces, those depositional outputs of fluvial systems that are preserved and that pique the curiosity of the earth scientist.

My work became even more interesting and interdisciplinary with the recognition of the crucial importance of plant communities on hills and streams sensitive to climate change, and with the realization of the utility and significance of soil profiles to Quaternary studies. Flights of stable alluvial surfaces provide opportunities to hold the soil-forming factors of topography, vegetation, and parent material approximately constant; thus allowing general assessment of the passage of time and, of course, the influences of changing climate. Soils chronosequences allowed recognition of synchronous aggradation events in large regions. Brief pulses of deposition induced by global climate change emerged as the subject of the four main chapters of the book.

Stimulating and fruitful discussions with colleagues, and especially with students, kept the voyage headed in the right direction through largely uncharted waters. It was my good fortune to learn about soils and landscapes while having fun with Pete Birkeland, Oliver Chadwick, Les McFadden, Phil Tonkin, and Dan Yaalon. This odyssey was successful, despite the risks, because I had achieved my goal of professional growth in the process, and now because of this special privilege of recognition by my colleagues.

By now it should be abundantly clear that I am an eternal optimist who persists with the job at hand. I am equally positive about the future of geomorphology. We have largely shaken the shackles of being descriptive and on the fringes of earth science. Our strengths lie in a better understanding of the complex processes shaping the landscapes that surround humankind, and abundant, diverse relevance to the environmental needs of society. So, let's integrate the special skills of many other scientists with our observational and modeling talents to solve mysteries that range from coastal erosion to forecasting of earthquakes. Awesome new technologies almost seem to have been developed with geomorphologists in mind, because they pertain directly to the surface of planet Earth. New models and techniques that use cosmogenic isotopes are ushering in a brilliant era of surface-exposure dating. Diverse and magical remote sensing tools, satellites that pinpoint one's global position, and digital map compilations—combined with the basic strength of field work—permit geomorphologists and Quaternary geologists to achieve goals that could only be imagined a decade ago. What a great time to be exploring subjects ranging from impacts of global climate change to active tectonics!

Leopold's advice to set one's sights high carries the risk of failure, but it is worth it. Few of us know what our limits are. Achieving the limits of our ever-changing personal abilities, whether in athletics or in the world of science, requires that we identify our limits by occasional failure to achieve specific goals. We learn by pursuit of carefully chosen goals. The fun of a scientific career is in the unpredictable nature of the pursuit, and the diversity of the fascinating colleagues and friends that one meets along the way.

Establishment of the Kirk Bryan Award surely has improved the quality of papers written by Quaternary geologists and geomorphologists. I'll admit that I myself sought to raise the quality of my work because of the contributions of the previous winners of the award. The award does indeed set a standard, but better papers (short or long) written by scientists (young or old) are the ultimate goal; acquiring an award should be secondary. Nevertheless, the extraordinary character of the Kirk Bryan Award has become much clearer to me in recent months in the form of sincere congratulations from you, my colleagues. I am deeply touched and am deeply appreciative of this privilege. Thank you.

Presentation of the

STRUCTURAL GEOLOGY AND TECTONICS DIVISION CAREER CONTRIBUTION AWARD

to

BENJAMIN M. PAGE

Citation by DARREL S. COWAN

My citation is brief. This should be a festive occasion, not one that makes our naturally humble awardee squirm with embarrassment during a lengthy recitation of how much he has contributed to our profession. Like many, I first encountered Ben Page when I was an undergraduate in his structural geology class at Stanford. As educators, we hear every day how students retrospectively can trace their interest in a certain discipline, or even their choice of career, back to a particularly inspiring teacher. Ben has taught literally generations of students during his half century of service at Stanford, and when you consider that many of them have made their own mark in structure and tectonics, it is clear that the seeds planted during his lectures, seminars, and one-on-one teaching have yielded a bountiful harvest.

Ben's research and publications have addressed the San Andreas fault and its neotectonic signature, chaotic rocks in Taiwan and Italy, and the geology of Nevada. But his singular contribution as a scientist has been to apply the concepts of plate tectonics to the interpretation of continental-margin geology. Nowadays, such an exercise seems routine. But some of us here can remember the heady years of the late 1960s, when geophysicists dropped the kinematic foundation of plate tectonics ready-made into the laps of geologists. Ben had already accrued decades of careful mapping and observation in the California Coast Ranges, and he instantly recognized that many of the puzzling aspects of Coast Range geology became understandable in a plate-tectonic context. More important, he gave the community outside California case histories of Coast Range geology that illustrated how ocean-plate underthrusting is expressed in the on-land record. Eventually his collaboration with Dave Engebretson culminated in the 1984 paper that taught us the feasibility and power of comparing the on-land geologic record against the history of plate motions determined by completely independent means. It still stands as a grand synthesis addressing the fundamental question of how the kinematics of oceanic plates influence the styles of deformation and the character of magmatism in continental margins.

I must point out that Ben's steady stream of publications on these topics mostly issued forth after he turned 60, and just after he stepped down from two stints as executive head of the geology department at Stanford. I cite these facts not as evidence that there is, indeed, life after the chairmanship, but rather as proof of Ben's open-mindedness and willingness to evaluate and adopt new ideas. Many geologists of Ben's vintage and maturity simply pulled in their antennae and switched off their receivers when plate tectonics came along. We should learn from his example: to treat a new idea not like a deadly microbe that is to be ignored until it goes away, or, worse, must be quickly exterminated, but rather as a possibly beneficial organism that needs to be cultured for awhile—which means, in his and our case, tested rigorously against extant and newly collected observational evidence.

I need to cite another of Ben's contributions to our community, and one that is probably the most familiar to those of you here. He served as editor-in-chief of the journal *Tectonics* from 1985 to 1988. His tenure, long after his so-called retirement, helped *Tectonics* mature from a fledgling into a thriving, robust adult that publishes some of the most important papers in our field. Speaking for myself, out of the tsunami of paper that periodically floods my office, *Tectonics* is the one journal that I will always browse through on the day it arrives. Even though his name is no longer on the masthead, I sense Ben's watchful stewardship in every issue.

I want to end by briefly talking about Ben Page as a person. Whether we acknowledge it nor not, some of what we contribute to our colleagues, and especially to students, lies in our conduct as professionals: how we deal with others individually or in groups; how we treat their manuscripts, proposals, and work in progress; even how we listen and respond to their talks. Ask anyone who has known or dealt with Ben and you will inevitably hear the words courteous, considerate, unassuming, kind. Put simply, he is a nice guy. Although he will argue his points firmly, and not yield or clam up out of mere politeness, I think what distinguishes him above all is his unfailing respect for, and willingness to listen to, your interpretations, opinions, and points of view, even when they differ from his own. I have often tried to imagine what our professional interactions—whether small field trips, or huge annual meetings—would be like if we could all emulate Ben. Our gatherings would probably be slightly more boring, but certainly less confrontational and more collegial.

So, Ben, in recognition of how much we have benefited, as individuals and as a community, from having you among us, please accept the highest honor of your Division, the Career Contribution Award for 1993.

Response by BENJAMIN M. PAGE

You have made me very happy, and I have decided to accept the award! I thank Darrel very much indeed, for his generous exaggerations. Darrel Cowan is one of those who have made my academic career rewarding, and he is one of those who has reversed the flow of knowledge, so I have received much more from him than he ever gained from me when he was a Stanford student. Actually, he was Bill Dickinson's student, but we all tried to share him.

At this point I must pay homage to Bill, such a shy and retiring little person. He was one of the best colleagues I ever had. I hope that all the other individuals who have been important to me realize that they have my profound gratitude; I cannot name them all in this brief response.

When I look upon the sea of eager young faces out there in the audience, faces that are only 30, 50, or 70 years old, I feel compelled to offer a few words of wisdom to you innocent youngsters. For this purpose, I have chosen three guidelines from my old Stanford teachers, as follows:

1. From Aaron Waters, who started me in geology, I learned the importance of careful, unbiased observations in the field. When I was a student, Waters was interested in the structure of the Basin and Range province, and his discussions on that subject indicated to me that the old debate over the origin of parallel mountain ranges and depressions in that province could have been much briefer if the debaters had just looked at the critical evidence. You have read that Clarence King initially thought that the ranges and valleys were the result of folding. Gilbert, Dutton, and Russell saw the evidence for block faulting. But Spurr noted vestiges of drainage systems, and proposed that the ranges and valleys were the result of differential erosion. Charles Keyes said that wind erosion was the main agent. C. L. Baker and W. D. Smith recognized faulting along some range fronts, but insisted that it was thrust faulting. Aaron Waters pointed out to us students some simple observations that anyone could make, that could have easily eliminated the wilder ideas. So we learned the importance of thorough observation and, I might add, the legitimate usefulness of circumstantial evidence.

2. From Eliot Blackwelder, another admirable teacher, I received the following brief advice, and I quote, "Think to scale." Experienced geologists do a lot of thinking to scale, and the general public would benefit greatly from this practice, whether considering time, distance, probabilities, or costs.

3. Finally, from Professor C. F. Tolman, I learned a profound fact. One day while in a reflective mood, Tolman said to me, "You know, Ben, people are almost as interesting as *rocks*."

I leave you with these three bits of wisdom, gained from my admired predecessors. I again thank all who have helped and encouraged me. I especially thank my wonderful wife Ginny for her patience, support, and understanding.

SAGE *continued from p. 60*

Effective Teacher Enhancement and Curriculum Programs, to help new program developers.

Partners for Excellence Program

As of December 31, 1993, the number of Partners for Excellence was 737 (Fig. 1). Of this total 367 were teachers and 360 were scientists (Fig. 2). In 1994 we anticipate that PEP membership will exceed 1000. Also in 1993 two issues of *PEP Reports,* the new program newsletter, were distributed. Communications with Partners during the year suggested that PEP could be improved by providing initial training for new partners, as well as support materials for active partners (classroom activity suggestions, places to get resources, etc.). To determine how broad-based these perceived needs are, and to get an idea of the level and types of activities partners are involved in, we will be conducting a Partners for Excellence members survey in 1994. In the meantime we will continue to plan and seek funding for In-STEP (Involving Scientists and Teachers in Educational Partnerships), our proposed partner training and support program.

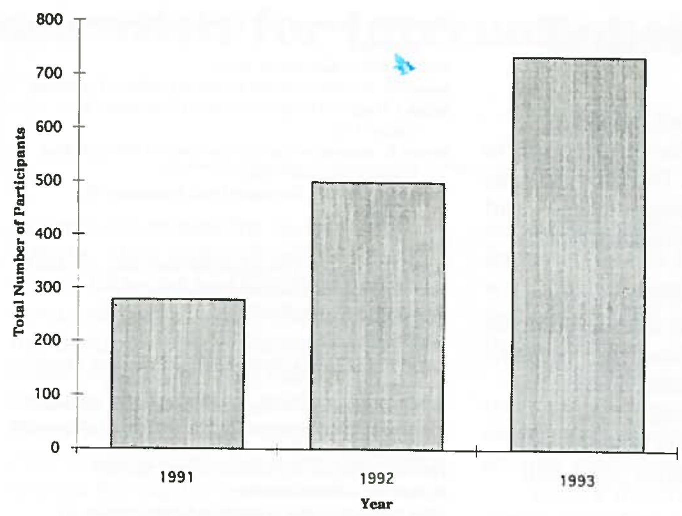


Figure 1. Partners for Excellence Program (PEP) participants.

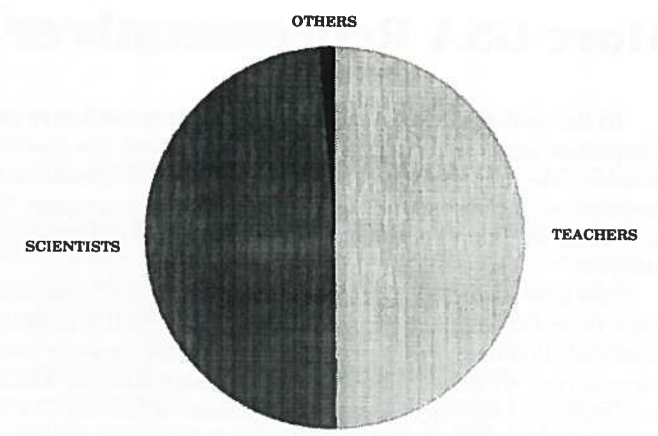


Figure 2. Partners for Excellence Program (PEP) participants by profession.

GSA Education Communication Network

In June of 1993 we established a communication network to enhance information exchange and prevent duplication of effort on educational activities, programs, and resources within GSA. Members of the network include GSA staff, councilors, division, and committee chairpersons, and officers of sections and associated societies. All members of this network receive periodic SAGE updates, and each member of the network has been requested to inform the SAGE director of ongoing or planned educational activities within their sphere of operation.

Colorado Earth and Space Science Education Network (CESSEN)

During 1993 GSA hosted a series of meetings to help bring together and focus the Colorado earth and space science education community. As a result of these efforts, the Colorado Earth Science Network has been re-energized and has agreed to expand its mission and change its name to the Colorado Earth and Space Science Education Network. Nine CESSEN organizations sponsored a joint booth at the October 1993 National Science Teachers Association meeting in Denver. Other 1993 CESSEN activities included (1) conducting a preliminary "needs" survey of Colorado earth science teachers, (2) developing a database of Colorado earth science educators, and (3) planning a directory of Colorado's earth and space science resources. The initial database and directory are expected to be completed in 1994.

Coalition for Earth Science Education (CESE)

Following the February 1993 meeting, CESE vision, goals, and mission statements were revised, and in the autumn of 1993, the ad hoc organizing committee was disbanded and a formal steering committee was elected. GSA's Education Coordinator is a member of this Committee. The second annual CESE Meeting will convene in Reston, Virginia, March 4–6, 1994. The energies of CESE during the next two years will be focused on (1) national and state science education reform efforts, (2) increasing the participation of minorities in the earth and space sciences, and (3) developing the operational and membership structure for the organization.

1993 Awards

SAGE's support of the National Association of Geology Teacher's Outstanding Earth Science Teacher (OEST) awardees and the Presidential awardees in earth science continues to be well received. Several of these outstanding teachers attended GSA meetings in 1993 and conducted education workshops for other teachers. Similar participation is expected by these teachers at the 1994 GSA meetings. In 1993, because of concerns about potential program costs, the GSA education committee recommended, and the Council approved, a cap on the number of K–12 teacher awards. The sum of $16,000 was allocated for K–12 teacher awards in 1993, and 15 teachers (11 OESTs and four Presidential Awardees) received awards. The remaining $1000 allocated in 1993 was used for several small awards to teachers and students for classroom resources, field trips, and science fair projects.

In 1993, SAGE, in conjunction with the Geoscience Education Division awarded the second Biggs Earth Science Teaching award to David Douglass, Pasadena City College (California).

New Projects, Products, and Meetings

During 1993 GSA began planning several new projects: (1) In-STEP, a partner training and support program to foster more effective scientist-teacher partnerships, (2) Project Earth S.E.E.D., a training, dissemination, and support program for potential project directors who want to develop their own teacher enhancement programs, (3) Project RISE, an interdisciplinary curriculum development and training program for K–12 educators, their students, and people whose jobs or volunteer efforts involve educating others about the natural systems of Earth and space and our relation to them, (4) the Earth Appreciation Project, a collaborative program with the National Park Service to enhance the public's appreciation of Earth's history, resources, and natural wonders, (5) Project MAP (Minority Access and Participation), a national conference to address minority issues and concerns in earth science education, and (6) a technology training facility at GSA headquarters, to provide scientists, teachers, and students with opportunities to learn about, explore, and develop innovative ways to integrate new computer and multimedia technologies into K–16 classrooms.

New products in 1993 included the PEP newsletter, PEP T-shirts, a new tabletop education display directed at K–12 educators, and an updated teacher resource packet. We also began work on the first GSA-Durrell slide sets, the Colorado Earth and Space Science Resource Directory, and the how-to guidebook on creating effective teacher enhancement and curriculum programs. The first slide sets, the initial Colorado directory, and the guidebook are all scheduled for completion in 1994. Plans to produce the "Geology, Why Bother" video have been put on hold pending teacher review of the project and identification of a likely funding source.

In 1993 we also began education program planning for the 1994 GSA Section and Annual meetings, as well as planning for a follow-up to the 1993 presidential conference. We are also working with the American Geophysical Union and the American Meteorological Society to plan and convene a joint SAGE-Chapman-AMS conference in 1994 on undergraduate earth science education.

1993 Funding Initiatives

In 1993 we submitted several funding requests to a variety of organizations and individuals. Significant grants were received from Richard and Lucile Durrell to initiate development of the slide sets, and from Marathon Oil and the Frederick H. Leonhardt Foundation for general SAGE program support.

Other foundations we approached in 1993 included the Boettcher Foundation, the Gates Foundation, the Kellogg Foundation, the Pew Charitable Trusts, the Ruth and Vernon Taylor Foundation, and the Temple Hoyne Buell Foundation. In 1994 we will continue to submit requests to a variety of funding agencies for support of SAGE programs.

For additional information on current and future SAGE programs and products, please contact Ed Geary or Barb Mieras at (303) 447-2020. ■

More GSA Representatives Needed

In the mid-1980s, GSA launched a new representative program, targeting companies, agencies, and consultants throughout the country. The purpose was to broaden GSA's representation to include all employment sectors. The program was modeled on the successful campus representative program that began in 1979 and now includes 543 representatives at colleges and universities throughout North America.

We now have 146 company, 91 agency, and 47 consultant GSA representatives. However, we need more volunteers. Our goal is to designate a representative at all major company offices and governmental agencies throughout the country. For example, we hope to have a GSA representative for ARCO in Anchorage, for the Geological Survey of Canada in Vancouver, for the U.S. Geological Survey in Reno, etc. We want to develop a similar liaison with GSA members who are self-employed and serve as consultants. They would also represent major cities and geographic regions.

Representatives serve as liaisons between GSA headquarters and their constituency in a particular city or region. They provide information on the programs and benefits of the Society to other members in the region and explain to prospective members the advantages of joining GSA. Each representative receives a notebook containing complete information on all GSA programs, activities, publications, meetings, and other benefits that the Society provides its membership.

We need your help to continue this communications link between GSA headquarters and the membership of the Society. If you are a Member or Fellow (not Student Associate) and are interested in serving GSA as a representative for your company, agency, or group of the employment sector, please contact T. Michael Moreland, Manager, Membership Services, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

We thank the following GSA representatives now serving to keep the program growing.

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GeoRef Offers Free Searching in March

During March 1994, free connect time will be available for searching the GeoRef database. Users of this special offer may access GeoRef for one-half to one hour at no charge. The offer is available through the cooperative efforts of the American Geological Institute and four search services that carry GeoRef: DIALOG, OCLC, ORBIT, and STN.

Among GeoRef's new programs and features for 1994 are
- direct user searching through the Internet,
- the addition of 7000 full-text abstracts,
- twice a month updates of the database (monthly updates have been standard).
- a new production system that has reduced to 21 days the average time from receipt of a priority journal to its inclusion in the database,
- a database that matches the coverage of the U.S. Geological Survey Library in Reston, Virginia—the preeminent library for the geoscience community, and
- timely, economical document delivery service.

Terms of the offer differ among the search services in regard to the limits on free search time and online displays. The free offer does not apply to offline prints and telecommunications charges.

The GeoRef database contains more than 1.8 million references to geoscience journal articles, books, maps, conference papers, reports, and theses. It covers the geology of North America from 1785 to the present and the geology of the rest of the world from 1933 to the present.

AAAS Seeks Information for Resource Directory

The American Association for the Advancement of Science Project on Science, Technology, and Disability invites scientists and engineers with disabilities to be included in the third edition of the *Resource Directory of Scientists and Engineers with Disabilities.* Potential candidates for the directory must hold, or be working toward, a degree in a scientific, engineering, or medical discipline, or currently be employed in a scientific field.

Funded by the National Science Foundation, the project's *Resource Directory of Scientists and Engineers with Disabilities* has assisted hundreds of individuals to enter and advance in scientific disciplines. The directory helps to connect persons with disabilities and their families with professors, teachers, and counselors who can serve as role models and mentors. The *Resource Directory* lists scientists, mathematicians, and engineers from all parts of the country with their disciplines, degrees, and disabilities. Individuals include professionals who were born with a disability and those who acquired their disability mid-career. Persons listed in the directory are also asked to consult for academia, government agencies, and industry as well as serve on peer-review panels and symposia.

To be included in the directory, or for more information, contact Laureen Summers, Program Associate, or Patricia A. Thompson, Editorial Specialist, AAAS Project on Science, Technology, and Disability, AAAS, 1333 H Street, N.W., Washington, DC 20005, or call (202) 326-6645 (V/TDD). Information can also be sent via fax to 202-371-9849.

Association of Geoscientists for International Development

Sandra M. Barr, AGID Treasurer

This year marks the 20th anniversary of the founding of AGID, the Association of Geoscientists for International Development. AGID is a world-wide, nonprofit, and nongovernmental organization that was established to provide a continuing forum for the exchange of ideas, experiences, and information among all persons concerned with geosciences and international development. AGID covers the various branches of geology, environmental science, and geological engineering, and it invites membership and active participation from all members of the global geoscience community. At present, AGID has more than 1700 individual and institutional members.

AGID is run by a 20-member council, which is elected by the membership every four years and which serves on a volunteer basis. The council, with a majority from developing countries, includes a cross section of world geoscientists. The officers are chosen among its members by the council itself. The current president is from Brazil. Regional vice presidents, currently in India, Zambia, Nigeria, and Colombia, coordinate activities in Asia, Africa, and Latin America.

AGID, founded in 1974, was initially headquartered in Canada, then Venezuela, then Thailand; in 1992, headquarters was moved to Brazil and is now at the Institute of Geosciences, University of Saõ Paulo.

Most AGID activities are in developing countries, because geoscientists in those countries know what aid projects are needed for their circumstances. Their major problem is to attract financial and logistical support from aid sources. AGID exists as a communication network through which these geoscientists can express their needs to colleagues in developed countries who in turn may help to focus relevant expertise and financial assistance toward solving the problems.

Recent activities in Latin America have included courses on field techniques for monitoring ground and ground-water contamination (Brazil), maintenance of an urban hydrology network for management of water resources (Bolivia and Brazil), and several conferences and symposia on environmental geology and geological risks in urban areas (Colombia, Costa Rica). AGID has also been active in the organization of meetings of Central American women geoscientists in Costa Rica.

In Asia, AGID has sponsored numerous workshops on geoscientific writing (Thailand, India, Sri Lanka), a conference on the role of women geoscientists in national planning and development programs (India), and training courses in topics such as ground-water exploration and assessment. AGID supports a data bank (based in Beijing) on natural disasters in Asia, and various regional conferences such as one on land use planning.

In Africa, AGID has recently supported workshops on gemstones and water resources management (Zambia), and is currently supporting a major multinational project on evolution and mineralization in the Mozambique and related belts in eastern Africa, as well as geoscientific writing and field workshops, and a network of women in geosciences.

AGID maintains a scholarship program to assist graduate students in developing countries with the expenses of their field work.

One of the chief goals of AGID is communication, and publications help to achieve that aim. The main publication throughout the history of the organization has been the quarterly newsletter, *AGID News,* with a distribution of over 2000 copies. A new directory of AGID members was published in January 1994. Several other books have been sponsored by AGID, including most recently the *International Mineral Development Source Book,* edited by James F. McDivitt. Based in Canada, the AGID Book and Journal Distribution Service sends donated geoscience literature to institutions throughout the developing world.

In most of its activities, AGID works closely with other organizations, often performing a catalytic role in which AGID members take the initiative and provide services, and other organizations provide financial and technical support. Thus, AGID works effectively with a limited budget, which is multiplied many times through its links with other groups. The Canadian International Development Agency (CIDA) has been a major donor and has provided much of the core funding for AGID operations.

AGID is an associated society of the Geological Society of America and works closely with the International Division of GSA. For further information, contact one of the AGID councilors or AGID Headquarters, c/o Institute of Geosciences, University of Saõ Paulo, CP 20.899, 01498-970 Saõ Paulo SP, Brazil.

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GSA Reps *continued from p. 88*

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Demetrius C. Pohl—American Museum of Natural History, New York
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Barry J. Rava—Conoco, Inc., Lafayette
Scott C. Reeve—Shell Offshore, Inc., New Orleans
Arthur T. Smith—Chevron, U.S.A., New Orleans
Charles W. Sprague—Fugro-McClelland (S.E.), Inc., Harahan
Neil M. Sullivan—Independent Oil Companies, New Orleans

Mississippi
Allen Lowrie—U.S. Naval Oceanographic Office, Picayune

North Carolina
Lindsay A. Bethel—Delta Environmental Consultants, Inc., Charlotte
Ivan K. Gilmore—Texasgulf, Inc., Aurora
Alexander S. Glover—Vulcan Materials Company, Winston-Salem
C. Edward Howard—Research Triangle Institute, Lillington
J. Daniel Walker—North Carolina Geological Survey, Raleigh

South Carolina
Gregory C. Simones—South Carolina Water Resources Commission, Columbia
Robert S. Van Pelt—Westinghouse Savannah River, Graniteville

Tennessee
RaNaye B. Dreier—Oak Ridge National Laboratory, Oak Ridge
Phyllis M. Garman—Garman Geologic Consulting, Nashville
William F. Kohland—Deltacon Consultants, Murfreesboro
Edward T. Luther—Tennessee Department of Conservation, Nashville

Virginia
Richard B. Carten—U.S. Geological Survey, Reston
Bruce Doe—U.S. Geological Survey, Reston
Wilson N. Felder—TRW Systems, Fairfax
John J. Hnat—Amherst
Robert C. Milici—Virginia Division of Mineral Resources, Charlottesville
Jan M. Pickrel—Virginia Water Control Board, Woodbridge
Robert Schneider—Arlington

West Virginia
John M. Lake—Staff Engineering Services, Cross Lanes
Peter Lessing—West Virginia Geological Survey, Morgantown

Other

Australia
John R. Conolly—Sydney

Colombia
Timothy B. Berge—Esso Colombiana (Coral Gables, Florida)

Dominican Republic
Gerald M. Ellis—Dominican Director General of Mines, Santo Domingo

India
Ram N. Choudhary—India Oil & Natural Gas Commission, Rajasthan

Puerto Rico
Pedro A. Gelabert—U.S. Environmental Protection Agency, Guaynabo

Singapore
Beng-Teck Oh—Singapore

South Africa
Fred Brown—Freddie's Mine, Odendaalsrus ■

Washington—The Ultimate Learning Experience

Murray W. Hitzman, 1993–1994 Congressional Science Fellow

For Christmas my brother gave me a copy of Frank Capra's classic 1939 movie "Mr. Smith Goes to Washington." In it, a young western senator goes to the nation's capitol and finds it teeming with unscrupulous politicians, lobbyists, and journalists. In the end, however, this Senator Smith fights for his ideals, and after a seemingly hopeless filibuster, wins the day.

I had seen the film as a child and it had made a deep impression, enticing me to consider government as a career. But as I grew up my interests turned more to science, and I became a geologist and then a manager for a multinational oil company rather than a politician or government bureaucrat. However, the film's idealism remained with me and after my years of working with a number of foreign governments, it spurred me to see what Washington was really like. I applied for the Geological Society of America Congressional Science Fellowship. I was pleasantly surprised, and somewhat overawed, when selected as the first GSA Congressional Science Fellow with a background in industry.

The Congressional Science Fellowship program was created to provide scientific assistance to the U.S. Congress, which increasingly deals with scientific and technical issues. Congressional Science Fellows serve in the office of a member of Congress, a congressional committee, or a congressional support agency and gain firsthand experience of the legislative process. The program, coordinated by the American Association for the Advancement of Science (AAAS), is the cooperative effort of approximately 20 national scientific and engineering professional societies. Each of these entities selects and sponsors one or more professionals as Fellows to serve as legislative assistants in congressional offices for one year. The Geological Society of America has sponsored a Congressional Science Fellow since 1986.

The fellowship begins with an intensive two-and-a-half week orientation program organized by the AAAS which provides an introduction to the substantive, procedural, and political aspects of public policy in Washington, D.C. It features meetings with members of Congress and their staffs; congressional support organizations such as the Office of Technology Assessment (OTA) and the Congressional Research Service (CRS); personnel from the White House such as the Office of Science and Technology Policy (OSTP); groups from the executive agencies such as NASA, the U.S. Department of Agriculture, U.S. State Department, and National Science Foundation; as well as groups from private "think tanks" such as the Brookings Institute; lobbyists from industry, consumer, and environmental groups; and representatives of the World Bank.

Although excellent, the orientation cannot totally prepare Fellows for the day they are set free on Capitol Hill and told to "find a position." Demand for Science Fellows in congressional offices is much greater than the supply, due to the limited number of scientists on Capitol Hill and because they are free labor. However, it is still a daunting task to review, select, and then interview with any of the 600+ offices open to the Fellows, nearly all of which have some interest in, or use of, science. Most Science Fellows have just completed their doctorate or come from academic positions and are free to chose any office. Those of us from the private sector found our choices partially limited by congressional ethics rules that do not allow us to work on congressional committees responsible for legislation directly involving our former employers. In my case this ruled out positions with the Senate Energy and Natural Resources Committee as well as House committees dealing with the petroleum and mining industries.

I interviewed with about 30 different offices in both the Senate and the House from across the political spectrum to get a taste of the differing operational styles and political viewpoints. The interviewing process itself was a fascinating, and valuable, lesson in the workings of Capitol Hill and will probably remain as one of the highlights of my Fellowship experience. I considered several offers before deciding to serve on the personal staff of Senator Joseph I. Lieberman (Democrat—Connecticut). The position was attractive primarily because of the senator himself, the quality of his staff, and the issues I would be working on—environmental and science-technology legislation.

My duties in 1993 included work on the environmental aspects of the NAFTA agreement, hearings on the Clean Air Act, attempts to get a National Environmental Technology bill passed in the Senate, and casework, or congressional help, for Connecticut individuals and business firms involved in science and technology. During 1994 it appears that I will be working on reauthorization of the Clean Water and Superfund acts, and interacting more closely with the Senate Environment and Public Works Committee, of which Senator Lieberman is a subcommittee chairman.

Like Capra's Senator Smith, I was thrilled by the sights of the capitol and the sense of power in its halls during the early weeks of my tenure. Unlike the film's character I have not found Washington to be a hotbed of corruption and graft. I have discovered, however, that work inside the Beltway is unlike that outside in corporate America.

Congress is organized quite differently from the corporate world. It is not a hierarchical organization, but rather an almost amorphous mass of competing interests. Power structures are not always obvious. Much of my time thus far has been spent talking to people to determine who are the key players in different issues. It is not always those one would initially suspect. In some cases it is the majority leader or a committee chairman. In other cases, it is an influential staff person, or more usually a coalition of several senators and their key legislative aides. History is very important inside the Beltway, not just the monuments and statues, but the more recent history of how legislation has been crafted and who has power over what issues.

In industry there is usually a clear bottom line—what is the most cost effective method to get something done. Although this includes a wide range of cost considerations—production, management, environmental, etc.—it is generally a relatively straightforward exercise. In Washington, decisions are less clear cut, even over technical issues with a scientific basis. Not having a hierarchical organization means that decisions require consultation with many individuals and groups. This leads to a significant amount of time, and compromise, for the decision-making process. There are many constituencies to consider as well as the history of past legislative practices and compromises. Swift boardroom actions are not a feature of Capitol Hill.

Another significant difference between Capitol Hill and the natural resources industry is the background of co-workers. Prior to the fellowship I worked with businesspeople, engineers, lawyers, and other geoscientists. On Capitol Hill, unsurprisingly, most members of Congress, and staff, are lawyers. It becomes critical to be able to think more like a lawyer and to frame the scientific information one is trying to convey in these terms. Science Fellows must be able to translate "black and white" scientific data into the more "gray" area of legislation.

Most technical people in industry deal with relatively compartmentalized fields of knowledge—mining engineering, seismic stratigraphy, ground-water hydrology, and remediation techniques. Managers, as they advance up the corporate ladder, need to have some knowledge of increased numbers of fields. However, in Congress the issues in play include every field of knowledge, from gun control to the environmental aspects of world trade to welfare reform. I have quickly discovered that I am no longer a geologist, but rather a scientist. This means I am expected to be able to answer questions, usually within several hours, on any aspect of science, from the Supercollider's particle physics to the research needs of the National Institutes of Health.

My first reaction to this was "You've got to be kidding!" When I immediately discovered they were not, my reaction changed to "Help!" But very quickly I learned to pull off this amazing feat. The currency of Washington is information, and the key is knowing whom to call. For information tangential to one's own field, Fellows probably have the contacts themselves. In other areas there is the expertise of the other 25 Congressional Science Fellows on the Hill to draw upon. But most important there is the whole U.S. government and innumerable professional organizations and private groups. It is amazing what a phone call from a Senator's office can do. I can usually have a response to a complex technical question within two hours.

Well-indexed phone directories are critical to life on Capitol Hill. Even more important are personal contacts. Life in Washington is an ongoing process of expanding one's circle of contacts. The more people you know, the more access you have to information. This means that work never really stops. At lunch you try to meet new people and discover what they are working on. In the evening it is important to go out to a technical presentation, professional society meeting, or cocktail party to make more contacts.

The result of obtaining information from all these contacts is most commonly data overload. In private industry, I studied all available information on a project or issue before committing major corporate resources. In Congress there are too many issues and, if anything, too much data. Within weeks of joining the Senator's office, my desk and all available adjacent space were overflowing with newspaper and popular magazine articles,

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current bills, past legislation, technical articles and books, and executive agency and congressional reports on the issues with which I was dealing. No matter how quickly I read and how much I took home to study in the evenings, the pile was larger by the next afternoon. It made keeping up with the technical journals on geology seem like child's play.

It became clear that for most issues, one only has time to scan the data, look for executive summaries, and focus on major points. Legislative aides have to absorb data and refine it to precise, one- or two-page summaries for the Senator. At first this was frustrating, and the implications of this process for well-crafted legislation appeared dismal. But I have discovered that even if I miss a significant point or a politically charged issue, there is always some other congressional staff member out there with a different viewpoint who will be sure to correct my oversight. Despite the lack of time and the frantic aspect of much of the work, the system is successful because of its competitive, sometimes adversarial, nature and its skilled people.

As a manager of a multinational oil company office, I commonly responded to public and governmental inquiries. In the Senate, however, responding to constituent inquiries is a critical part of the job. Several times a day the mail is delivered to our office, in several large baskets. The dramatic amount of mail dumped into the Senate chamber in Capra's film represents only one or two days worth of normal mail in a congressional office.

Each letter or card is read by a staff member, and the name, address, and topic or concern is entered into a database. Every letter asking for a response receives a reply. The telephone begins ringing early in the morning with requests and comments by constituents and rarely stops during the day. The majority of the Senator's staff works with, and for, constituents, answering questions, helping them with government inquiries, making sure the Senator knows how his constituents feel about an issue. Congressional offices are geared to listen and respond to constituent concerns, from individuals, citizen groups, and businesses. Frustrating as this casework can be at times, it also provides another means of getting to know different subjects, meeting more people, and expanding the range of contacts.

My experience thus far is that there is much more of Senator Smith's idealism in Congress than I would have imagined. Watching Capra's movie again after so many years reveals many aspects obliquely hinted at in the film that I did not fully appreciate: the power of good congressional staff (Senator Smith's secretary) and the necessity of contacts (the senator's success with the press because of the secretary's contacts). During Senator Smith's final impassioned filibuster speech he says, "Get up there with that lady that's up on the capitol dome. That lady that stands for liberty. Take a look at this country through her eyes if you really want to see something. And you won't just see scenery. You'll see the whole parade of what man's carved out for himself after centuries of fighting."

Capitol Hill is a fascinating place, in many ways the ultimate learning experience. To do the job, one must be able to grasp at pieces of that "whole parade." And increasingly, those pieces have more and more to do with science and technology, especially the earth sciences.

It's going to be an interesting, and informative, year. ■

Murray W. Hitzman, 1993–1994 GSA Congressional Science Fellow, is serving on the staff of Senator Joseph I. Lieberman (D—CT). Hitzman may be contacted at (202) 224-4041. *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.*

MEETINGS

■ Indicates new or changed information

GSA Penrose Conferences

March 1994

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

April 1994

Triple Junction Interactions at Plate Margins, April 21–26, 1994, Eureka, California. Information: Virginia B. Sisson, Dept. of Geology and Geophysics, Rice University, P.O. Box 1892, Houston, TX 77251-1892, (713) 285-5234; Terry L. Pavlis, Dept. of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148, (504) 286-6797; David J. Prior, Dept. of Earth Sciences, University of Liverpool, P.O. Box 147, Liverpool L69 3BX, UK.

June 1994

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

1994 Meetings

March

International Convention on Global Exploration and Development, March 6–9, 1994, Toronto, Ontario, Canada. Information: Rita Plaskett, Convention Manager, Suite 1002, 74 Victoria Street, Toronto, Ontario M5C 2A5, Canada, (416) 362-1969, fax 416-362-0101.

Lunar and Planetary Science 25th Annual Conference, March 14–18, 1994, Houston, Texas. Information: 25th LPSC, Publications and Program Services Dept., Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113, (713) 486-2166, fax 713-486-2160.

Geology and Exploration and Development Potential of Energy and Mineral Resources of Vietnam and Adjoining Regions, March 14–17, 1994, Hanoi, Vietnam. Information: Mary Stewart, 5100 Westheimer, Suite 500, Houston, TX 77056, (713) 622-1130, fax 713-622-5360.

10th Mining and Geothermal Institute, March 17–18, 1994, Reno, Nevada. Information: American Association of Professional Landmen, 4100 Fossil Creek Blvd., Fort Worth, TX 76137, (817) 847-7700.

GSA South-Central Section Meeting, March 21–22, 1994, Little Rock, Arkansas. Information: Philip L. Kehler, Dept. of Earth Sciences, University of Arkansas, 2801 S. University Ave., Little Rock, AR 72204, (501) 569-3546, fax 501-569-8020.

GSA Cordilleran Section Meeting, March 21–23, 1994, San Bernardino, California. Information: Joan Fryxell, Dept. of Geological Sciences, California State University, 5500 University Parkway, San Bernardino, CA 92407-2397, (909) 880-5311, fax 909-880-7005.

Second International Conference on Ground Water Ecology, March 27–30, 1994, Atlanta, Georgia. Information: American Water Resources Association, 5410 Grosvenor Lane, Suite 220, Bethesda, MD 20814-2192, (301) 493-8600, fax 301-493-5844.

Seventh Annual Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP), March 27–31, 1994, Boston, Massachusetts. Information: EEGS, Mark Cramer, P.O. Box 4475, Englewood, CO 80112, (303) 771-6101.

GSA Northeastern Section Meeting, March 28–30, 1994, Binghamton, New York. Information: H. Richard Naslund, Dept. of Geological Sciences, SUNY, Binghamton, NY 13902-6000, (607) 777-4313, fax 607-777-2288.

Contaminated Soils and Ground Water, Fifth Annual Association for the Environmental Health of Soils West Coast Conference, March 28–April 1, 1994, Long Beach, California. Information: Mary K. Terry, Association for the Environmental Health of Soils, 150 Fearing St., Suite 20, Amherst, MA 01002, (413) 549-5170, fax 413-549-0579.

Simpson and Viola Groups in the Southern Midcontinent, March 29–30, 1994, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, 100 E. Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3013.

April

GSA Southeastern Section Meeting, April 7–8, 1994, Blacksburg, Virginia. Information: Lynn Glover, III, and Robert J. Tracy, Dept. of Geological Sciences, Virginia Tech, Blacksburg, VA 24061-0420, Glover's direct (703) 231-6213, fax 703-231-3886, Tracy's direct (703) 231-5980.

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

Full listing to appear in April.

GEOTRIP

Rim to River: Moab, Canyonlands, and Cataract Canyon

7 days, 8 nights: May 28–June 4, 1994

Scientific Leaders:

Kenneth Kolm, *Department of Geology and Geological Engineering, Colorado School of Mines*

John A. Campbell, *Department of Geology, Ft. Lewis College*

John Emerick, *Division of Science and Engineering, Colorado School of Mines*

This trip is an exceptional educational opportunity for the physically active person. The itinerary includes geologic features found nowhere else. More than 1500 natural stone arches stand in Arches National Park, which is the world's highest concentration of these remarkable features. Nearby is Canyonlands, Utah's largest national park, a unique area of sandstone pillars and mazes of incredible beauty that have been formed into three districts by the Colorado and Green rivers. Cataract Canyon is a major whitewater experience. We are glad to be offering these experiences, as well as the trip to the La Sal Mountains, at the very best time of year.

For pre- or post-trip interest, Moab is within driving distance of Natural Bridges, Capitol Reef, Bryce Canyon, Zion, Grand Canyon and the Glen Canyon Lake Powell recreational area.

GEOVENTURES REGISTRATION FORM

Registration Open

The GeoVentures program is a special benefit created for members but open also to spouses and friends. GeoVentures is the overall name for adult educational and adventure experiences of two kinds: GeoTrips and GeoHostels. Both are known for expert scientific leadership. Fees for both are low to moderate (relative to the length of time and destination) and include lodging and meals as designated. The venues, however, are quite different.

Please keep in mind that the GeoVentures fill quickly and it is best to make a decision early.

If you would like to send a deposit to hold your reservation, please pay by check or credit card, which will be used only for this deposit. (Future charges will be authorized by you first.) You will receive further information and a confirmation of your registration within one week after your reservation.

Cancellation: Each GeoVenture has its own set of cancellation dates which will be sent out to registrants and provided in response to phone queries.

Name ____________________

Institution/Employer ____________________

Mailing Address ____________________

City __________ State ____ Country __________ ZIP ________

Phone: ( ) __________ (Business) ( ) __________ (Home)

Guest Name ____________________

GSA Member # __________

	Deposit Per Person	No. of Persons	Total Paid Deposit
GT941 —Canadian Transect	$200	_____	_____
GT942 —Canyonlands/Cataract Canyon	$200	_____	_____
GH943— Gunnison/Central Colorado	$100	_____	_____
TOTAL DEPOSIT			_____

☐ I've enclosed no deposit, but I'm interested. Please send more information.

☐ VISA ☐ MasterCard ☐ American Express

Credit Card # ____________________ Exp. Date _______

Signature ____________________

Make checks payable to: **GSA 1994 GeoVentures**

Mail registration form and check or credit card information to:
1994 GSA GeoVentures, GSA Meetings Department,
P.O. Box 9140, Boulder, CO 80301

Non-U.S.-based registrants are encouraged to use GSA's fax number:
303-447-0648

Itinerary

May 28, Saturday—Travel day to Moab. Orientation at 7:30 p.m.
May 29, Sunday—La Sal Mountains. Lodging in Moab.
May 30, Monday—Arches National Park. Lodging in Moab.
May 31–June 3, Tuesday–Friday—Hike to the River on Lathrop Trail. Hiking in Canyonlands (Island in the Sky, Maze, and Needles districts). Tent camping.
June 4, Saturday—Rafting Cataract Canyon. Side hikes. Overflight of Canyonlands and return to Moab. Farewell Party.
June 5, Sunday—Travel day.

Transportation, Lodging, Meals

Travel will be by four-wheel drive vans, motorized rafts, or on foot. During the days in the Arches area, Behind-the-Rocks, and the La Sal Mountains, transportation will be in vans. Travel on the Colorado River will be in motorized rafts (J-rigs). Lodging in Moab will be in a comfortable modern motel. Camping near the river for three nights will be in tents and sleeping bags provided by the rafting outfitter. Meals are provided except for the arrival night and the departure morning.

Physical Requirements

This trip includes several substantial hikes for which each person will carry a day pack with camera, water, and snacks. The longest hike is 12 miles—downhill. Although taken at a reasonable pace with many points to rest or to explore the geology, these hikes should be undertaken only by persons in good health who are physically active. No rafting experience is necessary.

Fee and Deposit

Estimated Cost: GSA Member: $1220. Nonmember: $1370.
Based on 24 people. May be more if there are fewer registrants. If you have previously traveled on a GSA GeoTrip, the nonmember surcharge will be waived.
$200 deposit, due with your reservation, is refundable through April 1, less $50 processing fee.
Total balance due: April 1. Minimum age: 21. Limit: 24 persons.

Fee includes all meals except dinner on the arrival day and breakfast on the departure day; comfortable four-wheel-drive van transportation; double-occupancy lodging in Moab; tents, sleeping bags, and pads when camping; geological reading material and guidebook; overflight of Canyonlands; and of course, the companionship of expert scientific leaders.

Not included is airfare to and from Grand Junction, Colorado, or transfer to

GEOHOSTEL

Scenic Geology and Natural History of the Central Colorado Rocky Mountains

Western State College, Gunnison, Colorado

5 days, 6 nights: June 25–30, 1994

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

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

Day One—Saturday, June 25
7:00 to 9:00 p.m.—**Welcoming Reception.** Meet in Denver at 12:00 noon for an optional van field trip to Gunnison through South Park, or in Gunnison in time for the Welcoming Reception and Orientation at Western State College.

Day Two—Sunday, June 26
8:00 a.m. to 5:00 p.m.—**Geological Sequence of Central Colorado.** Field trip to Black Canyon of the Gunnison River, with stops at Blue Mesa Reservoir, Cimarron, Morrow Point Dam, and various viewpoints at the Black Canyon. Optional hike at Black Canyon.

Day Three—Monday, June 27
8:00 a.m. to 1:00 p.m.—**Geology of the Gunnison Valley.** Field trip north through Crested Butte and Gothic to Schofield Pass (10,700'), south of Aspen. Local geology, hydrogeology of glacial outwash and Mesozoic sedimentary rocks, spectacular exhumed intrusions, and gondola ride to the top of Crested Butte.

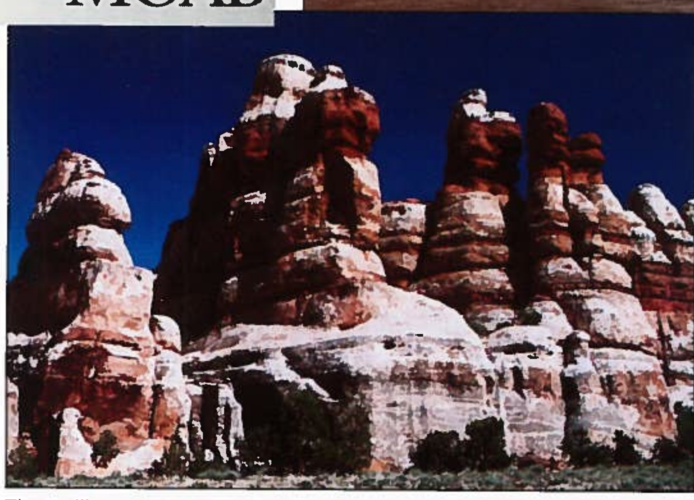
Day Four—Tuesday, June 28
8:00 a.m. to 5:00 p.m.—**Geology of the Northern Rio Grande Rift.** A field trip loop from Gunnison to the Arkansas River Valley over Monarch and Cottonwood Passes. Precambrian basement, rift faulting, glacial moraines and terraces, roots of the Mt. Etna Caldera, mountain hydrogeology, tundra at Cottonwood Pass. Gondola ride at Monarch Pass.

Day Five—Wednesday, June 29
8:00 a.m. to 12 noon—**Features of Calderas and Ash Flow Tuffs of the San Juan Volcanic Field.** Field trip south over Cochetopa Pass. See Cochetopa Canyon and well-preserved Cochetopa caldera, and review details of ash-flow tuff features in outcrops.
1:00 p.m. to 7:00 p.m.—**Optional afternoon field trip to the Great Sand Dunes.** Field trip to the Great Sand Dunes and review of the San Luis Valley hydrogeology and controversies. Dinner break in Alamosa.

Call today for more information: Matt Ball or Edna Collis at (303) 447-2020 or 1-800-472-1988

RIM TO RIVER: MOAB

Cataract Canyon
Ken Kolm



The Dollhouse, Maze District, Canyonlands *Ken Kolm*

Moab, Utah. We will arrange for an optional group pick-up and return. The cost is about $20 each way (100 miles).

Air Transportation

Air transportation can be arranged by Cain Travel Agency in Boulder, 1-800-346-4747, Monday through Friday, 8:30 a.m. to 5:30 p.m. MST. Please ask for Robyn Langerak, who has been serving GSA travelers well for several years. She can also advise you on other travel in the Four Corners area, including Zion, Bryce, and Grand Canyon National Parks.

Please make your decision as soon as possible. There is active interest in this unusual trip, and it will fill soon.

Day Six—Thursday, June 30
8:00 a.m. to 5:00 p.m.—**Lake City Tour.** Powderhorn carbonatite, Slumgullian slide and geotechnical aspects of landslides, Lake San Cristobal, Lake City caldera features. Late-day hike or tourist activity in Lake City.
The Farewell Party begins at 7:00 p.m.

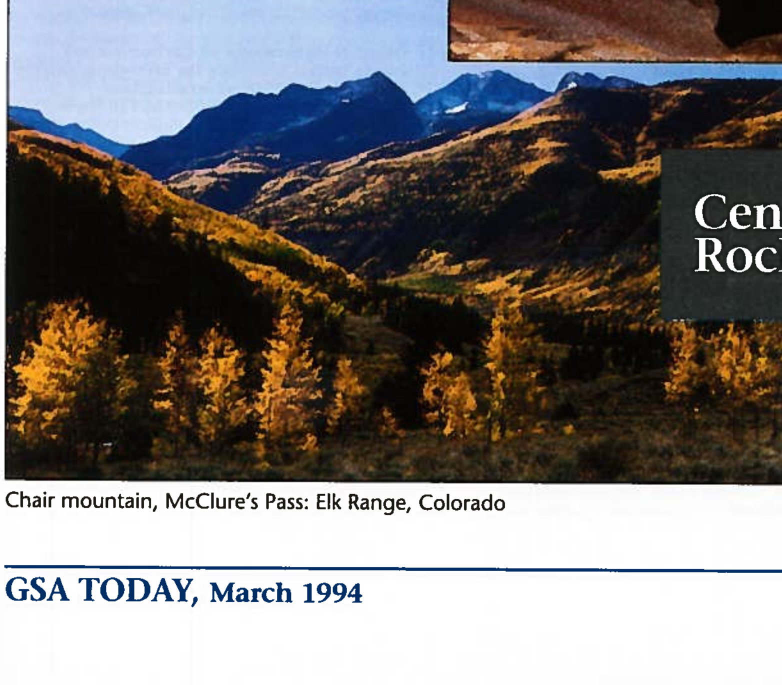
Fee and Deposit

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

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

Mt. Owen Ridge, Keebler Pass: Elk Range, Colorado. *Ken Kolm*

Central Colorado Rocky Mountains



Chair mountain, McClure's Pass: Elk Range, Colorado *Ken Kolm*

Peyto Lake, Banff National Park, Canada. *Mark Duvall*

GEOTRIP

Calgary to Vancouver:

Transect across the Southern Canadian Cordillera: A Cross Section through a Convergent Margin

15 days, 16 nights: August 13–27, 1994

Scientific Leaders:
J. Murray Journeay, J.W.H. Monger, Randall R. Parrish, *Geological Survey of Canada*
J. Brian Mahoney, *University of British Columbia*
Philip S. Simony, Deborah A. Spratt, *University of Calgary*

Itinerary

This trip is a geological excursion across the southern Canadian Cordillera, from Calgary, Alberta, to Vancouver, British Columbia. Participants will journey through the Canadian Rocky Mountain fold-and-thrust belt, the Omineca metamorphic complex and Mesozoic arc assemblages, sedimentary basins, and plutonic complexes of the accreted terranes. The trip will focus on the tectonic evolution of the region and will emphasize the current level of understanding and areas of current research. As with all GeoTrips, the daily itinerary is planned with both the geologist and nongeologist in mind.

Physical Requirements, Transportation, Lodging, Meals

The leaders have planned several extensive day hikes. Persons in good physical health with the ability to hike several miles uphill are encouraged to consider this trip; however, bus will be the primary transportation mode. Also included will be a trip by horseback, another with jeeps, and very possibly one by jet boat. Lodging (double occupancy) will be in comfortable hotels or inns. Camping may be planned for two or three nights. Meals, including a final farewell dinner, will be included, with the exception of the arrival night, "the on-your-own day," and the departure morning.

Orientation is the evening of August 13. Departure is the morning of August 28. The arrival point is Calgary, and the end point is Vancouver. For most departure points there is a modest differential for the airfare from Vancouver back to Calgary or the continuing airfare from Vancouver to your home destination. Call Cain Travel Group and ask for Robyn Langerak if you want an estimate: 1-800-346-4747, 8:30 a.m. to 5:30 p.m. MST, Monday through Friday.

Fee and Deposit

Cost: Member: $2300. Nonmember: $2450.
Based on 24 people. The trip may be slightly more if fewer register. If you have previously traveled on a GSA GeoTrip, the nonmember surcharge will be waived. $200 deposit is due with your reservation, and is fully refundable through April 30 less a $50 processing fee.
Total balance due: June 15. Minimum age: 21. Limit: 30 persons.

GSA ANNUAL MEETINGS

■ 1994

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

Seattle at the leading edge

General Chairman: *Darrel S. Cowan*

Technical Program Chairmen: *Mark S. Ghiorso, Thomas Dunne*
Symposia and theme proposals were due January 4, 1994.

Field Trip Chairman: *Donald A. Swanson*
Field trip proposal deadline was May 15, 1993.

All of these chairmen are located at the Dept. of Geosciences, University of Washington, Seattle, WA 98195, (206) 543-1190, fax 206-543-3836.

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

Call for Papers: April Issue— Themes, Symposia, Field Trips and Continuing Education.

■ 1995

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

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	***Duncan Goldthwaite***
Louisiana Geological Survey	4608 James Drive
P.O. Box G, University Station	Metairie, LA 70003
Baton Rouge, LA 70893-4107	(504) 887-4377
(504) 388-5320	

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

■ FUTURE

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

For general information on technical program participation (1994 or beyond) contact Sue Beggs, Meetings Manager, GSA headquarters.

GSA SECTION MEETINGS

South-Central Section, University of Arkansas, Little Rock, Arkansas, March 21–22, 1994. Philip L. Kehler, Department of Earth Sciences, University of Arkansas—Little Rock, 2801 S. University Ave., Little Rock, AR 72204, (501) 569-3546, fax 501-569-8020. *Abstract Deadline was November 30, 1993.*

Cordilleran Section, California State University, San Bernardino, California, March 21–23, 1994. Joan E. Fryxell, Department of Geological Sciences, California State University, 5500 University Parkway, San Bernardino, CA 92407-2397, (909) 880-5311, fax 909-880-7005. *Abstract Deadline was November 29, 1993.*

Northeastern Section, SUNY at Binghamton, Binghamton, New York, March 28–30, 1994. H. Richard Naslund, Department of Geological Sciences, SUNY, Binghamton, NY 13902-6000, (607) 777-4313, fax 607-777-2288. *Abstract Deadline was December 2, 1993.*

Southeastern Section, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, April 7–8, 1994. Lynn Glover, III and Robert J. Tracy, Department of Geological Sciences, Virginia Tech, Blacksburg, VA 24061-0420, Glover's direct (703) 231-6213, Tracy's direct (703) 231-5980, fax 703-231-3886. *Abstract Deadline was December 1, 1993.*

North-Central Section, Western Michigan University, Kalamazoo, Michigan, April 28–29, 1994. Alan Kehew, Department of Geology, Western Michigan University, Kalamazoo, MI 49008, (616) 387-5495, fax 616-387-5513. *Abstract Deadline was January 6, 1994.*

Rocky Mountain Section, Fort Lewis College, Durango, Colorado, May 4–6, 1994. Douglas Brew, Department of Geology, Fort Lewis College, Durango, CO 81301, (303) 247-7254, fax 303-247-7310. *Abstract Deadline was January 13, 1994.*

Student Travel Grants

The GSA Foundation will award matching grants up to a total of $3500 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist GSA Student Associates traveling to the 1994 GSA Annual Meeting in Seattle in October and to the 1994 Section meetings. Contact your Section Secretary for application procedures.

Cordilleran	Bruce A. Blackerby, (209) 278-2955
Rocky Mountain	Kenneth E. Kolm, (303) 273-3932
North-Central	George R. Hallberg, (319) 335-4500
South-Central	Rena M. Bonem, (817) 755-2361
Northeastern	Kenneth N. Weaver, (410) 554-5534
Southeastern	Michael J. Neilson, (205) 934-5102

March *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 106, Number 3, March 1994

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GEOLOGY

VOLUME 22
NO. 3
P. 193–288
MARCH 1994

CLASSIFIED ADVERTISING

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

Classification	Per line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
Positions Open	$4.50	$3.80
Consultants	$4.50	$3.80
Services & Supplies	$4.50	$3.80
Opportunities for Students		
first 25 lines	$0.00	$1.35
additional lines	$1.35	$1.35
Code number: $2.75 extra		

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

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

Positions Open

SURFICIAL PROCESSES GEOLOGY

The Department of Earth and Atmospheric Sciences of Purdue University invites applications for a tenure-track Assistant Professor faculty position in Surficial Processes Geology, with emphasis in Environmental Geosciences, for research and teaching in both theoretical and applied studies. The position is expected to be filled by the Fall, 1994, semester. Applicants must have a Ph.D. degree, and postdoctoral experience is preferred. The successful candidate will be expected to teach at both the graduate and undergraduate level, and to develop a strong funded research program in his/her area of specialization. The individual must have strong quantitative capabilities with extensive course work and emphasis in the geological sciences, and with demonstrated abilities in data collection, modeling, and analysis of earth systems. Familiarity with Remote Sensing is desirable. The candidate may be one of the following specialists: Quaternary Geologist/Geomorphologist, Specialist in Natural Geologic Hazards, Specialist in Fluvial Processes, Low-Temperature Geochemist, or Hydrogeologist (physical or chemical). Applications from minority and female candidates are particularly welcome. Consideration of applications began December 1, 1993, and the search will continue until the position is filled. Applicants should send their resume, publications list, statement of their long-term research and teaching interests, and the names, addresses, and phone numbers of three references to: Professor Darrell I. Leap, Chairman, Surficial Processes Search Committee, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907-1397. Purdue University is an equal opportunity/affirmative action employer.

DIRECTOR AND STATE GEOLOGIST
MONTANA BUREAU OF MINES AND GEOLOGY

THE BUREAU AND COLLEGE: Located in Butte, Montana, the Montana Bureau of Mines and Geology, established by State Statute in 1919, is a non-regulatory, research and public service department of Montana College of Mineral Science and Technology (Montana Tech). The Bureau is the State's geological research agency and as such conducts investigations and evaluates and disseminates information on Montana geology, hydrology, and mineral, energy, and ground water resources. Montana Tech is a unit of the Montana University System and serves approximately 2000 students. The College has a strong undergraduate and graduate engineering instructional and research tradition in the minerals, mining, and energy industries, with more recent additional emphases in safety and environmental engineering. Additionally, Montana Tech offers degrees in business, chemistry, math, computer science, and liberal arts. A collegial relationship is fostered between the Bureau and the larger College. Butte has been recognized as an All American City and is located in beautiful and geologically interesting Southwest Montana. There is an abundance of civic and outdoor activities to be found in the immediate vicinity.

THE POSITION: The Directory reports directly to the President of Montana Tech and is responsible for the continuing development of the Bureau and for the accomplishment of its mission and goals, including both research and public service. The Director must be committed to the pursuit of excellence and professional productivity of the highest quality in these endeavors, which are statewide in scope and which ultimately benefit all the people of Montana and beyond. It is expected that the activities of the Bureau will contribute actively to that body of professional knowledge related to the Bureau's mission. Current Bureau activity includes nearly 60 major projects on subjects as varied as field geology, mineral resources, both metallic and non-metallic energy resources (including coal, oil and gas, and geothermal), environmental geology (including geologic hazards, particularly seismic and landslides), groundwater assessment and characterization, wellhead protection, aquifer pollution and remediation, saline seeps, and basically the entire range of geology and hydrology. This diversity requires the ability to integrate the various efforts and talents of the Bureau and to work toward effective teamwork. Recognizing the need for financial support beyond legislative appropriation, the Director is expected to seek funding from other external sources.

QUALIFICATIONS: Terminal degree and an established, documented, and distinguished professional background in geology and/or geological engineering is required as well as significant abilities with documented progressively responsible experience in financial and human resource management, including verbal and written communication, leadership, and motivation. The successful candidate will have broad knowledge and understanding of geology in order to effectively understand and guide Bureau research. The Director is held accountable to a rigorous ethical code that guides Bureau scientists. It is essential that the Director be able to relate to a diverse group of constituents including miners, college faculty, university system personnel, legislators, state agencies, industrial representatives, federal officials, the general public, students and others. It is important that the Director have knowledge and experience in research methodology, editing and technical review of maps and reports, the preparation and publication of technical reports, and the uses and requirements of an analytical laboratory.

APPLICATIONS: Applicants must include a letter of application, a resume, and at least three references, and any other supporting information. The anticipated starting date is July 1, 1994. Applications will be accepted until a qualified candidate is selected, however, applications received by April 22, 1994, will receive priority consideration. Send applications or requests for information to: Dr. John Hintz, Chair, Search Committee for the Director of Montana Bureau of Mines and Geology, Montana Tech, 1300 W. Park St., Butte, Montana, 59701-8997. Montana Tech is an Equal Opportunity/Affirmative Action Employer.

DEPARTMENT OF GEOGRAPHY AND GEOLOGY
MOUNT HOLYOKE COLLEGE

The Department of Geography and Geology, Mount Holyoke College, is seeking candidates to fill a one-year sabbatical replacement position in Stratigraphy, Sedimentology, and Paleontology. Applicants should be qualified to teach introductory, intermediate, and advanced courses in sedimentology and historical earth science, a total of three lab courses during the academic year.

Mount Holyoke is part of a Five College Consortium along with Amherst, Hampshire and Smith Colleges, and the University of Massachusetts. Mount Holyoke is committed to fostering multi-cultural diversity in its faculty, staff, and students; is an Affirmative Action/Equal Opportunity Employer; and especially encourages women and minorities to apply. Submit letter of application, curriculum vitae, and three letters of reference by April 15, 1994.

Apply: Dr. Girma Kebbede, Chair, Search Committee, Department of Geography and Geology, Mount Holyoke College, South Hadley, MA 01075. Phone: (413) 538-2278/2204. fax: 413-538-2239.

FACULTY POSITION
SOUTHERN OREGON STATE COLLEGE
GROUNDWATER GEOLOGIST

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

UNIVERSITY OF TEXAS PAN AMERICAN
DEPARTMENTOF PHYSICS AND GEOLOGY
GEOLOGY FACULTY POSITION
ASSISTANT PROFESSOR-TENURE-TRACK

The Department of Physics and Geology, The University of Texas-Pan American, is seeking applicants to fill an assistant professor vacancy beginning August 1994. Applicants must have the minimum of a Ph.D. in geology or geophysics in hand and a strong commitment to excellence in teaching introductory undergraduate lecture courses and laboratory sessions. The possibility of summer teaching exists when sufficient funds are present. Duties will include teaching and developing geology lecture and laboratory courses and conducting field trips in Texas and Mexico.

Special consideration will be given to applicants with a broad knowledge of geophysics who can teach a variety of undergraduate courses and are knowledgeable in Texas Gulf Coast and northern Mexico geology and environmental studies. Minorities and women are strongly encouraged to apply

UT-PA is a liberal arts university with 13,000 students. Its student population is predominantly Hispanic, and it is located in the warmth of extreme South Texas near the Gulf of Mexico and 15 miles from the Texas-Mexico border. Salary will be commensurate with degree and experience. To apply send application, including resume, college transcripts, three letters of reference with telephone numbers, and information on teaching and research interest and background to: Dr. S. E. Giuoco, Chair, Department of Physics and Geology, The University of Texas-Pan American, 1201 W. University Dr., Edinburg, Texas 78539, (210) 381-3521.

Application deadline is April 1, 1994, or until position is filled. FY 93/94-20.

SEDIMENTOLOGY
UNIVERSITY OF NORTH CAROLINA, CHARLOTTE

The Department of Geography and Earth Sciences invites applications for a two-semester leave replacement position in the area of sedimentology beginning August 16, 1994. ABD or Ph.D. at the time of appointment. The successful candidate will be expected to teach four courses: sedimentology, Earth history, stratigraphy, and physical geology. Physical geology and Earth history together fulfill the general education science requirement at UNCC and generate large enrollments. Sedimentology and stratigraphy are integral parts of the geology and geotechnology options within the B.S. in Earth Sciences, with expected enrollments of 10-15 per course. The Department has about 100 Earth Sciences majors.

Applicants should send a statement of teaching and research interests, vita, and names and addresses of three references to Wayne Walcott, Chair, Dept. of Geography & Earth Sciences, University of North Carolina–Charlotte, Charlotte, NC 28223. Application deadline is April 1, 1994, or until the position is filled. UNCC is an affirmative action/equal opportunity employer.

Services & Supplies

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

Opportunities for Students

Research Grants Available. The Colorado Scientific Society invites graduate students to apply for monetary research grants to be awarded by the Society in early May 1994. Applicants must be enrolled in a Masters or Ph.D. program at an accredited private or state college or university. Four to six grants ranging from $500 to $1000 each will be awarded for field-oriented Earth-science thesis projects in Colorado and the Rocky Mountain region. Also, one or more grants from $500-$1000 will be awarded for an engineering geology thesis (with no aerial restriction). Interested students can obtain grant applications from the Chair of their department or by mail from the Chairman of the Memorial Funds Committee, Colorado Scientific Society, P.O. Box 150495, Lakewood, CO 80215. Deadline for applications is April 9, 1994.

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

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

Applications should be submitted to the JOI office according to the following schedule: Leg 159: Site 735, 5/1/94; Leg 160: Equatorial Atlantic Transform, 5/1/94; Leg 161: Mediterranean I, 5/1/94; Leg 162: Mediterranean II, 5/1/94; Leg 163: Atlantic Arctic Gateways II, 5/1/94; Leg 164: Gas Hydrates, 5/1/94; Shorebased Research (regardless of leg), 12/1/94.

These legs will be staffed during the next few months. Students interested in participating as shipboard scientists must apply to the ODP Manager of Science Operations in College Station, Texas. An application form is available in the JOI/USSAC Ocean Drilling Fellowship application packet. For more information and to receive an application packet, contact: JOI/USSAC Ocean Drilling Fellowship Program, Joint Oceanographic Institutions, Inc. 1755 Massachusetts Ave. NW, Suite 800, Washington, DC 20036-2102 (Andrea Leader: (202) 232-3900).

Graduate Assistantships, Texas Christian University. The Geology Department has assistantships available for students working toward an M.S. degree. Areas of department expertise include carbonate and clastic sedimentology, paleovolcanology, structure and tectonics, paleontology, hydrogeology, computer applications in geology, remote sensing, and environmental geology. Field-oriented thesis topics include Paleozoic and Mesozoic volcanic arc rocks in the Sierra Nevada, California, Cambrian rhyolites and Paleozoic carbonates in southern Oklahoma, Devonian carbonates in Scotland, and Mesozoic and Cenozoic geology of Big Bend National Park, West Texas. Financial aid includes a yearly stipend of $7,000, full tuition waiver, and up to $1,500 for research expenses. Contact the Graduate Advisor, Department of Geology, Texas Christian University, Fort Worth, TX 76129 (817) 921-7270.

Traveling Fellowship: Interdisciplinary Research Training Group (RTG). Graduate students are invited to Minnesota for up to 3 months to enhance training in "Paleorecords of Global Change." Stipend (provided for citizens, nationals, or permanent residents of the U.S.), travel and living allowance, and tuition. Application deadline: April 1 (for travel July 1–December 31) and October 1 (for travel January 1–June 30). For application contact Sue Julson, University of Minnesota, Ecology, Evolution and Behavior, 1987 Upper Buford Circle, St. Paul, MN 55108. Phone (612) 624-4238; fax: 612 624-6777. An equal opportunity educator and employer.

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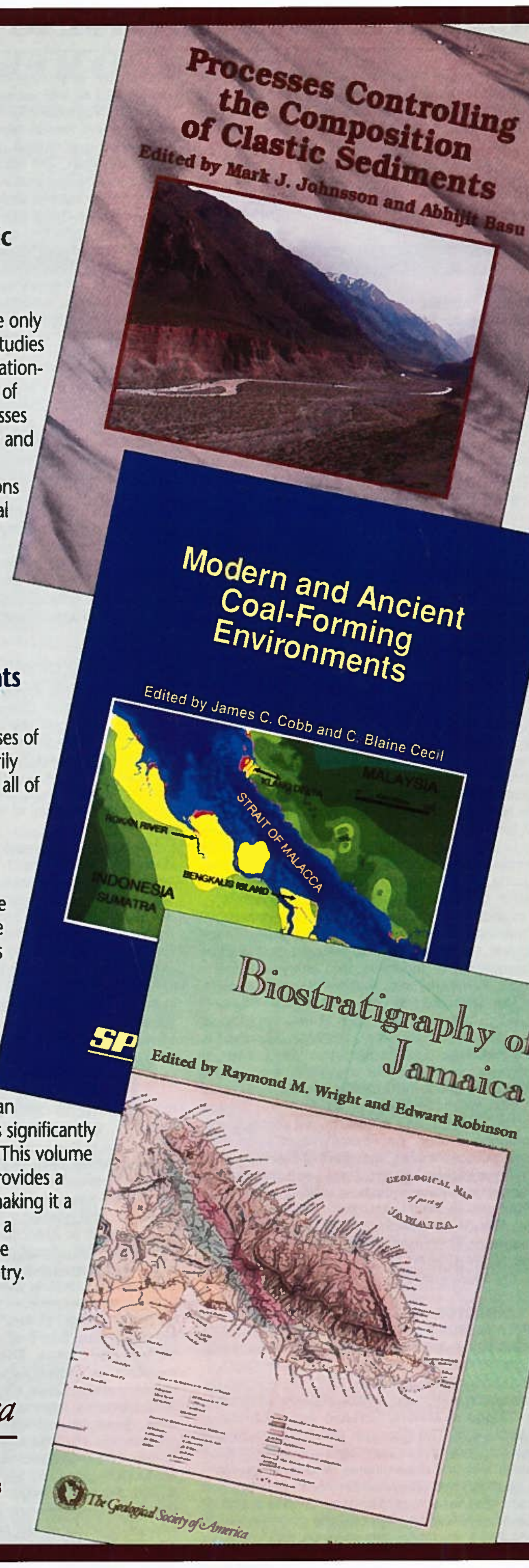

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