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INSIDE

An Ocean of Ice—Advances in the Estimation of Past Sea Ice in the Southern Ocean

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Divergent winter pack ice illustrating areas of open water between floes that have started to refreeze with a thin cover of nilas. Recent ecological studies have shown that sea-ice diatom communities are differentiated by variations in the type of sea ice formed and the changes that occur over the seasonal cycle of sea-ice advance and decay (Gleitz et al., 1998). Photo by Tony Worby, Antarctic Cooperative Research Centre, University of Tasmania.

ABSTRACT

The estimation of past sea-ice cover has been improved recently by advances in diatom ecology, biogeography, and taxonomy and in the satellite imagery of sea ice. Diatoms live in and around sea ice, are sensitive to sea ice, and are widely distributed as microfossils in Southern Ocean sediments; thus, they provide the best tool available for reconstructing sea-ice cover and oceanographic features in Antarctic regions. New approaches use diatoms to reconstruct sea ice through the late Quaternary from core sites in the Southern Ocean. The sea-ice records provide evidence of increased sea ice at the Last Glacial Maximum (21,000 yr ago) and changing sea-ice cover through the past 190 k.y. Results from such sea-ice estimations may be useful to general circulation and energy balance models that require sea-ice parameters to predict future climate change.

INTRODUCTION

One of the most important modulators of Southern Hemisphere climate is the seasonal sea ice that surrounds Antarctica. Sea ice is a key element in understanding climate change because it acts as a thermal and physical barrier, reducing heat and gaseous exchange between the ocean and the atmosphere. The latitudinal extent and seasonal duration of past sea-ice cover provides information on the atmospheric and oceanic systems and also on the past variations of the climate system to changes in climate forcing (e.g., carbon dioxide and stratospheric dust). During the past 27 years, sea ice has been observed and studied in detail by means of satellite sensors that record the radiation emitted from the ocean and sea ice (Gloersen et al., 1992). Sea-ice algorithms and filters provide corrected sea-ice concentrations (the fraction of open water within the sea-ice cover, 0%–15% = open ocean, 100% = total ice cover) that can be sourced as a modern database for reconstruction of paleo–sea ice. Many new approaches are coming to light in the quest for documenting past sea-ice extent and cover, in part a result of improved satellite imaging of sea-ice cover.

Although satellites can now show us the polar sea-ice cover, we cannot use them to look back at past sea-ice variation. The answer to the past is found in the sea-floor sediments that underlie ice-covered ocean through the annual cycle of sea-ice advance and decay. Sediments around Antarctica are dominated by remains of diatoms (siliceous unicellular algae) that form a belt of diatomaceous ooze between approximately 50° and 60°S (Lisitzin, 1972; Burckle, 1984). The major sedimentation flux of diatom remains from the surface waters to the sea floor occurs over summer in open-water conditions, whereas less than 5% of the total annual diatom flux to the sediments occurs during ice-covered periods (Abelmann and Gersonde, 1991). However, the variation of diatom species between sea-ice and open-ocean environments that remain preserved in the sea-floor sediments allows the signature of sea-ice presence to be studied (Fig. 1). Diatoms are ideal for analysis of past sea-surface conditions, as they are restricted in life to the euphotic (sunlit) zone, typically within the upper 100 m. Some diatom species live specifically within or under the sea ice. Advances in understanding the role sea ice plays in diatom ecology now provides an opportunity to use fossil diatoms to make quantitative sea-ice estimates.

DIATOM ECOLOGY AND THE SEA-ICE HABITAT

Enclosed within, on, and under the sea ice are communities of diatoms that are distinctly different from those in the open water. As the ice melts, sea-ice diatoms are released into the water, where some species equally adapted to the melt-water environ-

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ment proliferate, making use of the low-salinity, high-nutrient, and stable surface waters. Other sea-ice diatoms dependent on the sea-ice substrate for their habitat do not survive and are lost to the ocean depths (Leventer, 1998). Although many sea-ice taxa dissolve after death and do not leave a permanent record in the sediments, there are several diatom species within the zone between the maximum winter sea-ice edge and the Antarctic coast (known as the sea-ice zone) that are frequently preserved in the sediments (Burckle, 1984; Pichon et al., 1992; Zielinski, 1993; Zielinski and Gersonde, 1997; Armand, 1997). Two species, *Fragilariopsis curta* and *Fragilariopsis cylindrus,* are often used as sea-ice proxies (Leventer, 1998) because of their occurrence in the ice and as "seeded" from the ice into the open water (e.g., Fryxell, 1989; Kang and Fryxell, 1992; Kang et al., 1993; Leventer and Dunbar, 1996; Cunningham and Leventer, 1998). These two species predominate in sediments underlying the sea-ice zone, which is why they are useful in identifying regions influenced by sea ice (Zielinski and Gersonde, 1997; Armand, 1997).

Although diatom assemblages in particle traps and receding sea-ice blooms show a change from ice-seeded, ice-edge species to open-water species (e.g., Fryxell

Dialogue

Sara Foland, CEO

At the Flatirons near Boulder, Colorado.

Stewardship of Science

> "We have a hunger of the mind which asks for knowledge of all around us, and the more we gain, the more is our desire; the more we see, the more we are capable of seeing."
>
> —*Maria Mitchell*

Last fall we began exploring GSA's commitment to science, stewardship, and service. Science was my topic the past four months, so now let's turn our attention to what GSA does with the tremendous body of work our members generate, and talk about stewardship. First we'll look at our role as stewards of earth science information, and in the coming months, we'll consider ways in which geoscientists are stewards of Earth itself.

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Some of our publications become part of the collections of other organizations. The most recent example is Special Paper 338, *Classic Cordilleran Concepts: A View from California,* edited by Eldridge Moores, Doris Sloan, and Dorothy Stout. In December 1999, a ceremony in Sacramento, California, marked the entry of this volume into the California State Library. According to Charlene Wear Simmons, assistant director of the library's California Research Bureau, "This GSA publication presents classic geologic concepts about California and the present status of knowledge about them. It's a potentially useful reference source for California policymakers, in a state where geology can be destiny, and is an important historical document."

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Our long-term vision for GSA publications includes completely digital submission, proofing, and editing systems. We also plan to develop enhanced reference and database linking in partnership with other organizations. Combined with more extensive search and retrieval capabilities and faster delivery, these changes offer enormous potential to revolutionize the way research is conducted.

When we talk about GSA's stewardship of geoscience information, the word "stewardship" has a somewhat old-fashioned ring to it. It is anything but.

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GSA expects to publish 12 special papers in 2000, including *Large Meteorite Impacts and Planetary Evolution II* (Special Paper 339).

Later this year, watch for the *Fourth Hutton Symposium on the Origin of Granites and Related Rocks* and Treatise on Invertebrate Paleontology, Part H (Revised), Vol. 2 and 3, *Brachiopoda.*

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and Kendrick, 1988; Fryxell, 1989; Abelmann and Gersonde, 1991; Garrison and Buck, 1991; Leventer, 1991; Garrison and Close, 1993), there is still considerable ecological work needed to sufficiently delineate tight ecological realms for the many diatom species occurring within the sea-ice environment. Only a few preliminary studies separate diatoms specific to sea-ice types (e.g., congelation or frazil sea-ice), thicknesses, and evolving nutrient conditions (e.g., Scott et al., 1994; Gleitz et al., 1998). Such studies, when used in conjunction with observations of diatoms that are associated expressly with open-ocean conditions, underpin the future ability to define the sea-ice edge and variations in cover from the sedimentary record.

In essence, the preserved diatom assemblage is used to interpret the development of overlying open-water conditions through the abundance and variation in diatom species observed, and their increased flux to the sea floor as a function of increased productivity during open-water conditions (Fig. 1). This simple interpretation neglects other important factors that may modulate diatom assemblages at the surface waters, such as water-column stability, nutrient supply, light availability, dissolution, advection, and grazing. However, many of these additional factors are also related to sea-ice presence. Comparison of sea-ice concentration (the amount of sea ice versus open ocean in a defined area) and annual duration with preserved diatom assemblages in the sediments reveals relationships between sea ice and species biogeography (Armand, 1997; Crosta et al., 1998a). It is the total assemblage and the relationships observed with the sea-ice cover and duration that make diatoms the most useful proxy available for estimating past sea ice. The limit to this relationship and the historical sea-ice record that is possible depend on the fundamental assumption that the relationship of diatom species to

Ocean of Ice *continued on p. 4*

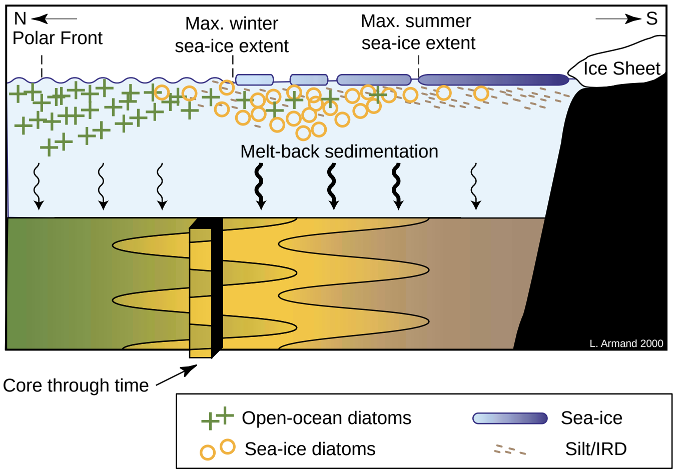

Figure 1. Relationships between sea-ice and open-ocean diatoms in surface waters, sediments, and sea-ice cover. Open-ocean diatoms are dominant north of maximum winter sea-ice edge. Sea-ice diatoms live within, on, and under sea ice and bloom (dependent on nutrient and other oceanic conditions) when sea ice melts back to its summer limit. Open-ocean diatoms produced when open-ocean conditions are established in the zone between maximum winter and summer sea-ice edges are preserved in sediments, along with sea-ice-related diatoms. This sedimentary signal provides basic reconstruction of Antarctic sea-ice cover. The assumption of this method is that the greater the proportion of open-ocean diatoms to sea-ice diatoms, the longer the duration of open-water conditions between winter and summer sea-ice cover. By studying these open-ocean and sea-ice diatoms in sedimentary cores, past natural variability of sea-ice cover can be estimated. Extended sea-ice cover with no summer melt-back results in reduced sea-ice diatom abundance and increased silt to the sediments. Polar Front is an oceanographical boundary separating Antarctic waters from Subantarctic waters and is usually defined by 2 °C subsurface temperature minimum of Antarctic surface waters. Sediments below Polar Front show elevated levels of diatom preservation around Southern Ocean (Burckle et al., 1982; Burckle and Mortlock, 1998).

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sea ice has not changed over time. A sea-ice record covering the past 200 k.y. is currently possible, but with additional assumptions related to the introduction of extinct species with unknown sea-ice relationships, estimation could go back more generally through the Neogene.

SIGNIFICANCE FOR FUTURE CLIMATE CHANGE

Sea ice, as the reflective interface and thermal and physical barrier between the ocean and the atmosphere, strongly influences climate-governing energy fluxes across this boundary. Thus, sea-ice extent is a key factor that must be considered in coupled oceanic-atmospheric models that are beginning to be applied to past climates (Ganopolski et al., 1998; Kim et al., 1998; Weaver et al., 1998). Without some estimates of the past natural variability of sea ice, modelers are forced to estimate future world climates using unrealistic conditions (e.g., prescribed fixed concentrations of 100%, 50%, or 0% sea-ice cover). Alternatively, they can rely on the CLIMAP reconstructions (e.g., Ramstein and Joussame, 1995), which, although still useful for glacial winter extent alone, are constantly being improved by approaches such as those presented below.

By reconstructing the natural variability of sea-ice cover over a range of geologic time scales, the chances of arriving at better models of our environment are enhanced. There are already general circulation models capable of simulating ocean-atmosphere surface flux conditions when modern sea-ice concentrations are provided to the model (Budd et al., 1997). Such work reveals the usefulness of past sea-ice estimation in the development of Southern Hemisphere climate dynamics.

LATE QUATERNARY SEA-ICE ESTIMATIONS

A focus of past climate and sea-ice estimation has been directed at Earth's most recent glacial period, the Last Glacial Maximum (LGM, ~21,000 yr B.P.). A recent coupled model by Weaver et al. (1998) provided data of modeled winter and summer sea-ice extent around Antarctica for the LGM. Their estimated expansion of sea ice through the LGM in winter exceeds current satellite-observed sea-ice extents, but only barely so in the summer season. Such mathematical models are not bounded by micropaleontological evidence of sea-ice conditions during this LGM period and do not compare as favorably against that evidence (Fig. 2).

Attempts to pinpoint the extent of Southern Ocean sea ice during the LGM have been made from changes in ice-rafted debris, foraminiferal and radiolarian faunal changes, and lithological boundaries between diatomaceous ooze and terrigenous silt (CLIMAP, 1981; Cooke and Hays, 1982). The CLIMAP compilation (CLIMAP, 1976, 1981) provided a large-scale circum-polar reconstruction of past sea ice, constructed by delineating the halfway point between the faunally identified Polar Front (Fig. 1) and the summer ice boundary (defined from changes in clay and diatomaceous sediments) (Fig. 3). Through the advance of diatom assemblage analysis in sediments of the Southern Ocean and satellite imagery of sea ice, the methods of past sea-ice reconstruction can be improved from these earlier sedimentological interpretations.

Two new approaches have tackled the LGM extent of sea ice around Antarctica. The first of these methods estimates sea-ice extent by finding similar diatom assemblages (or analogs) for past samples

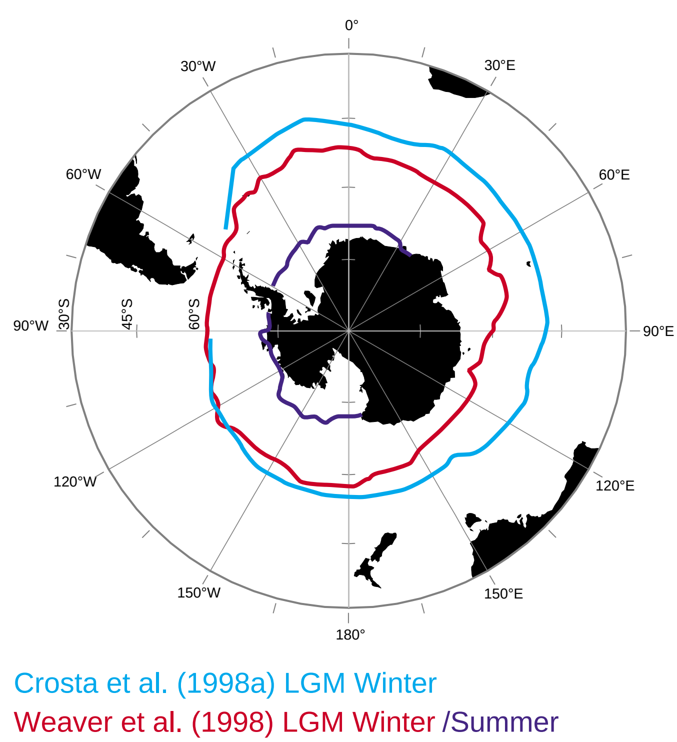

Figure 2. Comparison of modeled and micropaleontological reconstructions of LGM sea-ice extents. Coupled general circulation model (Weaver et al., 1998; purple line) consistently underestimates winter LGM sea ice compared to geological-paleontological reconstructions (e.g., Crosta et al., 1998a; blue line). Coupled models also indicate that summer LGM sea-ice extent (red line) was similar to today's summer extent. Modeled reconstructions including that of Weaver et al. (1998) also have problems simulating modern sea-ice extents, especially in Southern Hemisphere, as pointed out by Kim et al. (1998). Use of paleontological sea-ice reconstructions will provide modelers with boundary conditions to refine simulations of past and future sea-ice conditions.

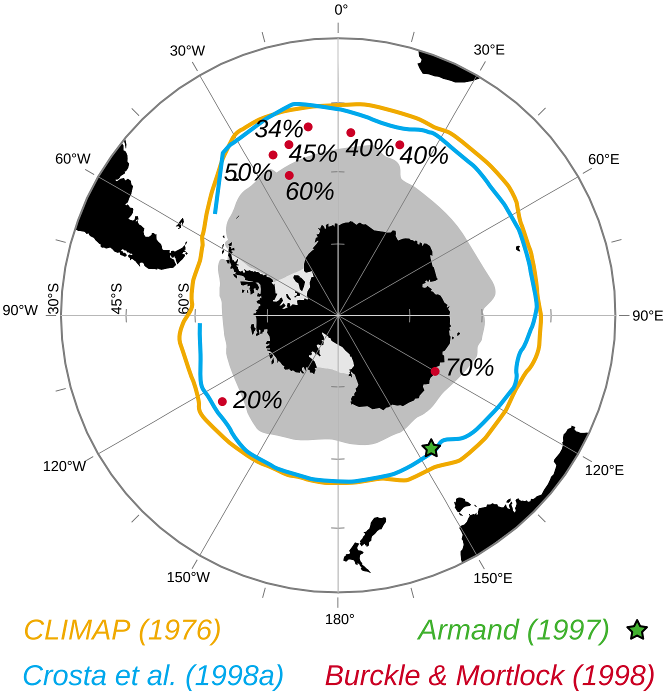

Figure 3. Positions of estimated LGM sea-ice extents of CLIMAP (orange line; CLIMAP, 1976) and Crosta et al. (1998a; blue line), and spot estimates of sea-ice concentration from Burckle and Mortlock (1998; red spots). Crosta et al. (1998a) winter sea-ice-extent reconstruction is similar to the CLIMAP reconstruction owing in part to a similar LGM data set employed. Diatom-based LGM reconstruction of Crosta et al. (1998a) reaffirms sedimentological and faunal based CLIMAP reconstruction. Averaged sea-ice concentration estimates of Burckle and Mortlock (1998) appear comparable to extent of sea ice estimated by Crosta et al. (1998a) and to modern sea-ice concentrations that increase from 15% at the sea-ice edge through unconsolidated (15%–40%) and consolidated (>40%) sea ice within the pack ice today (Schweitzer, 1995). Green star indicates core site of Armand (1997) in southeast Indian Ocean. See Figure 4 for continuous sea-ice concentration data from this core.

throughout a Southern Ocean data set and uses an averaged estimate of the environmental conditions of those sites to estimate paleo-conditions (in this case, sea ice) (Crosta et al., 1998a, 1998b). The Crosta et al. (1998a) estimated maximum LGM winter sea-ice edge lies well to the north of the modern sea-ice limit (northern boundary of the shaded region in Fig. 3), doubling the modern sea-ice surface area coverage of 19 x 10^6 km^2 (Gloersen et al., 1992).

The second approach has been directed at the distribution of opal in sediments of the Southern Ocean (Burckle and Mortlock, 1998). Here, the inference underpinning the work is that the maximum winter sea-ice edge is a limiting boundary to surface water productivity of the diatoms and the abundance of biogenic opal contained in the sediments. Near the seasonal sea-ice edge, less biogenic opal will be preserved in the sediments, whereas in the open ocean near the Antarctic Polar Front, more opal will be preserved in the sediments. A comprehensive database of biogenic opal in surface sediments around Antarctica provides the data from which LGM biogenic opal data can be compared to current sea-ice concentrations. Eight LGM sites around Antarctica revealed increases in sea-ice concentration (i.e., decreases in opal) compared with the present-day sea-ice distribution, but the eight sites do not allow a reconstruction of the maximum sea-ice extent during the LGM. The sea-ice concentration results do compare favorably to the estimated sea-ice edge of Crosta et al. (1998b) and the understanding of sea-ice concentration distributions in the Antarctic winter ice field (Fig. 3). Although both large-scale LGM reconstructions show increased winter sea-ice conditions and an extension of the sea-ice edge as suggested by the lithological study of CLIMAP (1976; Fig. 3), they do not provide detail that will allow us to understand the natural variation of sea-ice cover through time. It is here that sedimentary cores from around Antarctica can demonstrate this variability.

The first attempt to construct a continuous record of past sea-ice concentration has been made from two cores in the southeast Indian Ocean along the 145°E meridian at 54° and 56°S (Armand, 1997). This approach is similar to that used by Crosta et al. (1998a, 1998b), where the Southern Ocean diatom data set has been matched to satellite observations of sea-ice concentrations which are used to construct statistical equations. Armand (1997) constructed equations for the estimation of minimum February sea-ice concentration, maximum September sea-ice concentration, and the number of months per year in sea-ice cover. Results from the 54°S core indicated no sea-ice cover through the past 60 k.y. In contrast, during periods of glacial conditions over the past 190 k.y., unconsolidated (20%–40% concentration) and consolidated (>40%) sea-ice cover occurred over 56°S during winter (September) (Fig. 4). In agreement with Crosta et al. (1998a, 1998b), a reduction of sea-ice cover during peak summer (February) is supported by the estimated open-ocean conditions over the site. The results did not indicate summer sea ice at 52°S as in the CLIMAP reconstruction (CLIMAP, 1981). Estimates of sea-ice cover in months per year are generally consistent with the seasonal variation shown by the winter and summer concentration estimates. Through additional comparisons with sea-surface temperature estimates and the presence of other sea-ice indicator species (i.e., *C. davisiana* abundances; Armand, 1997), I considered that my estimates reflected past sea-ice conditions in the Southern Ocean.

When we compare the detailed core data at the LGM with the large-scale esti-

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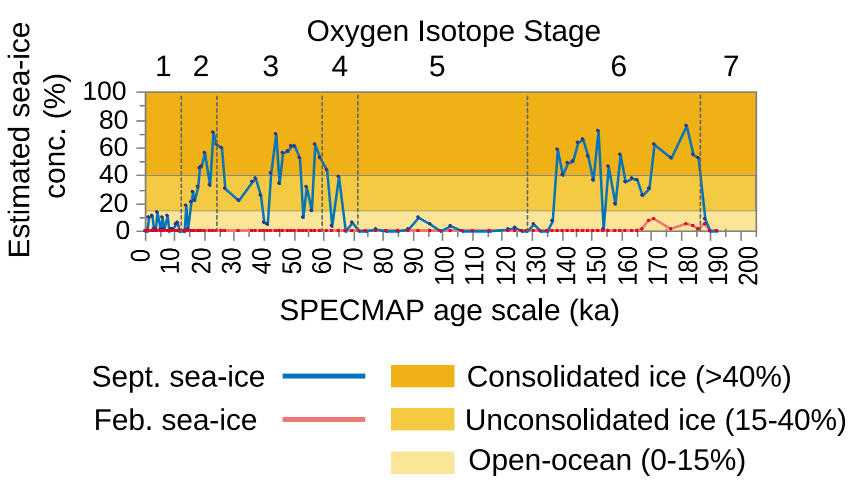

Figure 4. Sea-ice estimation results from core MD88-787 (56°S, 145°E; see Fig. 3). Estimates of September (blue line) and February (red line) sea-ice concentrations are plotted over time. During glacial intervals (marine oxygen isotope stages 2, 3/4, and 6), there are indications of unconsolidated (15%–40% concentration) and consolidated (>40%) sea-ice cover in September (Austral winter). In contrast, there was no sea ice (0%–15% considered open ocean) during LGM summer (February). Results from Armand (1997) suggest that during LGM winter (~21 ka) this site was covered by consolidated sea ice (70% ± 20%) for up to 8 months of the year.

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mates of sea-ice extent (compare Figs. 3 and 4), it is evident that although all estimates agree with sea ice out to 56°S in the southeast Indian Ocean, there is a difference in the amount of sea ice estimated. My results suggest 8 m/yr sea-ice cover and 70% concentration in September; in other words, consolidated sea-ice cover rather than ice-edge conditions as implied by the CLIMAP and Crosta et al. (1998a) reconstructions. It would appear that bias from the geographical distribution of samples in the diatom data set and corresponding sea-ice attributes for these sample sites used by me elevates my sea-ice estimates. The important point to consider is whether the disconnection between the large-scale studies and those of the more detailed down-core work will continue to be seen in future down-core estimations. The other main finding gaining support from the new approaches and that of the modeling community (e.g., Weaver et al., 1998) is the idea that large-scale melt-back of winter sea ice to near the modern summer sea-ice extent occurred during the LGM. Such large-scale melt-back has significant implications about the heat balance of the ocean, the atmospheric system, and the oceanographic circulation during glacial periods. The search continues for additional evidence of the LGM summer sea-ice extent from cores closer to the Antarctic coast; however, this task is a difficult one because of the expansion of the continental ice shelf around Antarctica and the ensuing disturbance of sediments along the Antarctic shelf. Finally, comparison between the fossil and modeled LGM sea-ice extents (Fig. 2) highlights the current discrepancies between the estimation efforts and the role that independent sea-ice data from diatom reconstructions can provide toward modeling of past climatic conditions.

CONCLUSIONS

The development of sea-ice concentration histories is a challenge, given the physical and biological information we have at hand, especially when trying to estimate past conditions for which we may not have applicable analogs in the Antarctic (e.g., multi-year ice, differing polynya systems). However, exciting new studies are now deciphering the composition and succession of sea-ice diatom assemblages in various sea-ice types (Scott et al., 1994; Gleitz et al., 1998). This information will become more crucial to the development of sea-ice histories (particularly those that work with sea-ice concentrations) from the sedimentological record in the future.

Since the CLIMAP years, we have learned that the remains of diatoms in the sediments of the sea floor are the keys to recovering the history of sea-ice cover around Antarctica; this includes the understanding of differences between the sea-ice and open-ocean diatom community structure in the Southern Ocean. Diatom remains allow us to estimate a crucial climate parameter. Our results have great capacity to further our understanding and interpretation of the historical sea-ice records and further our knowledge of our present climate dynamics. Because they provide natural variability boundaries, these same results have great appeal to potential users such as modelers. The current approaches discussed here focus on two components of the diatom sedimentary record (species and abundances versus opal content). Whether it will ultimately be easier to extricate a sea-ice history from the diatom species and their abundances or from their percentage contribution to the sediments is yet to be determined. There are still many gaps to fill in piecing together sea-ice histories from the diatom record. We still need to know more about specific diatom tolerances and niches in the ice community, the succession of diatom species against the annual cycle of sea-ice growth and decay, and the transport to and preservation within the sea floor of sea-ice diatoms. Some scientists are critical of the amount of information truly portrayed by sea-ice diatoms in the sedimentary record. They suggest that only defining a maximum sea-ice edge is possible. The future of sea-ice estimation depends on careful micropaleontological research and a better understanding of the environment, biology, and oceanographical processes that diversify the prolific micro-siliceous algae—otherwise known as diatoms.

ACKNOWLEDGMENTS

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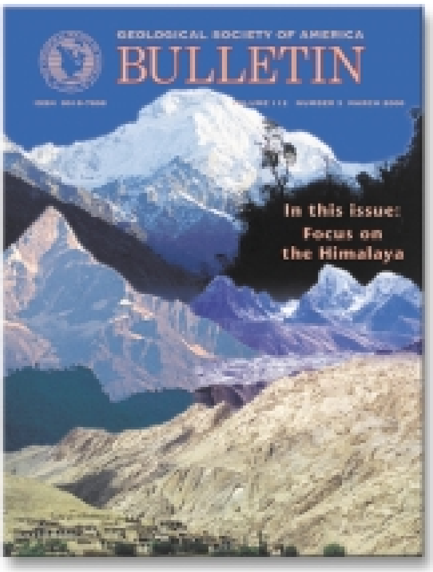
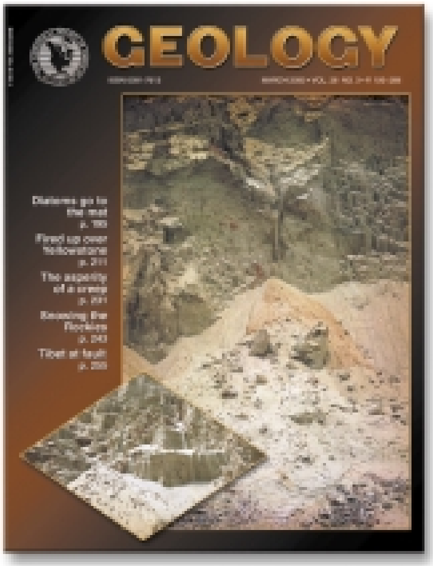
Because *Bulletin* and *Geology* are now online as well as in print, their contents listings will no longer appear in *GSA Today*, but here are March *Bulletin* and *Geology* highlights:

In March *Bulletin*—



Special Focus Issue: The Himalaya

In March *Geology*—



- **Diatoms go to the mat**
- **Fired up over Yellowstone**
- **The asperity of a creep**
- **Snowing the Rockies**
- **Tibet at fault**

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Engaging "My Neighbor" in the Issue of Sustainability Part III: Doubling Time: It Works for ANY Rate of Change

A. R. Palmer, *Boulder, Colorado*

A parable: "When was the pond half full?" I lived by a large pond with a thriving community of fish, so fishing was good. One day some algae began to grow in the pond. Their population was doubling every minute. Yesterday morning I went fishing and everything was fine. Yesterday noon when I looked out at the pond, it was suddenly filled with green algal scum, and the fish were suffocated from lack of oxygen. Why didn't I see the disaster coming and do something? When was the pond half full? One-quarter full? One-eighth full? Suppose, instead of my pond, we were considering an island, or a continent, or Spaceship Earth?

At the heart of the concept of doubling (or halving) is the exponential function familiar to many from mathematics, science, and engineering. Geologists are perhaps most familiar with this in its backward-running version—i.e., the description of the rates of decay of radioactive isotopes. Most of us, however, learned about exponential growth as compound interest in the context of a personal savings account. If we put our money in a bank and let the interest accumulate, our annual income grows as the capital increases, even though the interest rate remains constant—our capital grows at an exponential rate. Recognition of doubling (or halving) time for ANY rate of change was not always emphasized.

Because we are discussing a "doubling" time, i.e. the time for a quantity in question to double (or halve), the exponential function has a user-friendly aspect that is very helpful. It turns out that any finite rate of change expressed as a percent (e.g., 5% per year) can be converted, to a good approximation, to a doubling time simply by dividing it into 70. For example, if the rate is 2%, the doubling time is 70/2 = 35 years. The proof of this statement makes a good exercise for a math class at the appropriate grade level. Rates of loss (for instance, depletion of resources) have a halving time that is calculated the same way. For anything diminishing at 2% per year there will only be half as much in 35 years.

This simple way to calculate doubling time (or halving time) should be an essential part of everyone's education. When the mayor is proud because the city has a healthy growth rate of 3% per year, that means the city will double in about 23 years if that rate continues, and double again in another 23 years, and double yet again in another 23 years, thus octupling from its original size in 69 years. One might ask if a city with eight times the present population is viable. Garbage also has a rate of growth, as do traffic, pollution, schools, and housing.

A city is not a closed container; thus, its limits to growth will be determined by cultural factors, but Earth IS a closed container for all practical purposes (more on this in the July essay in this series). Growth in a closed container will ultimately fill it up. Thus, we should look carefully at anything in our culture with a growth rate, calculate its doubling, quadrupling, and octupling time and make a judgment about whether we think this is healthy for our future. We should do similar calculations and make similar judgments about those aspects of our culture where, as a result of our consumption habits, a resource is diminishing at a measurable rate. Thus, calculations of doubling (or halving) time are critical components of the issue of sustainability—by which we mean the indefinite continuation of the entire human enterprise within some steady-state limits imposed by space and resource availability (the October essay).

Global population growth rates may be diminishing, but they are still positive. Thus, population is still growing, and it has a doubling time. Currently the rate is about 1% per year (thus doubling in 70 years). Consumption of resources (the April essay) increases with population size, even if individual rates of consumption do not increase.

If we could slow the present population growth rate to 0.1% per year, it would still be double its present size of about six billion in 700 years, quadruple in 1,400 years, and octuple in 2,100 years—equivalent to only the time represented by the Christian era. Forty-eight billion people may make things a bit crowded. Such a population, with its attendant FOOTPRINTS (the areas of productive land necessary to support each one of us, see the June essay), may not be sustainable. It is not even clear that we can handle one more doubling with a reasonable quality of life for all.

Such doubling-time scenarios should make us wonder if there is such a thing as the politically popular "smart growth"; perhaps that's a euphemism for "predictable and voluntary disaster." Every time you see a headline or magazine article mentioning rates of change (either increase or decrease), do the quick mental math to calculate the doubling (or halving) time. It is a very revealing exercise.

Next month: Sustainability and Resources. ■

Congressional Science Fellow Report

Geologist on a Soapbox

Melody Brown Burkins, *1999–2000 GSA Congressional Science Fellow*

My interest in the role of the geosciences in public policy decision-making began early in graduate school at Dartmouth College and grew with every instance in which I noticed how easily my studies dovetailed with a politically charged issue. As I studied hydrogeology and ore exploration, I found that issues of natural resource availability, water quality, and land use jumped at me from the pages of popular magazines. When I moved to studies of Antarctic soils, I found myself poring over articles citing Antarctic biota declines as harbingers of climate change and papers about Antarctic tourism impinging on sensitive lands.

The dynamics, trends, and sustainability of human interactions with natural earth processes are more and more the topic of popular public debate. Global climate change, air and water quality, the extraction of resources on public lands, the teaching of evolution—these are only a few of the politically charged issues facing lawmakers today. As geoscientists, we are in a unique position to inform these debates with a wealth of earth systems knowledge. And, I would argue, we have a responsibility to do so.

Yet communicating scientific evidence or ideas to policy-makers most effectively, especially to lawmakers on "the Hill," is not straightforward for scientists. Lawmaking and science are not quite oil and water, but the two cultures do not blend easily. Policy-making is about rapid, timely decisions made in the face of constantly inadequate information. Science is about tentative conclusions made only after thorough examination of well-researched data. Policy-makers shun uncertainty. Scientists embrace it as their life's work. Obstacles to communication are simply inherent to the difference in thinking by both cultures. I have now seen many legislators learning to value, and understand, the world of science. Scientists should be encouraged to do the same.

The need for better science and policy communication is why the American Association for the Advancement of Science (AAAS) created the Congressional Science and Technology Fellows program more than 25 years ago. Representing scientific fields from food safety to civil engineering, 31 of us now roam the halls of Congress. As this year's GSA-USGS Fellow, I have the privilege of working in the office of Senator Patrick Leahy (Democrat—Vermont), a legislator I have long admired for his educated and reasoned positions on energy and environment issues. I also have the privilege of seeing how important the flow of good, sound science into policy-making can be—there are few lawmakers on the Hill who do not crave good scientific information to help them make decisions.

EFFECTIVE COMMUNICATION BETWEEN SCIENTISTS AND LAWMAKERS

One of the best books I have seen summarizing what I have begun to learn in the past three months in Washington is William G. Wells's *Working with Congress: A Practical Guide for Scientists and Engineers* (AAAS, 1996, second edition). In his book, Wells emphasizes that Cardinal Rule Number One for effective communication with legislators is to "convey that you understand something about Congress."

This advice comes before all other rules, even those detailing how to best present scientific facts, for good reason. You would not think much of a job candidate who, no matter his qualifications, arrived for an interview and did not show even the most basic understanding of the staff assignments, schedule demands, and general goals of your particular program. It would show a lack of respect for you, your time, and your profession. Just like academia or industry, Congress is a culture with special relationships, priorities, and procedures that should be learned, and respected, by those who want meaningful, constructive communication.

What should you know about Congress? Lawmakers do not expect scientists to know the details, but do expect some understanding of their culture. Hundreds of books and essays have been written about this, but two essential tenets of congressional culture bear repeating: (1) relationships count, and (2) there is never enough time.

There is a reason that hundreds, perhaps thousands, of interest groups have offices in or near Washington, D.C. Forging a strong relationship with legislators and their staffs means engendering trust and recognition through repeated, positive interactions. As reported in Wells's book, the late Congressman George E. Brown of California always remembered a veterinarian from his state who took time to visit him. Wells quotes Representative Brown as saying, "Now there are not many bills that come through Congress that involve a veterinary issue. But when such an issue or question does come up ... I remember him."

The most effective communication with Congress also respects the extraordinary time constraints all legislators and staff live with each day. Their time is in demand by hundreds of issues at once, from international crises to a constituent's dispute with town hall. I am still in awe of the organization and dedication this takes of congressional staff—eleven-hour work days are expected and, when Congress is in session, 15 and 20 hour days are not uncommon.

The best information is transferred to Congress clearly and concisely, with scientific evidence separated from personal opinion, and a recognition of legislators' need to be sensitive to issues beyond scientific evidence. I personally have a newfound respect for a half-page, bullet-list fact sheet that deftly summarizes all scientific, social, political, and economic implications (pro and con) of an issue. These may seem impossible in my former world of academia, but in a time-stressed culture where information leads to public law, they are true art as well as extremely valuable currency.

ROLE OF SCIENCE IN PUBLIC POLICY

Effective communication also means understanding the role of science in public policy debates. Scientific evidence, no matter how broadly accepted in the scientific community, is still only one small piece of a complex and multidimensional decision-making puzzle. Legislators must deal with constituent needs, commerce needs, national and international needs, economic implications, and social trends.

Scientists are welcome to present their facts to Congress without framing them in terms of these other issues; this is safer and keeps scientists from appearing partisan. However, scientists should bear in mind that someone in Congress, and probably not a scientist, will still have to frame the issue—and perhaps not in the way the scientist intended—in order to judge its value in the lawmaking process. In scientific journals and professional articles, experiment and data define the context of the argument. In public policy, scientific evidence is a side issue, with varying degrees of importance, within the larger framework of a legislative agenda.

I first learned this lesson, strangely enough, about 16,000 miles from Washington, D.C. It was January of 1998 when my field team and I learned that six United States senators would be visiting Antarctica on a fact-finding mission about polar research. We knew to present our science in general terms, with no jargon, and to make two or three points clearly and concisely. Yet, after we had met the senators and given well-rehearsed presentations on the science of frozen soils, Antarctic biota, and glacial dynamics, the senators wasted little time getting to their point. How did we justify our science budget? How did the science provide tangible and otherwise economic benefits?

It was only with the gentle urging of adept National Science Foundation administrators who hosted the visit that we Antarctic scientists began to get it. Our grants, we explained to the senators, were attained only after rigorous competition among peers—a checks-and-balances system understood and respected by federal legislators. Economic and social benefits ranged from a better understanding of climate change trends (potentially helping end uncertainties in regulatory proposals) to valuable science education programs that had stemmed from the research.

We later heard that the senators had given glowing reviews of the visit and we heaved a collective sigh of relief: One visitor had been Senator Ted Stevens of Alaska, Chairman of the Senate Appropriations Committee (ultimate funder of all government programs) and a potential critic of the amount of money moving to southern, rather than northern, polar regions. Phew.

BUT, REALLY, WHY SHOULD I GET INVOLVED?

Finally, I think it is important to reiterate why geoscientists should concern themselves with the multitude of social, political, and legislative processes that create public policy. It takes time and may do little to advance a professional career. So why should we care?

The primary reason: It is our responsibility as educated citizens. Few geoscientists can say that they have been educated, trained, or employed in this country without some level of public funding, be it via school tax dollars or federal research grants. Put bluntly, I believe we owe something to all of those who have allowed us to pursue our love of science, including public taxpayers. We tabulate grant expenditures for government agencies. We write numerous journal articles for professional colleagues. We may even teach students and graduate students. Yet all of this activity only indirectly educates our communities and government, if at all.

Active citizenship does not have to have a political agenda: Two of the most valuable contributions geoscientists can make to public policy debates are utterly nonpartisan. First, geoscientists can contribute their unparalleled knowledge of fundamental earth processes. Geoscientists, and geoscience organizations, must make themselves visible, accessible, and valuable to legislators whenever earth science–based issues are publicly debated. Second, geoscientists can contribute their voices, strongly urging our representatives to support geoscience-related research and education programs. Even in these years of putative budget surplus, the annual competition for appropriations dollars is intense. Why should Congress, through its funding for the National Science Foundation, support research and education programs in the geosciences? Geoscientists should always be prepared with a ready answer (half-page, bullet-list ...).

This leads to a final statement on "why get involved?" If trained geoscientists do not take the responsibility to educate their communities and Congress about Earth system dynamics and the importance of the geosciences, who will? A lack of geoscience voices in our government may or may not bother your sense of scientific responsibility. But if you do believe that your years of education, training, and expertise may better inform public debates or lead to clearer, more critical thought in earth and environment-related decision-making, then step up, take responsibility, and be heard.

SOURCES OF GEOLOGY AND PUBLIC POLICY INFORMATION

The Geological Society of America's new Public Interest Web page (see below) is an excellent starting point for learning more about earth science issues in public policy. The page, which is frequently updated, has links leading to hundreds of science and policy sites, including several within GSA. Two links of special note are those of the American Geological Institute (AGI) and the American Geophysical Union (AGU), groups with which GSA works closely on public policy issues. These sites, and other science and policy sites, are listed below.

A final note: If I have learned one truest thing in three months on the Hill, it is that Congress listens to its constituents. Letters and phone calls from home state residents are taken extremely seriously by representatives and are responded to, and compiled, by staff as a priority. Clips from hometown newspapers are read throughout the day and continually discussed. Time taken to contact your representative, to get involved in local science issues, or to educate your community about basic geoscience, is never time wasted. Spread the word.

Geoscience and Public Policy Links

- Geological Society of America's Public Interest pages
  www.geosociety.org/science/index.htm
- American Geological Institute Government Affairs Program (GAP)
  www.agiweb.org/gaphome.html
- American Geophyscial Union Government Affairs
  www.agu.org/sci_soc/policy/sci_pol.html
- Congressional Science Fellow Homepage
  www.geosociety.org/science/csf/burkins.htm

Other Valuable Science and Policy Links

- American Association for the Advancement of Science policy pages
  www.aaas.org/spp/
- American Institute of Physics (AIP) Legislative Updates
  www.aip.org/gov/

For Proposed Legislation and More

- Library of Congress: Thomas's Legislative Information on the Internet
  www.thomas.gov
- AGI: Communicating with Congress
  www.agiweb.org/roster/howto.html

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Students—Don't Miss These Section Meeting Workshops

If you are interested in pursuing a career in applied geoscience, you will find these Section workshops valuable, informative, fun, and filling (free food). Each of the workshops, made possible by the Roy J. Shlemon Mentor Program in Applied Geology, springs from a GeoMentor Program established at GSA in 1996. They are designed to extend the mentoring reach of individual professionals from applied geology to advanced undergraduates and graduate students attending Section meetings. Mentors talk with the student membership about the opportunities and realities of employment outside academia or government.

Check on the Section meeting closest to you (and note the low- or no-cost registration fee for the workshops). Registration forms available at www.geosociety.org/meetings.

Northeastern Section Meeting; March 12, 1:00–5:00 p.m., Wright-Reiman Labs, Rutgers University, New Brunswick, New Jersey. Three practicing geoscientists with different educational backgrounds and career emphases will engage students in thought-provoking dialogue. Kathleen Browne, browne@rider.edu. Limit: 40; cost: $10. *Preregistration required.*

South-Central Section Meeting; April 3; 12 noon–4:00 p.m., Room 409 Center for Continuing Education, Fayetteville, Arkansas. Energy Resources: Opportunities for Geologists. Interactive panel discussion workshop encouraging dialogue with participants. Led by a team of four geoscientists practicing in domestic and international petroleum exploration from Southwestern Energy Company (SWN), this program includes scheduled one-on-one counseling time for those students looking for "personalized" answers to their questions. Lunch is provided. Dianne Phillips, cdp01@comp.uark.edu. Limit: 30; no cost. *Preregistration required.*

North-Central Section Meeting; April 6, 12 noon–5:00 p.m.; Government Center, Indianapolis, Indiana. Half-day workshop, led by Mentor Steve Sittler of Advanced Pollution Technologists, Limited, from Mishawaka, Indiana, encourages students to participate in interactive dialogue, one-on-one counseling sessions, and a round-table discussion of job skills versus educational goals. Lunch is provided at no cost to students. Gabe Filippelli, gfilippe@iupui.edu. Limit: 30; no cost. *Preregistration required.*

Rocky Mountain Section Meeting; April 17–18, 12 noon–1:30 p.m.; Missoula, Montana. Two different programs—one each day. Plan to attend both luncheon meetings. These interactive workshops will deal with "real life" issues about professional opportunities and challenges beyond graduation. Limit: 30; cost: $10. Lunch provided. Christine Brick, brick@selway.umt.edu. *Preregistration required.*

Cordilleran Section Meeting; April 28, 8:30 a.m.–5:00 p.m.; Vancouver, British Columbia. This one-day workshop and field excursion will address practical aspects of engineering and environmental geology. Lunch is provided. Students wishing to attend should e-mail a short letter of interest by March 15 to Jeff Fillipone, jfillipone@golder.com. Limit: 30; cost: $10. *Preregistration required.* ■

CALL FOR NOMINATIONS

To reward and encourage **teaching excellence** in beginning professors of earth science at the college level, the Geological Society of America announces:

THE NINTH ANNUAL
Biggs Award

For Excellence In Earth Science Teaching For Beginning Professors

ELIGIBILITY: All earth science instructors and faculty at 2- and 4-year colleges who have been teaching full time for 10 years or less. (Part-time teaching is not counted in the 10 years.)

AWARD AMOUNT: An award of $750 is made possible as a result of support from the Donald and Carolyn Biggs Fund. The GSA Geoscience Education Division provides up to $500 in travel funds to attend the award presentation at the GSA annual meeting.

NOMINATION PROCEDURE: For nomination forms contact Leah Carter, Science, Education, & Outreach, Geological Society of America, P.O. Box 9140, Boulder, CO 80301-9140, lcarter@geosociety.org, or visit our Web site at www.geosociety.org.

DEADLINE: Nominations and support materials for the 2000 Biggs Earth Science Teaching Award must be received by May 1, 2000.

GSA ON THE WEB

Check out our new look at www.geosociety.org.

From our home page you can link to many information resources.

Let us know what you think. We always appreciate your feedback on content and navigation, as well as graphics.

Critical issues will be in the new Public Interest section. Look for a link under "What's Hot" to see the latest on science and creationism.

Nomination forms for GSA Fellows are available on the site under "Member Services." Find the link under "What's Hot" and download the form in PDF format.

GSA Education: New Directions and Strategies for Excellence

The report of the ad hoc Education Task Force, which met in January, positions education as critical to the mission and strategic plan of the Society, and outlines new directions that will enable us to fulfill this mission. The nine-member task force, led by Robert Ridky, comprises representatives from a wide range of educational settings and organizations. Its report to the GSA Council, GSA Education: New Directions and Strategies for Excellence, will be available on the GSA Web site and will be printed in the April issue of *GSA Today*. Below are the basic premises of the New Directions document:

- GSA Education should be oriented toward providing leadership.
- GSA Education should base its efforts on the inherent strengths of the Society, and on opportunities presented by and assessed amid a changing educational environment.
- GSA Education should support and publicize the educational activities of associated, affiliated, and sibling organizations, and it should avoid redundancy.
- GSA Education should establish affiliated academic centers for geoscience excellence.

The task force is also developing a job description for an Education Director. The position will be advertised in the April issue of *GSA Today*. The task force anticipates filling the position by January 2001. ■

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Call for Abstracts • Conference Announcement

AAPG-EAGE International Research Conference on Carbonate Reservoir Characterization and Modeling for Enhanced Hydrocarbon Discovery and Recovery

Program Committee: • *Wayne Ahr*, Texas A&M University; • *Mike Bowman*, BP-Amoco; • *Hans Dronkert*, Technical University of Delft; • *Peter Gralla*, Veba Oil & Gas GmbH, Germany; • *Charles Kerans*, Bureau of Economic Geology, University of Texas; • *Ernest Mancini*, University of Alabama; • *Emily Stoudt*, Texaco.

The ***AAPG-EAGE Conference is scheduled for October 1–5, 2000 at the Camino Real Hotel (downtown location), El Paso, Texas.*** The objective of the Conference is to present new advances in carbonate reservoir and petroleum systems research for enhanced detection of new petroleum resources and improved development of known reserves. The objective will be achieved through an integrated experience of oral and poster sessions (2.5 days), a field excursion to view West Texas and New Mexico Permian carbonates (1 day), and "hands-on" core workshop, including classical carbonate reservoirs. We invite submission of abstracts for presentations on the following topics:

Carbonate Reservoir Exploration: • Carbonate petroleum systems; • Carbonate cyclo- and sequence stratigraphy; • Advances in correlation of carbonate strata; • Exploration models for traps and reservoirs on carbonate shelves and ramps; • Geological and computer modeling of reef and carbonate shoal development; • 3-D seismic imaging and modeling of carbonate traps and reservoirs; • Carbonate source rock biogeochemistry; • Characteristics of evaporite seals; • Case histories from European Permian carbonate system.

Carbonate Reservoir Development: • Application and use of seismic attributes for porosity mapping; • Quantitative characterization and 3-D reservoir simulation; • Time-lapse seismic for carbonate reservoir management; • Reservoir architecture and heterogeneity; oIntegrated reservoir characterization and modeling; • Rock-fluid interactions and petro-physical properties; • Porosity development and pore system characteristics; • Distribution patterns of diagenesis; • Fracture develop-ment and detection; • Outcrop analogs for field development; • Field case studies demonstrating improved hydrocarbon recovery.

Abstract Submittal: Please send a 1-page abstract, including optional figures (up to 2) to: Debbie Boonstra, AAPG Educational Dept., P.O. Box 979, Tulsa, OK 74101-0979. Fax: 918/560-2678, e-mail: debbi@aapg.org. Please specify that your abstract is for the AAPG-EAGE Conference. Include ALL co-authors names (including contact information for the primary author). **DEADLINE FOR SUBMISSION OF ABSTRACTS: MAY 15, 2000**.

GEOLOGICAL SOCIETY OF AMERICA

MEDALS AND AWARDS FOR 1999

PENROSE MEDAL

presented to

M. GORDON "REDS" WOLMAN

Citation by John E. Costa

It is my honor to introduce the 1999 Penrose Medalist, M. Gordon Wolman, known to friends and family as Reds. Reds is a geomorphologist whose scientific accomplishments have consistently prophesied major public policy issues that affect every one of us. Before river bed material was recognized as a determining factor in the spawning habitat of endangered salmon species, Reds developed the standard method to characterize river gravel in the field. Before sediment was officially classified as a pollutant, Reds tracked the cycle of erosion and sedimentation beyond agricultural land use through construction and finally urbanization in a well-known and high-visibility publication. Before the Clean Water Act required states to define and quantify the quality of water in their streams, Reds published a paper describing a broad view and interpretation of the nation's water quality. Before the full environmental consequences of dam construction were understood or appreciated, Reds published a USGS Professional Paper on the downstream effects of dams on channels. And before the National Flood Insurance Program, now the second major financial obligation of the U.S. government after Social Security, Reds was studying the effects of large floods and defining the meaning of the relationship among flood magnitude, flood frequency, and effective force in geomorphic processes. Reds is co-author of what is probably the most cited book in fluvial geomorphology, *Fluvial Processes in Geomorphology.* This book captured and organized the fledgling field of quantitative geomorphology and motivated a generation of scientists to new insights on river and landscape processes. For many of us, Reds gave instruction and example. His qualities as a human equal his scientific accomplishments. He has never been known to say an ill word about another person. Although his shadow is long, he provides much light and plenty of nutrients in Baltimore. He let us grow to what we could be. There are trees of all kinds and sizes in Reds's forest, including some mighty oaks and big firs. He cherishes the diversity of his progeny. One beautiful spring day I was outside Reds's office when a staff member commented that "those students playing lacrosse on the quad should be studying for finals in the library." Reds purposefully rose from his chair, raised up his window as far as it would go, and yelled to the students "cradle that ball closer to your body when running like that!" This should be no surprise from the man whose resumé includes a recent paper titled "Play: The Handmaiden of Work."

Reds has been interim university provost twice, part-time fashion model, board president of the Park School, board chairman of Sinai Hospital in Baltimore, chairman of Resources for the Future, member and committee chairman of the National Academy of Sciences, recipient of the John Wesley Powell Award from the U.S. Geological Survey, the Distinguished Career Award from the Association of American Geographers, the Linton Award from the British Geomorphological Research Group, the Cullum Geographical Medal from the American Geographical Society, the Rachel Carson Award, and the Ian Campbell Medal of the American Geological Institute, and is past-president of the Geological Society of America.

I know no better person than Reds Wolman to be the scientific capstone of GSA for the 20th century, and the moral and ethical cornerstone of the new millennium. For you, Reds, I borrow a wonderful statement from your colleague J. D. H. Donnay, uttered while he was trying to teach crystal optics and morphology to a group of your geomorphology students. This time his words fall on your shoulders, not ours. He said, "I'm not asking you to believe any of this; but I challenge you to deny it!"

It is my singular honor to present M. Gordon Wolman, recipient of the 1999 Penrose Medal.

Response by M. GORDON WOLMAN

I am honored beyond measure by the award of the Penrose Medal. I thank you. With your indulgence, perhaps without it, I will reflect briefly on two themes: geomorphology and fortune.

The last half of the century has been an interesting time for what many of my fellow graduate students, not in the specialty, called "superficial geology." Much of this period was characterized by studies of surface processes, many at modest scales. More recently, analysis of major landforms has come into its own, with promise of linking the small and larger scales.

The study of earth surface processes involving both quantitative techniques and quaternary stratigraphy began to piece together a rough picture of how riverine and hillslope processes work under different climatic and, on occasion, tectonic regimes. This study of surface processes coincided with the emergence of environmental consciousness. An understanding of the impact of human activities is inseparable from an understanding of the way in which the landscape behaves in the absence of human interference, if places can still be found where nature alone performs. This conjunction of man and nature has been a boon to the field of physiography. Acceptance of the inseparability of human and naturally driven processes has also been accompanied by recognition that biological processes, from fish and macro-invertebrates in streams to the distribution and evolution of plants on the landscape, are inseparable from physical and chemical processes at the earth surface. Perhaps lacking have been comparative comprehensive drainage-basin studies of significant duration, but it appears that recognition of the value of long-term ecological research studies may stimulate comparable collaborative work in geomorphology.

As exciting as the study of processes is, the more recent beautiful work on the relationship between mountain building, denudation, and landscape form opens new avenues for geomorphic study. Landforms are a function of structure, process, and time where form can be related to relative rates of uplift and erosion. New techniques for dating surfaces and measurements of topography and structure, combined with modeling of surface processes, have begun to join studies of processes at smaller scales with analyses of landforms at the largest scales. The reciprocal relationship between models and measurements is beginning to be realized. Conceivably, erosivity, a fundamental property of the rocks, will become a measured quantity rather than an equation-balancing coefficient.

It has been a good half-century for geomorphology. Soon it will be a grand new millennium, in which geomorphologists can talk to politicians about river restoration with four-year time horizons and to geologists who wallow in millions of years.

So much for geomorphology. Now, fortune.

I am one of those lucky ones. I survived three years of war; no one ever fired a shot at me; I simply fell overboard several times from small boats. I went to college and graduate school with Kirk Bryan and his grand group of students in an optimistic era and to work with the U.S. Geological Survey, where I had the extraordinary good fortune to work daily with Luna Leopold, Walter Langbein, Tom Maddock, John Hack, Charles Denny, and other remarkable Survey colleagues. A day for Luna is 28 hours, one packed with ideas, with field and laboratory skills, whiskey, good food, and friendship. Fine graduate students and academic colleagues followed. During much of the era, optimism rode upon rising research budgets. Now, I find myself in company following an extraordinary lineage of Penrose Medalists, and in the presence of the best of a grand geologic tradition.

Thank you.

DAY MEDAL

presented to

DONALD DEPAOLO

Citation by Frank Richter

My pleasure in giving the citation for Don DePaolo as the 1999 Day medalist derives in equal parts from scientific admiration and personal affection.

The Arthur L. Day Medal of the Geological Society of America is awarded for outstanding distinction in contributing to geologic knowledge through the application of physics and chemistry. Don is a geochemist, and it's been said—by Yogi Berra, I believe—that outstanding contributions to geologic knowledge by geochemists are 90% high-quality analytical measurement, and the other half is choice of problem.

Don is widely recognized for making very high precision, often very difficult and innovative, isotopic measurements. He is among the pioneers in measuring the neodymium isotopic compositions of terrestrial samples. One of his most influential works (done in collaboration with his thesis advisor G. J. Wasserburg) involved the use of the Nd isotopic composition of ocean island basalts relative to that of mid-ocean ridge basalts to argue that the MORB source could not be the entire mantle. This led to a simple, concrete, two-layer geochemical model of the mantle, which because of its implications regarding the large-scale, long-term structure of the mantle, represented a very significant intellectual invasion of a geophysical theme (structure and evolution of the mantle) by geochemists. By extending Nd isotopic measurements to older rocks, Don was able to define a Nd isotopic evolution curve for the depleted mantle, which in turn allowed him to develop Nd model ages for the mantle separation time of various segments of the continental crust. Such mantle separation ages give a truer picture of the age of the continents than traditional radiometric ages, which can be, and often are, reset by subsequent events. An excellent summary of many of his other important contributions using Nd isotopes is given in his 1988 monograph *Neodymium Isotope Geochemistry: An Introduction.*

While Nd isotopes were the focus of much of Don's early work, his present interests and analytical capabilities range at least from mass 3 (^{3}He) to 238 (^{238}U). Even restricting myself to a limited subset of works involving the limited mass range 86–87, I can give you some idea of the ever-expanding range of topics that Don has addressed. Lynn Ingram and Don DePaolo (her husband) developed high-resolution stratigraphy based on the Sr isotopic evolution of seawater recorded by sediments. They later used Sr isotopes in San Francisco Bay sediments to get a 4,500 year record of paleosalinity and freshwater inflow reflecting climatic variations in rainfall over the very large part of California being drained into the bay. Don and I used the Sr isotopic composition of deep-sea carbonates and pore waters to estimate rates of diagenesis and quantify the relationship between the present-day chemical properties of these sediments and the chemical properties of seawater at the time they were deposited. The effect of diagenesis on the oxygen isotopic record preserved in sediments was explored with Dan Schrag. Together with Tom Johnson, Don used Sr isotopes to study fluid-rock reactions in groundwater systems. With John Christensen, he used the Sr isotopic zoning of garnets to determine the kinetics of garnet growth under metamorphic conditions. Don and John Christensen also used Sr isotopes to document time scales of large silicic magma systems. And even for masses 86 and 87, this is only an illustrative, not an exhaustive, list!

All the high-precision measurements combined with a very good nose for important problems are not, I would argue, enough to fully explain why Don's work has been so influential. The extra term in the equation is Don's mastery of a very subtle and elusive art—that of model making. Virtually all of Don's most influential contributions have at their core an elegantly simple model formulation that identifies the essential components of the problem at hand. The model becomes the necessary statement of the relationship of measurable data to process. And at the end of the day, the model becomes the vehicle for phrasing the conclusions in such a way that it's hard to miss the point.

Exceptionally high quality measurements connected via powerful model formulations to problems of first-order geological importance are what give Don DePaolo's work the distinction worthy of the Day Medal.

Response by DONALD DEPAOLO

I am deeply gratified to be chosen as this year's Arthur L. Day medalist. This award embodies in its requirements precisely what I strive to accomplish in research, and I must admit, guiltily, that I had hoped that at some point I might be found worthy of it. Receiving it, however, is disconcerting. The list of previous awardees is humbling indeed, and the requirements are relentless in providing expectations along with congratulations.

It is particularly appropriate to receive this award in Denver. My first job in geology was an NAGT summer field assistantship with the U.S. Geological Survey here. I spent that summer working on a Wilderness Area project in the Laramie Range in Wyoming. It was this NAGT assistantship that suggested to me that I could conceivably make a career in geology, and in no small part it is the reason I chose to. My first Ph.D. student, Lang Farmer, is a faculty member at the University of Colorado, and helped organize this 1999 meeting, and my second Ph.D. student, Brian Marshall, works for the USGS in Denver as well. I attended my first national GSA meeting in Denver in 1976, when I was still a Ph.D. student. I remember it distinctly because of the postmeeting field trip in the Front Ranges, during which I made myself conspicuous by collecting rock samples that were just a bit too large—as I imagined a good isotope geochemist should!

I am here as a result of a series of unlikely events and because I have benefited from associations with extraordinary people. I started college as a civil engineering major at Cornell, and partly due to the dizzying effects of the late-60s political environment, toyed with becoming a political science major before recognizing that my only academic love was geology. I finished my undergraduate geology degree at SUNY Binghamton, and applied to Caltech for graduate school mainly because it was in California and there was no application fee! My graduate experience at Caltech was the real launching pad for my career, and I doubt there is a better place to start. My thesis advisor, Gerry Wasserburg, has since provided booster rockets at various times, balanced of course by occasional taunts, criticisms, and challenges. Gerry sets the standard in isotope geochemistry, and in my view in the "application of physics and chemistry to geology." My conception of good science was influenced strongly by him. Dmitri Papanastassiou was largely responsible for teaching me what it takes to do careful work in the lab. But I always thought of myself first as a geologist, and it was Lee Silver who provided the role model there, and who kindled my interest in igneous geochemistry and petrology.

Immediately after getting my Ph.D., I was given the opportunity to develop my own isotope geochemistry laboratory through the combined largesse of UCLA and the National Science Foundation. My time in the Department of Earth and Space Sciences at UCLA was highly productive, in part because the senior faculty were especially good at giving young faculty a sense of support as they developed their research programs.

Over the past 12 years, my benefactors, in addition to NSF, have been UC Berkeley, the Lawrence Berkeley National Laboratory, and the Geosciences Program of the Department of Energy. Berkeley provides an astonishing intellectual and cultural environment, both on and off the campus. It is no accident that UC Berkeley is a great university; the administration, from the chancellor down to the department chairs, prove time and again that they know what really counts in maintaining the highest possible standards in both research and teaching. A special aspect of my time in Berkeley has been my association with the Lawrence Berkeley National Laboratory. Both Tom McEvilly and Sally Benson, as Earth Science Division directors, have worked hard on my behalf at LBNL, and helped me to build a substantial program in isotope geochemistry.

To continue to pursue science vigorously over an entire career, one needs to have stimulating colleagues and a source of continuing education. The person I have learned the most from since getting my Ph.D. is Frank Richter. Over the years, in addition to providing friendship and opportunities for fruitful collaboration, Frank provided the instruction I needed in mathematical modeling (not to mention many other things). Those who have read my papers might conclude that perhaps he hasn't provided quite enough instruction, but I certainly appreciate the difference it has made. In the past several years I have developed a rewarding working relationship with Ed Stolper, who has been a friend for many years, and Don Thomas from the University of Hawaii, as we have attempted to foster and then carry through the Hawaii Scientific Drilling Project.

The reason anything at all gets done in my lab is that Tom Owens ensures that it gets done; that's been the case for 20 years. I also benefit greatly from my association with Mack Kennedy and his noble-gas isotope lab at LBNL, and Mark Conrad, who has a stable isotope lab at LBNL. They are my cohorts in the Center for Isotope Geochemistry, and without their efforts, there would be no center. My administrative assistant Marilyn Saarni keeps the center together, and does everything else you can imagine, from answering the telephone to maintaining our computer hardware and software.

My students and postdocs continue to make my job stimulating, and at times effortless. Over the years I have supervised 23 Ph.D. students, several postdoctoral fellows, and three master's students. The range of experience I have had with them is substantial, and one thing I have learned is that there is more than one way to have a productive time in graduate school or as a postdoctoral fellow. I am proud of all of them, partly because they were fun to work with, partly because of their accomplishments, partly because they are my friends, and partly because they have been true to themselves in pursuing varied careers.

I stay in the mood to do science almost all the time, in large part because my wife and colleague, Lynn Ingram, my son, Daniel, and my daughter, Tara, have been continually supportive, and, more important, fun to live with.

I hope to continue applying geochemical methods to geology, and I hope to get better at it. This award will make it just that much more pleasurable to continue.

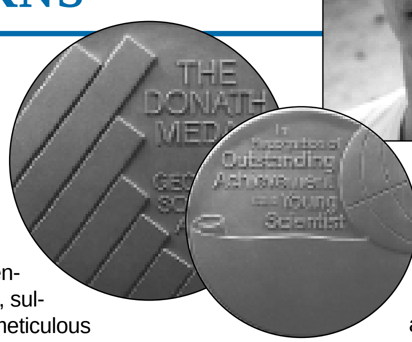
Thank you.

YOUNG SCIENTIST AWARD (Donath Medal)

presented to

PETER C. BURNS

Citation by Frank C. Hawthorne



Peter Burns has made important contributions to our understanding of the crystal chemistry of several major mineral groups of current environmental importance: uranium oxysalts, sulfates, and copper oxysalts. His meticulous experimental and theoretical work on the numerous secondary uranium minerals has brought order and insight to a hitherto disorganized array of information. In particular, he and his collaborators have produced a hierarchical organization of uranium-oxysalt structures based on their bond topologies. This allows structural interpretation of the paragenesis of secondary uranium minerals, and has also greatly furthered our understanding of the crystal chemistry of uranium. This, in turn, has led to the identification of pentavalent uranium in minerals, a discovery that affects geochemical modeling of uranium in low-temperature environments. Peter has done similar work on the borate minerals, and has also shown, via ab-initio molecular-orbital calculations, that the fundamental building blocks of the resultant structure hierarchy are the lowest-energy arrangements. In addition, his meticulous optical work and transmission-electron microscopy showed that some borate deposits previously thought to be pristine have been, in fact, metamorphosed.

Peter's enthusiasm for science, his capacity for hard work, and his insight into the way that Nature behaves mark him as an absolutely outstanding scientist, young or old.

Response by PETER BURNS

It is an honor to be chosen as the 1999 recipient of the Donath Young Scientist Award by the Geological Society of America.

The Donath Medal recognizes my research accomplishments in mineralogy, but more important is that it draws attention to the many scholars who have mentored me, placed faith in my abilities, and supported me through my education and as I developed my career.

I grew up in rural northern New Brunswick, Canada, on the banks of the Miramichi River. Even by Canadian standards, this area is largely wilderness, with houses no more than two deep along the banks of the river. As a boy, my free time was spent casting for Atlantic salmon or brook trout and hiking in the wilderness. It was through these activities that I developed an appreciation for nature and preservation. The economy of the region was, and still is, resource-based, and this fact inevitably leads to conflicts between the interests of employment and environmental management. These experiences helped to guided me into my research in low-temperature mineralogy, which has so many applications to environmental issues. However, my research interest trajectory was not without tangents.

I entered the University of New Brunswick with a desire to learn more about science. Thanks to the superb geology faculty at UNB, my interest in geology was nurtured and began to grow. I was extensively mentored and encouraged by professor Lowell Trembath, who introduced me to mineralogy. He instilled in me a fascination in mineralogical research, and a dedication to excellence in research and education. My senior research project at UNB concerned local borate mineral occurrences. This can be marked as my first foray into low-temperature mineralogy.

After UNB, I joined Mike Fleet's research group at the University of Western Ontario for a year. There I studied ordering in high-temperature synthetic feldspars, the only major time I strayed from low-temperature mineralogy. After finishing a master's degree at Western Ontario, I moved to the University of Manitoba to work toward a Ph.D. with Frank Hawthorne. His advising style was ideal for me; he provided ample guidance and inspiration, while still leaving me free to follow my interests, which included many research tangents that were unrelated to my dissertation. The university has a long-standing tradition of excellence in mineralogical research, and it maintains superb faculty and facilities. While at Manitoba my research moved back toward low-temperature mineralogy, which caught my fancy largely owing to the vast complexity and diversity of low-temperature minerals. However, at this stage, my research largely lacked an environmental application.

My first year of postdoctoral research was done in the Department of Earth Sciences at the University of Cambridge with Michael Carpenter, who provided much-appreciated guidance and inspiration. I am also grateful to the Fellows of Clare Hall for many lively discussions concerning various aspects of academia. The year at Cambridge was mostly spent learning the details of transmission electron microscopy, with applications to phase transitions in minerals.

I decided to move to the United States to follow my interests in low-temperature mineralogy, specifically with applications to environmental issues. I joined Rodney Ewing's research group at the University of New Mexico as a postdoctoral fellow and began my studies of uranium in natural systems. Working within Rod's excellent group exposed me to many applications of mineralogy to the environment, such as the geological disposal of nuclear waste.

Following postdoctoral research, I joined the Department of Geology at the University of Illinois in Urbana as a visiting faculty member. I am grateful to the faculty for much assistance, especially Jim Kirkpatrick, who arranged for me to work in the X-ray laboratories in the Department of Chemistry. Scott Wilson introduced me to the CCD-based X-ray diffraction system, and I benefited from many fruitful discussions concerning data collection and structure solution strategies.

After one year at Illinois, I moved to a permanent arrangement in the Department of Civil Engineering and Geological Sciences at the University of Notre Dame. I am grateful to the university for providing resources for the establishment of the Environmental Mineralogy and Crystal Structures Laboratory. Much of the work done in mineralogy at Notre Dame is through the efforts of my research group: undergraduates Erin Keppel and Rebecca Glatz, graduate students Jennifer Jackson, Sarah Scott, and Yaping Li, and postdoctoral fellows Frances Hill, Sergey Krivovichev, and Christopher Cahill. This group is a pleasure and an inspiration for me. I thank David Kirkner, former chair of the department, for supporting my research program.

I believe that we have entered a new phase in earth sciences, and especially mineralogy. Research emphasis in mineralogy traditionally focused on rather detailed studies of the few hundred common rock-forming minerals. By scanning the contents of a current issue of a premier mineralogical journal, you can see that the emphasis of mineralogical research has undergone considerable change. The focus is moving from common rock-forming minerals to the several thousand less-common low-temperature minerals. This transition is being driven by increasing recognition of the role that low-temperature minerals play in environmental issues. Unlike common rock-forming minerals, low-temperature minerals have rather limited stability ranges, and as such are sensitive indicators of temperature, pressure, pH, and oxidation potential. However, these minerals are tremendously complex: understanding assemblages of low-temperature minerals severely challenges our current knowledge of mineralogy.

A tremendous challenge lies ahead for mineralogists and geochemists: the occurrences, structures, stabilities, and paragenesis of low-temperature minerals require detailed study if geoscientists are to be properly equipped to tackle environmental problems today and in the future. A tremendous amount of work remains to be done in mineralogy, both in research and in educating young scientists for tomorrow.

Finally, I want to thank the most important person in my life. My wife, Tammy, has made many sacrifices for me, as well as providing the best advice available; I am exceedingly grateful to her for all she has done.

It is gratifying to be rewarded for doing something that you love to do, and I thank you for this recognition.

GSA PUBLIC SERVICE AWARD

presented to

STEPHEN JAY GOULD

Citation by Carolyn S. Shoemaker

The first Public Service Award of the Geological Society of America could go to no more fitting candidate than Stephen Jay Gould. Just as a good wine may get better with time, so does he. Perhaps this is because of his seasoning in the cause of truth and reason; perhaps it has to do with his deep-seated curiosity about the human condition and his constant probing for honest answers. Some people spend their lives learning and forgetting; Stephen seems never to forget anything, but builds upon his questioning and hypothesizing and reexamining.

As an outstanding and dedicated scientist, he bridges the worlds of geology, biology, planetary science, and philosophy through his work in paleontology and the evolution of life. As a professor at Harvard, he has influenced countless students, but as a writer and speaker he has given many more the benefit of his understanding of the progression of life. Few scientists are so well prepared to address the issues of our planetary welfare, whether they be basic or political, as is Stephen, and few can do it as honestly and wittily as he. He has not hesitated to plunge into the battle against creationism and played a major role in the defeat of a law requiring its teaching in Arkansas some years ago. Creationism continues to sew its seeds of ignorance wherever it can gain a toehold, be it in Kentucky, Kansas, Arizona, or other countries like Australia, but Stephen continues to speak up as needed.

He uses scientific evidence to explain the physical and biological causes for gaps in the stratigraphic record. Together with Niles Eldredge, he propounded the theory of punctuated equilibrium, which says that evolution proceeds by fits and starts rather than by gradualism. (This fits very nicely with Gene's and my concepts of geologic evolution through catastrophe rather than by the Lyellian principle of slow change.) Stephen is not only occupied with general evolution, but also with the development of ideas, and he believes in the freedom needed to explore them with a healthy dose of skepticism.

As a measure of the esteem in which he is held by his colleagues and public, by 1994 more than 81 institutions throughout the world had honored him with awards, including 34 honorary doctorates of science, humanities, and law, and 12 literary and 36 other academic honors. My sources of information cannot keep up with this prolific individual, who never rests on his laurels, but I am sure there have been more honors in the five years that have elapsed since that count.

As a youngster, Stephen was awakened to the excitement of natural science when he encountered his first *Tyrannosaurus rex* at the American Museum of Natural History, long before dinosaurs became a hot topic for every school-age child. He spent many hours, while growing up, at that museum while his curiosity about science continued to evolve.

Today, along with his many other projects, he writes essays and books drawing upon popular subjects to illustrate science. His keen sense of imaginative description has produced book titles such as *Hen's Teeth and Horse's Toes, The Flamingo's Smile, Bully for Brontosaurus,* and *Eight Little Piggies.* One of his essays, entitled "Losing the Edge," is about baseball. We are fortunate that he chose science over his passionate love for baseball.

Stephen, you have more than earned the Public Service Award of the Geological Society of America. In these days of rapid expansion of the sciences and equally rapid diminishment of public support for science, we are very much in need of those who can and do speak effectively for us. We hope that you will never "lose your edge" but will keep on batting 400, whether in the midst of controversy or in pursuit of fundamental truths. Our deepest thanks go to you for your public service in science and education.

Response by STEPHEN JAY GOULD

At Last to the Stars Themselves

Peter Medawar, Nobel laureate in biology, and a superb writer as well, often noted the pomposity of his humanistic colleagues who would label any scientist ignorant of Shakespeare as an illiterate philistine, but who took active pride in their own failures to understand even the most basic principles of science. All scientists should, of course, brush up on their Shakespeare (neither Medawar nor I would dispute the first part of the literati's lament). But all folks who wish to enjoy the epithet of "educated" must comprehend the basics of the greatest human intellectual adventure of all—the enterprise known as "science"—and not only for the practical reason that successful life in the highly technical society of our new millennium requires this form of literacy, but also, indeed primarily, because science is so damned thrilling that only a narrow-minded fool could fail to be seduced by such surprising but verifiable concepts as expanding universes and the genealogical tree of earthly life.

We make this vitally important job of advancing the "public understanding of science" (to use the catch phrase of the moment) all the harder for ourselves with two false assumptions and practices inherent in the story of my opening paragraph.

1. We assume public incomprehensibility and resistance, if not outright hostility—as depicted in several pop-culture myths from the evil (or at least morally insensitive) Dr. Frankenstein, to the kindly but utterly arcane Einstein figure filling a blackboard with unintelligible squiggles (and no vernacular words at all). In fact, public fascination for science stands high, if not paramount, on the list of intellectual subjects that educated people must learn to approach without fear. (If we could quantify and concentrate the cerebral power involved in the correct spelling of horrendously complex dinosaur names by tens of millions of children in America, then we could move mountains, and land without fail on Martian polar regions.)

Moreover, the sciences of natural history make the most immediate contact with public delight—and our own field of geology, where the beauty of scenery meshes so admirably with the clarity of theory, has always ranked particularly high in general interest. One would have to be a hopeless dolt (or just too obedient to the authority of flight attendants when they ask you to lower the shades for better viewing of the movie; I have always refused; we really do retain such rights in our individualistic democracy) to be unmoved and uninstructed by the sights I enjoyed en route from my New York home to this GSA meeting: the folded Appalachians, the flood plain of the Mississippi, and the Rocky Mountains rising behind Denver.

2. We do not grant sufficient professional honor to colleagues with skills in public communication. We think of such activities as "public service," as though we engage in them only as a duty and a sacrifice of time from our higher callings. But "popularization"—even the name has an unfortunate ring of "debasement" or "adulteration," whereas the implications should be entirely opposite and positive—is not a detraction from science; it *is* science. Discovery and communication are indissoluble parts of a coherent enterprise. And communication to intelligent and inquisitive nonscientists is not an exercise in prattling to babies, but an honored and respected part of the great humanistic tradition in Western scholarship throughout our history. Just remember that Galileo wrote both of his great works as dialogues in Italian (not as monographs in Latin), so that all his literate countrymen might understand the new architecture of the heavens. And Darwin wrote The *Origin of Species* as a general book for popular distribution, not as a technical treatise accessible to his scientific colleagues alone.

The GSA is my "parent" professional organization, and I strongly believe in fealty as just about the highest pleasure and responsibility of our institutional commitments. Thus, I would have been flattered and humbled (a rare attitude for me) by this honor under any name chosen by the GSA—say, as a hypothetical example, the Walcott medal for gradualistic and god-given progress. But I do, in all seriousness, wish to say how touched, indeed how moved, I have been by the naming [Public Service Award in Honor of Eugene and Carolyn Shoemaker] of this award in honor of one of the very dearest men and finest intellects who has ever graced our profession, and whom I had the incomparable privilege of knowing as a great soul as well as a great scientist.

Eugene and Carolyn Shoemaker must represent the greatest connubial team in science since the Curies. I accept this award from Carolyn with great joy, while I honor the memory of Gene with sadness because I will no longer see that smile or hear those generous, wise, and enthusiastic words, but also with joy for a life so superbly achieved. I especially rejoice that Gene, in the best epitome of triumph (and with a wry humor that he would have appreciated), lived a life of such accomplishment that he completely belied and reversed the oldest motto connected with the profession of his name, an epigram stated by Pliny in the first century A.D., but attributed to Apelles in the fourth century B.C.:

> *Ne supra crepidam sutor judicaret.* (A shoemaker should stick to his last.)

(A last is an old wooden model for a human foot, so the statement says that we should not look above or beyond our appointed station.)

Has anyone ever transcended, both figuratively and now literally, further than Gene Shoemaker? Pliny himself died with his boots on, and in the name of science, when he sailed too close to Mount Vesuvius in 79 A.D. (the same eruption that buried Pompeii and Herculaneum), went ashore to save some friends and make scientific observations, and died under a cloud of volcanic ash, where his remains lie to this day. Gene also died with his boots on, but a portion of his mortal remains, with a boost from NASA, now lie on the Moon. To paraphrase a famous poem in a different but equally worthy context: there is now in that rich earth [of that section of the Moon] a richer dust concealed.

Meanwhile, Gene's ideas and his work shall live forever, and his memory shall bring eternal pleasure to all who knew both his goodness and his greatness.

DISTINGUISHED SERVICE AWARD
presented to
RANDOLPH W. BROMERY

Citation by Robert L. Fuchs

Doctor, Professor, President, Chair, Director, Chancellor, Senior Scientist, Project Chief, Exploration Geophysicist—how should one address Randolph W. Bromery? Any of these titles is appropriate, for he has held each at one time or another during a 50-year career in geology, geophysics, academia, and business. But perhaps the unofficial title that means the most is Pioneer.

Project Chief Bromery was born in Cumberland, Maryland, and served as one of the Tuskegee Airmen during World War II. He began working for the USGS in 1948 as a geophysicist, and during the ensuing 19-year period also earned B.S., M.S., and Ph.D. degrees from Howard, American, and Johns Hopkins universities, respectively. Professor Bromery entered the academic world at the University of Massachusetts at Amherst and was associated with that state university for most of the balance of his career. The list of jobs is impressive: professor, department chair, vice chancellor for student affairs, office of the president, chancellor of the Board of Regents. For two years he was acting president of Westfield State College. From 1992 to 1999 President Bromery held that position at Springfield College, an "interim" job that became another success story.

Pioneer Bromery was the first black scientist and educator to arrive on the scene in a large number of organizational and geographic venues. His career paralleled the giant advances in race relations and recognition post–World War II, and his quiet achievements served as a model for the members of minority groups who now populate science, education, and business. Pioneer Bromery's role in this sociological revolution was recognized in 1997 when he was named an outstanding black scientist by the National Academy of Sciences, where his portrait now hangs.

Director Bromery was welcomed to the boards of many large and a few smaller corporations in U.S. industry. Among the former were Exxon, Chemical Bank, NYNEX, John Hancock, Singer, New England Telephone, and Northwestern Life. He provided presidential services to Massachusetts companies Weston Geophysical International and Geoscience Engineering.

Chair Bromery did not exclude GSA from the benefits of his hard work and leadership. After service on the Audit, Nominations, and Minority committees and a three-year term on the Council, he became the lead-off president of GSA's second century. From there it was but a short step to chair of the Second Century Fund, the GSA Foundation's successful $10+ million capital campaign. Without Chair Bromery's fund-raising experience, direction, and pragmatism, the outcome could have been significantly different.

Finally, there is a simple name that is worn more comfortably than all his titles by this immensely friendly man, and that is simply "Bill." Say hello to Bill on the street, in the hall, in a meeting room, and you are opening the door to a heart full of warm, engaging, and really funny stories and insights. It is well known that Bill Cosby derived much of his material from his long-time friend and science advisor. How fortunate for GSA that there was a place for our Society in Bill Bromery's very full life.

Response by RANDOLPH W. BROMERY

I want to extend my sincere appreciation to the members of the GSA Council for voting to grant me this award. I am deeply honored and pleased to have been a member of the Geological Society of America for many years and a member of the geological profession for the past 51 years.

I also want to recognize and to thank my wife Cecile, a very close and co-equal partner, for her support and encouragement during these past nearly 53 years of our marriage.

Among the many challenges we all must face in our adult lives, I have selected three challenges that I consider significant in my personal and professional life. The first challenge began very early in my life, soon after the attack on Pearl Harbor. It was the struggle that my fellow servicemen and I faced every day while training and serving during World War II with the Tuskegee Airmen of the U.S. Army Air Corps. It was a very hostile military and social environment during the 1940s in this country.

Following the expected challenges associated with acquiring a university education, the next challenge in my life was far more pleasurable. It was the association with my professional colleagues in the Geophysics Branch of the U.S. Geological Survey. Planning, conducting, and interpreting airborne and ground geophysical surveys in the conterminous United States, Alaska, and West Africa were most rewarding experiences.

The third professional challenge was the teaching and research conducted while serving as a faculty member in the Department of Geosciences at the University of Massachusetts at Amherst. I eventually strayed, however, and spent the balance of my professional life as a college and university president and chancellor. But, even then, I continued to dabble in my favored geological and geophysical profession.

Here is an interesting bit of "life's true irony," which I hope that you will appreciate and understand. Considering the circumstances of race relations in this country a decade or two ago, it would have been inconceivable for me to consider retiring and living on a plantation in South Carolina. In fact, my friends and family would have thought that I had totally lost my mind. However, since I finally retired in 1998, closing out more than 50 years of my professional life, Cecile and I now spend much of the winter living on a plantation on Hilton Head Island, South Carolina. The significant difference between today and 10 to 20 years ago is that we can now own and live in the "big house" on the plantation. Look us up; we are in the telephone book. If you give us a call, we may consider having the plantation guards open the gates and allow you to enter our plantation.

Again, many thanks, and I am truly honored.

DISTINGUISHED SERVICE AWARD

presented to

SUE S. BEGGS

Citation by Sharon Mosher

Sue Beggs devoted her almost 20 years as GSA's meetings manager to excellence and improvement. She became known to meeting attendees and exhibitors alike as a problem solver and innovator, organized, efficient, and visionary. She instituted electronic submission of abstracts to GSA and review of abstracts by the Joint Technical Program Committee via the Web. She pushed persuasively for program innovations-ways to make GSA Annual Meetings more effective and interesting. She investigated and evaluated every component of each meeting and made excellent suggestions for change. Her primary concern was always service to the 5,000 to 8,000 geoscientists who attend GSA meetings, and she constantly strove to find ways to cut costs for attendees.

Sue's vision led to GSA establishing the GeoVentures program, which includes GeoHostels in the United States and GeoTrips to places such as Iceland, Great Britain, the Galapagos, and New Zealand. She made sure that knowledgeable and respected scientists lead these educational and enjoyable events.

Sue's dedication to GSA extended to its relationships with the Associated Societies and to planning for the Society's future. As part of the Strategic Planning Committee, she helped to craft a plan that will broaden and deepen GSA's service to society and the geosciences.

Sue Beggs left GSA richer in this spirit of service and with a clearer idea of what can be dreamed—and what can be accomplished now.

Response by SUE S. BEGGS

I deeply appreciate this honor by the Society. Living from Annual Meeting to Annual Meeting kept my life full, varied, and interesting for close to two decades, from San Diego to Toronto and points in between. I especially thank the general chairmen and the many hundreds of geologists who volunteered their time to be part of local committees or to lead field trips. Above all, I'll be eternally grateful to the technical chairmen who have been the unsung heroes of these meetings. I accept this award with deepest appreciation to each and every one of you.

DISTINGUISHED SERVICE AWARD

presented to

LYNN M. WALTER

Citation by Faith Rogers

Lynn Walter saw editorship of the GSA *Bulletin* as a chance to stir things up and inject new life into what some considered a stodgy—if respected—journal. During her four years as co-editor, she did just that, recruiting energetic, young Associate Editors in fields for which the *Bulletin* needed coverage, researchers on the cutting edge of relatively new disciplines in the geosciences.

She saw the GSA *Bulletin* as a reflection of the evolution of GSA and geoscience in general, and encouraged submission of manuscripts on the results of large-scale, multidisciplinary, data-rich research projects, as well as shorter, topical papers of broad interest. She considered herself an advocate for the author's point of view, and made sure that her interaction with authors was sympathetic and encouraging. She appreciated the Associate Editors and thanked them repeatedly and publicly.

To highlight the changes in scope, both geographical and topical, of papers in the *Bulletin,* Lynn pushed for an overhaul of the cover, encouraging the GSA production staff to make it both more attractive and more clearly reflective of the scope of the journal's contents.

During her four years as *Bulletin* editor (the first woman to hold the post), Lynn continued her own research and teaching at the University of Michigan; where she became the first woman in the Department of Geological Sciences to attain the rank of full professor. Lynn's infusion of freshness into GSA's 100-plus-year-old journal left a lasting legacy of energy, breadth of scope, and service to the geosciences. GSA is fortunate to have had the benefits of her efforts on behalf of the *Bulletin.*

Response by LYNN M. WALTER

I deeply appreciate the Society's recognition of my efforts on behalf of the GSA *Bulletin.* I enjoyed serving the *Bulletin's* authors and readers during my four-year term. I want to acknowledge the enthusiastic and supportive help I received from the editorial staff in Boulder, especially Faith Rogers and Larry Bowlds. I was also lucky to have a great compadre in my co-editor, John Geissman, and an outstanding team of associate editors.

Thanks, everyone.

RIP RAPP ARCHAEOLOGICAL GEOLOGY AWARD

presented to

JULIE K. STEIN

Citation by William R. Farrand

If someone says, “shell mounds,” we all think immediately of Julie Stein. She came storming on the scene in the late ’70s with her study of the mounds at the Carlston Annis site on the Green River in Kentucky. In the ’80s, she came storming back with her field school at British Camp, more or less in her own backyard in the San Juan Islands of Washington. The latter study climaxed in the publication of *Deciphering a Shell Midden* (Academic Press, 1992), of which Julie was the editor and the author or coauthor of six chapters. This is a landmark publication in the study of American shell middens, in particular because of its geoarchaeological emphasis—sediments, shells as sedimentary particles, and detailed stratigraphy, including the application of facies concepts.

This research has certainly caught the eyes of archaeologists and geoarchaeologists all around the country and abroad, but that, by no means, is all there is to Julie Stein. She’s not just mussels, clams, and cockles. In fact, I don’t know whether she would eat any such seafood. Julie has been involved in quite a variety of research projects, before, during, and after her shell midden work—projects that have taken her to many corners of the world since her humble beginnings in Kalamazoo, where as an undergraduate at Western Michigan University she did a sediment study of the Late Archaic Schmidt site in Saginaw. It was not published, but that study has been widely used by Michigan archaeologists interested in the Saginaw basin. In fact, I first met Julie (briefly) in Kalamazoo, being introduced by Rip Rapp, with whom she was working at the time, at the GSA North-Central Section meeting, where she presented a paper on her University of Minnesota master’s thesis—“The Archaeological Geology of the Nichoria Site, Southwestern Greece.” Although we did not know it at the time, we both were working in different parts of the Peloponnisos in the mid-’70s.

In the years between the Kentucky shell mound study and the British Camp midden research, Julie popped off to the high Andes in Peru, for another University of Minnesota project, and then to lowland Belize to contribute to a Mayan agricultural study. Concurrently with the San Juan Islands (British Camp) field school, Julie was involved in a sediment study in the Marianas (in the Pacific), the Big Bend Archaeological Project and the Fort Jefferson historic research project (both in Kentucky), and a number of other research projects.

One might think that Julie’s research has recently taken a turn toward the macabre—sewage, slave trade, and privies. She worked in a sewage treatment plant setting (actually the West Point shell midden project), then was searching for slave quarters at Monticello, and finally, just a couple of years ago, she was looking for Lewis and Clark’s privies! On the other hand, recognition of a sort has come this past year when Julie was chosen to study some very small sediment samples—those adhering to the Kennewick Man skeleton, an important and controversial discovery that demands particular attention.

Not all of Julie’s research is empirical—or traditional—excavation and synthesis. She has also been active on the theoretical front, especially on questions of the principles of stratigraphic practice in archaeology. She has repeatedly written about “deposits for archaeologists” and about the need to understand the sedimentary context of artifacts in the ground. In fact, Julie and I have aided and abetted each other in this endeavor, as seen in the volume *Archaeological Sediments in Context* (Center for the Study of Early Man, Orono, Maine, 1985). That book is now out of print, and we are preparing a revised version. Others of Julie’s theoretical contributions have dealt with the role of earthworms in archaeological deposits and with the application of the facies concept drawn from geological stratigraphy. Also, Julie has raised her voice properly in protest against the proposition of Edward C. Harris that archaeological stratigraphic practice is fundamentally different from that of geologists.

Julie has used all this good research and wide-ranging experience to establish one of the most viable academic programs in geoarchaeology anywhere in the New World. Arguably, she has trained more geoarchaeologists since she began teaching at the University of Washington in 1980 than all the rest of us. She has also gotten the public involved in digging, as in the case of the Vashon Island Archaeological Project, a project requiring the blessing of a Native American tribe. Julie has become a role model for many students interested in our field, males as well as females.

Julie’s research and teaching roles slowed down a bit—although many of you know that you can’t really slow Julie down—when she took over as curator of archaeology at the Burke Museum of Natural History and Culture on the Seattle campus, where she discovered that a lot of energy was necessary to bring the Burke’s archaeological collections up to modern curation standards. And now, Dean Julie! As Divisional Dean for Computing, Facilities, and Research in the College of Arts and Sciences at Washington, Julie is exploring a change in academic lifestyle that will take her farther away from her own research activities, at least for a while. However, I imagine that she will still be out there digging in the dirt whenever the opportunity arises.

It is my very great pleasure to present to you Julie K. Stein, the recipient of this year’s Rip Rapp Award.

Response by JULIE K. STEIN

On an autumn day in 1972 at Western Michigan University, a young woman met with three professors in geology: Lloyd Schmaltz, Tom Straw, and Dave Kuenzi. They invited the young woman—a lowly junior—to cram into a van along with faculty, graduate students, and undergraduates on their way to the national GSA meeting. These three professors, knowing of this student’s interest in both geology and archaeology, had seen in the preliminary program that some talks on that interdisciplinary subject were scheduled. They thought she might want to come along.

Putting it mildly, the experience at my first GSA meeting was at once exhilarating and a bit depressing. I realized that other people had seen the possible relationship between archaeology and geology. I immediately wanted more geological archaeology or archaeological geology (and the difference was being hotly debated at the time), but I didn’t know who to ask about doing geoarchaeology, or if such a thing was a viable course of study.

In 1973, the arrival of the GSA meeting abstracts sent me rushing to plead with these same mentors—they simply had to arrange for another GSA pilgrimage. A fellow named Rip Rapp had organized a must-see symposium devoted entirely to archaeological geology. It was at this symposium that I sat in the last row, a quiet, unassuming undergraduate and listened intently to the likes of Bill Farrand, Roald Fryxell, Rip Rapp, Don Johnson, Chris Kraft, and Vance Haynes. My enthusiasm for the future, a life of interdisciplinary study that embraced both geology and archaeology, could not have been higher.

I approached some of these pioneers to explore with them my prospects for graduate study. Their responses, however, were rather deflating. It was, after all, 1973; no GSA Archaeological Geology Division yet existed, and no real graduate training had been conceived. Several of these scientists encouraged me to join them at their universities, with the clearly stated caveat: “You must apply to either anthropology or geology.” Two of the group warned me off: “Don’t bother coming to my institution.” I was too scared to ask why. One voice, however, could be heard loudly and clearly espousing the future of interdisciplinary research and of the impending fruitful collaboration of geologists and archaeologists; that voice emanated from a crewcut marathoner with a curious name—Rip Rapp.

From the very beginning, no one appeared to grasp the vision of archaeological geology quite as clearly as Rip. So sure was he of this field's future that he even offered me an incredible three-year fellowship to join him and his colleagues at the University of Minnesota, to study not solely in anthropology or geology, but in the Center for Ancient Studies—a newly constituted interdisciplinary program. With the promise of truly interdisciplinary research and the opportunity to design my own unique curriculum, I, of course, accepted. And thus I became one of the center's inaugural five graduate students, free to reap the benefits of interdisciplinary scientific collaboration long before others visualized such an approach.

In no uncertain terms, my apprenticeship with Rip enabled me to jump-start my research and publication career, an opportunity for which I will be eternally grateful. He handed me my master's project, a field study of the Bronze Age site of Nichoria, Greece. When this work was completed, like any thoughtful mentor, he encouraged me to find my own doctoral dissertation topic and fashion my own future. My heart rested in American archaeology, so I began the search for a research project there.

A major problem still existed, however. In the year 1976 most archaeologists were as yet unfamiliar with the gestating field of geoarchaeology, or even saw the need to invest in it. Thus it took a venerable and preeminent geologist, Herbert E. Wright, who by his own admission longed to be an archaeologist as well, to point me in the right direction. In this case, the direction was toward the south and east of Minneapolis to the fascinating, albeit tick-infested, bottomlands of western Kentucky. There I would meet Patty Jo Watson, who, along with Rip and Herb, became one of my most beloved mentors. Pat and Herb shared an interdisciplinary leaning, which stemmed from their collaboration on Robert Braidwood's Jarmo Project. Jarmo is the site that brought together a team of geologists, archaeologists, and biologists to investigate the origin of agriculture in the Near East. Now, Pat had turned her attention to an American project, one conceived to investigate the origin of agriculture in the eastern woodlands of North America. For this venture, she sought a disciple of Herb's interdisciplinary zeal for both geology and archaeology, and thus began my career-long involvement in the Shell Mound Archaeological Project, a research path along which I am still traveling today.

In the intervening span of 25 years, there has been a remarkable change in the role of geoarchaeology in archaeological research. Virtually all archaeologists acknowledge the value of geoarchaeology, and many of them actively recruit geoarchaeologists to collaborate on their projects. Unlike the young Western Michigan bronco back in '73, students with these interests no longer must plead for the opportunity to study this field; rather, they are actively recruited to conduct geoarchaeological research at archaeological sites. Geoarchaeology at the turn of the millennium is integrated into the research goals of a substantial number of current excavations. And in the world of Cultural Resource Management, a geoarchaeologist's input is often mandated by the granting agency. Today, a student can consult the *Directory of Graduate Programs in Archaeological Geology and Geoarchaeology* on the Web and view the viability of graduate studies in geoarchaeology. Rip Rapp created this guide, and Rolfe Mandel continues to maintain and expand it. No longer do students have to resort to ambushing conference presenters. Most archaeologists appreciate that the formation processes of the archaeological record must be considered before they can interpret the behavioral aspects represented by the artifacts.

Clearly, such was not the case 25 years ago when I first started publishing my research. My first publications appeared principally in traditional archaeological journals, such as *American Antiquity* and *Southeastern Archaeology.* A host of diverse scientists—soil scientists, geologists, and archaeologists—commented on my early work on earthworms and coring, but without modern database search engines, those studies were lost to new scholars concerned with lithics, Mayan glyphs, or archaeological theory. Four edited volumes about geoarchaeology had appeared in the late '70s and early '80s (one by Stein and Farrand), but a person had to be a dedicated sleuth to access much of the geoarchaeological literature.

Today, the journal *Geoarchaeology* is devoted exclusively to geoarchaeology, and the *Journal of Archaeological Science* highlights the subject regularly. Numerous edited volumes and texts have appeared. Today's students can readily access the subject and study a varied selection of methodological and research results.

Securing an academic position in geoarchaeology has been perhaps my most satisfying personal accomplishment. I won't soon forget my first job interview at the 1979 AAA meetings; I had but 15 minutes to convince a group of skeptics that geoarchaeology was an exciting and potentially valuable new enterprise in archaeology. That group of archaeologists, who saw some possibilities and were willing to take a risk on something new and unproven, invited me to join them at the University of Washington. At the time, I was one of only a handful of geoarchaeologists working in a department other than geosciences, and those circumstances undoubtedly influenced my early work.

At the turn of the millennium, many more anthropology departments seek geoarchaeologists for tenure-track positions. Almost every year, one or two positions appear, some organized jointly with geoscience departments, others exclusively within anthropology departments. Search criteria vary; some positions seek geoarchaeologists with environmental and geomorphology training; others emphasize geochemical and geophysical backgrounds. Such employment opportunities were virtually nonexistent 25 years ago.

Receiving this award, I cannot help but feel extremely optimistic about the future of this field. Yes, the changes have been, for many of us, a bit slow in coming, and perhaps these changes remain too few and far between to meet the growing needs of the field. Whenever I grow impatient for change, I simply need to recall that 25 years ago, I had to hitch a ride to the GSA meeting, sit in the back of a dark room, and corner the experts on their way out the door to plead for an opportunity to work with them. Today, no one would consider it unusual for a young woman to stroll across a campus toward meetings with multiple faculty, who all understand the potential of geoarchaeology and would be able to guide her in this interdisciplinary research. In fact, at this [1999] GSA meeting, we have awarded just such a student, Jennifer Smith, the Albritton scholarship toward advancing geoarchaeological research. Things have changed.

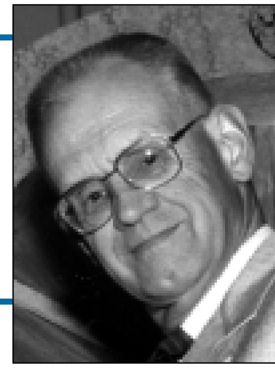
By any standard, the fact that students expect faculty to know about geoarchaeology represents remarkable progress for those of us who dreamed decades ago of weaving archaeology and geology together into one unique discipline.

I am happy that I was able to contribute to this remarkable change, along with the many other people in this Division, and I thank you for this award.

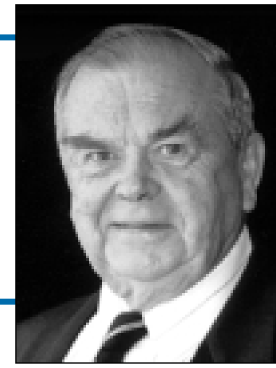
E. B. BURWELL, JR., AWARD

presented to

PAUL F. KARROW
and
OWEN L. WHITE



Karrow



White

Citation by Robert A. Larson

I am honored to present the 1999 E. B. Burwell, Jr., Award to Dr. Paul F. Karrow and Dr. Owen L. White for their publication *Urban Geology of Canadian Cities.* This book, Geological Association of Canada Special Paper 42, is 500 pages long, covers 25 cities, and was written by 59 geoscientists, including the editors. It represents a seven-year effort by Paul Karrow and Owen White, and it covers Canada from the Atlantic to the Pacific oceans. The editors proposed to revisit the cities included in the 1971 Geological Survey of Canada project to create a geotechnical data bank on Canadian cities with a population of at least 50,000. The charge to the authors was to summarize the geology and engineering geology of a city, review the current status of the geotechnical data bank, and discuss the fate of the 1971 compilation. They succeeded to a remarkable degree in achieving these goals.

The Burwell Award is presented annually to the authors of a published work of distinction which advances our knowledge concerning the principles or practice of engineering geology. *Urban Geology* is a work of distinction because collectively the papers provide a cross section of the geologic constraints and hazards facing Canadian cities; individually, each paper provides data pertinent to the practitioners of our profession who work in these cities; and the book will create awareness among the public and government officials of the inherent environmental problems that affect these cities. Each paper is well written and has excellent color and black and white diagrams, maps, and photographs.

Urban geology is a unique discipline with major ramifications for the health, safety, and welfare of the public, as well as the ability to cost-effectively build those microenvironments we call cities. For those who practice and for students who wish to practice this discipline in the future, *Urban Geology of Canadian Cities* will be the standard reference for years to come.

Paul F. Karrow received a bachelor of science degree in geological engineering from Queen's University, followed by a doctorate in geology from the University of Illinois in 1957. He then went to work for the Ontario Department of Mines for six years. He began a long association with the University of Waterloo, becoming professor of earth sciences in 1970. He has been a visiting scientist at the Scripps Institution of Oceanography, the University of South Florida (Tampa), the British Columbia Geological Survey, and the University of Arizona. He was director of the Quaternary Sciences Institute at the University of Waterloo from 1987 to 1989.

Dr. Karrow's expertise in Quaternary geology has been sought by numerous organizations and committees, including the National Research Council's Associate Committee on Quaternary Research, the National Advisory Committee on Research in the Geological Sciences, and the Toronto Advisory Committee on Subway Geology. He has served the Quaternary Geology and Geomorphology Division of the Geological Society of America and the American Quaternary Association. For nine years he was associate editor of the *Canadian Journal of Earth Sciences.*

Urban Geology is Dr. Karrow's fourth book. His association with Robert Legget led to his coeditorship of the 1983 publication of *Handbook of Geology and Civil Engineering.* His continuing efforts were recently recognized by the Canadian Quaternary Association, which in 1995 awarded him the W. A. Johnston Medal for professional excellence in Quaternary research.

Owen L. White received his bachelor of science degree in geology from the University of Melbourne, a master of applied science degree in geology and civil engineering from the University of Toronto, and, in 1970, his doctorate in engineering geology from the University of Illinois. Following his master's degree, he served as project engineer with the firm of Racey, MacCallum and Associates in Toronto. In 1960, he was appointment lecturer in the Department of Civil Engineering at the University of Waterloo, moving up in rank to assistant professor and, in 1972, associate professor. Dr. White left the university in 1977 to become chief of the Engineering and Terrain Geology Section of the Ontario Geological Survey in Toronto. He served in this position until retirement in 1991. He continues to teach and consult, but his major activity now is distributing geoscience books to overseas universities through the Association of Geoscientists for International Development.

Dr. White has provided distinguished service to professional societies. He belongs to 15 organizations and has served in more than 28 positions so far. From 1973 to 1979, he served as the first chairman of the Engineering Geology Division of the Canadian Geotechnical Society. He then became the vice president for North America for the International Association of Engineering Geology, and in 1987 he became the president of that prestigious organization. Dr. White was the first North American to serve in this capacity.

With more than 50 publications, Dr. White has contributed to our understanding of engineering and urban geology, Quaternary geology, and neotectonics. His achievements have been recognized by the Canadian Geotechnical Society, which presented him the Thomas Roy Award in 1996. In 1998, the International Association for Engineering Geology and the Environment awarded him the Hans Cloos Medal, the highest honor in the field of engineering geology.

Response by PAUL F. KARROW

I thank the Geological Society of America Engineering Geology Division for adding me to their select group of distinguished awardees of the E. B. Burwell, Jr., Award. It is indeed a great honor to receive this award for being coeditor and coauthor with Owen White of Geological Association of Canada Special Paper 42. Of course, the honor is shared with the 57 other authors, 56 reviewers, and GAC staff who helped produce the book. This award is a highlight of my life and career and has caused me to reflect on the events of the past half century.

At the time I was finishing high school, we were living in the Canadian capital, Ottawa. Parental encouragement for continued education was enhanced by advice on a possible career in geology arranged through meetings with George Hanson, director of the Geological Survey of Canada, and Robert Legget, director of the Division of Building Research of the National Research Council. I also talked to the registrar at Queen's University about geology programs in arts vs. engineering. I was told that the engineering program involved more structured drill work, whereas arts was more self-directed study and less structured. Having had some recent academic lessons along the lines of the Seven Sages' dictum "know thyself," I opted for engineering.

In 1952 I was hired for a GSC groundwater-Pleistocene geology field party in Quebec with Nelson Gadd. While the monotony of collecting water-well data discouraged me from a groundwater career, thanks to Nels's efforts to teach his field assistants geology, my interest was strongly engaged in the glacial stratigraphy and the Champlain Sea. At that time the young

Pleistocene Geology Section of the GSC under Vic Prest was a staff of ten, all engaged in Ph.D. work at different U.S. universities and each working in a different province. What a smorgasbord of experience and advice that offered! Nelson Gadd was at the University of Illinois and, although other alternatives for pursuing glacial geology were considered, the strength in engineering and soil mechanics directed me to Illinois for graduate work, with a thesis based on further GSC field work in the St. Lawrence Valley of Quebec and the Champlain Sea.

My program at Illinois specialized in Pleistocene geology with a minor in civil engineering. I was privileged to have courses from Ralph Peck, Tom Thornburn, and Don Deere, as well as enjoying the annual visits of Karl Terzaghi, as I progressed toward my Ph.D. I nevertheless became more interested in pure geological research than in engineering applications. When job opportunities arose, I chose the Ontario Department of Mines over a job with an international consultant working on a dam site in the West Indies. Thus, in 1957, I moved to Toronto.

Although this may sound like good-bye to engineering, it was not. My main government work was mapping glacial geology. I identified as my main purposes delineating not only the distribution of surface materials, but, as far as available information allowed, the three-dimensional geometry of sediment bodies, at the surface and below. My focus was on stratigraphy as the avenue to understanding geological history and the relationships between sediment bodies. Data and interpretations had obvious application to engineering practice for construction with, on, and in geological materials. Work for the Ontario government was done in a context of practical ends, so engineering, including aggregate assessment, was the chief application for the mapping. At the same time, much was learned and much discovered that enhanced our state of geological knowledge.

Urban geology really became important in my mapping in Ontario. Population density was a factor in prioritizing areas to be mapped. My engineering training gave me appreciation of the information needed for engineering design, gave me the language of geotechnical engineering, and gave me access to rich resources of engineering data to enhance the geological work. Among other things, I soon contacted the Metropolitan Toronto Works Department to log all their borehole samples. I was not deterred by their storage in a sewage plant and that by the end of the day I was reeking.

In 1959, I met Owen White, just arrived from Australia to do an M.Sc. in geology at the University of Toronto. We soon discovered much of common interest and established a continuing friendship and professional relationship. He took a lectureship in civil engineering at the University of Waterloo in 1960 with my civil engineering classmate from Queens, Don Scott (also an Illinois Ph.D.). When I decided to leave the Ontario Department of Mines (ODM) and try university teaching in 1963, it was to join the Department of Civil Engineering at the University of Waterloo. In my last year at ODM, I had begun mapping the Bolton area, northwest of Toronto. I persuaded ODM to hire Owen as my senior assistant in 1963 to map the area; this study became the subject of Owen's Ph.D. thesis in geology at the University of Illinois.

While I was in civil engineering at Waterloo, 1963–1965, Owen was on leave for his Ph.D. at Illinois. On his return, the plan was to form a geotechnical group in civil engineering. However, Scott departed for Ottawa, and the university decided to establish a Department of Earth Sciences, for which I became chairman and left civil engineering in 1965.

In the Waterloo Department of Earth Sciences, I successfully advocated that we complement existing geology departments, leaving mining and petroleum to them and developing strength in hydrogeology, environmental geology, and engineering geology. Thus, after developing the undergraduate programs and as we were about to get into graduate programs, we hired Bob Farvolden to succeed me in 1970 and carry on department expansion into the new areas. A couple of years before, we had hired Bob as a session lecturer to offer the first groundwater course in Ontario, on Saturday mornings so a large number of the staff of the Ontario Water Resources Commission could come from Toronto to get their first course in the subject.

In the early 1970s, Owen and I were awarded a contract by the GSC to gather geotechnical data for Waterloo as part of a national urban program. This system was computerized on the mainframe at Waterloo. In 1977, Owen left Waterloo for the Ontario Geological Survey, and in a later role reversal hired me to map the Brampton area (1984–1987).

Association with R. F. Legget and our common experience and interest led me to suggest to Owen late in 1991 that we organize a symposium on urban geology for the 1994 annual meeting of the Geological Association of Canada, then being planned for Waterloo. During and returning from sabbatical at Victoria, B.C., in 1992, I recruited authors for Victoria, Vancouver, Edmonton, Saskatoon, Winnipeg, and Ottawa. By 1994 papers on 17 cities were presented at the Waterloo meeting, and additional cities were included after it. As objectives for the papers, we identified a summary of the geology, a review of the engineering and environmental characteristics and problems, and the status of geotechnical databases, including the fate of the GSC project of 25 years earlier. It is indeed a pleasure to have our efforts judged worthy of the Burwell Award for 1999.

We share our appreciation through thanks to parents, teachers, family, for University of Waterloo infrastructure, and to the many people involved in making the book a reality.

Response by OWEN L. WHITE

Thank you indeed for the great honor that you, through your colleagues in the Division and the Society, have bestowed upon Paul Karrow and me in awarding us the E. B. Burwell, Jr., Award. I thank you, too, on behalf of the contributors to the volume who share this honor with Paul and me.

When I remember the previous recipients of this award, I am indeed honored and grateful that you have chosen Paul and me to join that distinguished group of colleagues.

Looking back on my lifetime in engineering geology, I acknowledge with pleasure and gratitude the many contributions that friends have made in my progress through the profession and who have contributed to the opportunity I have to be in this position today. Many of those friends have been and are members of this Division, but perhaps one of the most remarkable of all those friendships is the 40-year friendship and professional association I have enjoyed with my corecipient, Paul Karrow.

I owe my start in engineering geology to a civil engineer who was undertaking his Ph.D. at the University of Melbourne when I was a technical assistant there in the Materials Testing Laboratory. Gordon Aitchison, then with the Commonwealth Scientific and Industrial Research Organisation, urged me to apply my geological studies, being undertaken on a part-time basis, to civil engineering and, in particular, to soil mechanics. After completing my degree at Melbourne, I headed for Toronto to take a master's degree in Quaternary geology and soil mechanics. At that stage of my career, I met Paul, recently arrived at the Ontario Department of Mines from the University of Illinois.

Another civil engineer, Douglas Wright, then dean of engineering at the new University of Waterloo (and, later, president) and recognizing the need for a significant geotechnical and geological component in the civil curriculum, appointed me to teach geology to the civil engineering students. Two years later and with much encouragement from the dean, my geotechnical colleague Don Scott, and Paul Karrow—all Illinois graduates—I could not escape from starting a doctoral program at Illinois. Contact with the infectious enthusiasm of our own Don Deere and the late Tom Thornburn at Urbana prepared me for a life in engineering geology.

Shortly after my return to Waterloo, I encountered another member of the Illinois "mafia"—John Scott, then with the Geological Survey of Canada. John provided support and advice in the years at Waterloo, as did Robert Legget. In the early 1970s, John Scott initiated the collection of geotechnical data in urban areas across Canada, starting the process that led to Paul's suggestion for "the book," 20 years later.

It was in this period of frequent discussions with John Scott that he encouraged me to get involved in the organizational aspects of engineering geology. At John's suggestion, I was appointed in 1973 the first chair of the Engineering Geology Division of the Canadian Geotechnical Society, and it was at his urging that I followed him as vice president, North America of the International Association of Engineering Geology for the period 1978–1982.

By this time, I had resigned from the University of Waterloo and was appointed chief of what was to become the Engineering and Terrain Geology Section of the Ontario Geological Survey. In an organization that was singularly devoted to Precambrian geology in northern Ontario and the exploration and mining industry, it was not easy to establish a program in engineering geology, especially in urban areas. But with the support of a very capable and enthusiastic staff (many of whom had graduated from Waterloo) we managed to almost complete the mapping of the Quaternary deposits of southern Ontario, develop an extensive database of the Paleozoic deposits at depth in both southern and northern Ontario, considerably expand the aggregate resources inventory of the province, and embark upon an almost unprecedented terrain evaluation of some 500,000 km^2. The latter was undertaken largely by a team of consultants led by John Gartner of Toronto and Jack Mollard of Regina (both of whom also provided much encouragement and input in the production of *Urban Geology).* Over the years, we did manage to compile some urban geotechnical data as a supplement to Paul's mapping and to participate in joint projects of site studies with the Ontario Hydroelectric Power Commission. My last few years at the Ontario Geological Survey coincided with my election to a four-year term as president of the International Association of Engineering Geology.

On retirement from the OGS, my adjunct appointment at Waterloo took on new life as I embarked with Paul on a project to invigorate the geological data bank of the Kitchener-Waterloo area, which had languished in the Waterloo mainframe for 15 years. In the meantime, John Scott had climbed several major rungs in the Geological Survey of Canada, but he provided moral support as we returned to action. At about this time, Paul suggested an urban geology symposium at the proposed 1994 Annual Meeting of the Geological Association of Canada at Waterloo.

Projects and results like *Urban Geology of Canadian Cities* are derived not from the efforts of one or two persons, but come from those of the authors and the editors and from all the people who have contributed to the honorees' past activities. For me this means especially my wife, Elizabeth, who has supported me through graduate school, professional life, and, now, retirement.

Again, Robert, thank you indeed for the honor that has been bestowed upon Paul and me. I shall cherish this award with the deepest gratitude.

GEORGE P. WOOLLARD AWARD
presented to
FRANK M. RICHTER

Citation by Donald J. DePaolo

In discussing the choice of Frank Richter for the Woollard Award, three questions suggest themselves. (1) Why give an award to Frank M. Richter? (2) Why give a geophysics award to Frank M. Richter? (3) If one gives a geophysics award to Frank M. Richter, why have a geochemist do the citation?

Why give an award to Frank M. Richter? Normally one might give an award to someone who has done particularly imaginative research. One might also choose a person whose research has provided lasting insights into the way Earth works, or provided the basis for much more research by others. Frank Richter, of course, has accomplished all three. From mantle convection, to planetary thermal evolution, to sedimentary diagenesis, to melt segregation, to ocean history, to Ar geochronology, to diffusion in silicate melts, Frank has provided imaginative approaches and deep insights. Frank has provided so many insights, on such a broad range of topics, that almost no one appreciates them all.

Frank is the quintessential reductionist. His business is making models of complex natural phenomena. His approach is to use "simple models." To quote from his first major published paper on the relationship between plate tectonics and mantle convection (slightly edited): "Simplicity has its virtues. It leads to solutions that can be confirmed by alternate mathematical techniques.... Furthermore, it may well be that, unless simpler models are first understood, complex cases will not be interpretable in terms of the contributions of individual factors to the overall result. It seems necessary, and perhaps even desirable, to consider relatively simple model problems at the outset."

Throughout his career, Frank has succeeded in solving and incisively interpreting model problems that teach us about how things work on Earth. He is often challenged with the statement, "Yes, but the real Earth is much more complicated." To which he typically replies, "Yes, but if you can't understand this simplified problem, how can you expect to understand Earth?"

Why give a geophysics award to Frank M. Richter? Frank is no longer identifiable as a "geophysicist," at least by most geophysicists. So what geophysics has he done? (Not that this is an issue, since George Woollard's interests also ranged outside of traditional geophysics.) By most reasonable measures, Frank did a career's-worth of geophysics in the first 10 years or so after receiving his Ph.D. from the University of Chicago in 1972.

In his first publication in 1973, which is based on his Ph.D. thesis, Frank used simple 2-D models of convection to investigate which of the available sources of energy in the earth could drive plate tectonics. It was the first formal application of fluid mechanics to the issues surrounding mantle convection on the global scale. The analysis begins with a critical appraisal of the simplifications made—and concludes that the models used are only barely good enough for the application. Nevertheless, with characteristic elegance, Richter showed that vertical temperature gradients in the earth were ineffective in driving the plates via traction at the base of the lithosphere, and that horizontal temperature gradients could break up continents, but could not drive plate motions in the long term. He also treated the contribution of phase transitions to convection, and finally concluded that the negative buoyancy of subducting plates was the primary driver of plate motions. This paper, with the Oxburgh and Turcotte paper of similar vintage, was the parent of modern studies of mantle convection which now take the form of 3-D, densely gridded simulations with strikingly beautiful color renditions of the output. But Richter got much of it right with simple models in 1973 (and, I might add, with characteristically frugal illustrations).

In the mid-70s, Frank addressed two other major issues of mantle convection—the small-scale convection beneath the plates and layered mantle convection. In a paper with Barry Parsons, he showed that small-scale convection is likely to be important. It would account for the heat flow in the older part of the ocean basins, but it would not contribute to driving the plates. Frank and Carl Johnson did a similarly elegant analysis of the requirements for producing layered convection.

There are a number of other papers, of course, in which Frank and colleagues investigated other aspects of mantle convection and the implications of different modes of convection for Earth's thermal history. Most of the major issues in mantle convection were addressed in these papers.

My conclusion is that it is entirely appropriate to give a geophysics award to Frank Richter, for although he was a youngster when he did geophysics, he was a prodigy.

If one gives a geophysics award to Frank M. Richter, why have a geochemist do the citation? To most geophysicists, Frank

Richter now appears to be a geochemist. He got himself on the slippery slope of geochemistry about the time I was finishing my Ph.D. at Caltech and while he was visiting there. It started with a paper entitled, "On the importance of advection in determining the local isotopic composition of the mantle," co-authored by Neil Ribe. Richter was the first of the mantle dynamicists to recognize that geochemical observations could provide information on mantle dynamics. Rather than be restricted to material properties like density and viscosity (thermal diffusivity doesn't vary much anyway), geochemistry offered the whole periodic table, radioactive decay, and chemical diffusivity (which does vary from element to element). Frank later recognized that geochemists sorely needed dynamicists to help organize their observations. Over the past 20 years, Richter has been a geochemical dynamicist, for the most part. The gap between geochemistry and geophysics has filled in to a substantial degree during this time, but Frank was among the first to jump into it. And what he has succeeded in doing (to paraphrase the citation for the Woollard Award) is to bring the "methods and approaches of mathematical geophysics, to geochemistry."

Because of Frank's efforts, we now understand better isotope redistribution during diagenesis (an advection–diffusion–chemical exchange problem), destruction of chemical heterogeneities in the mantle by convective stirring, the frequency sensitivity of paleo-ocean geochemical records, the loss of Ar from minerals at high temperature, the chemical effects of melt segregation from partially molten mantle regions, and the effects of multicomponent diffusion in silicate liquids. More is on the way. At the beginning of the 20th century, the term "geophysical chemist" was in use, and perhaps it should be revived. But in any case, one can't go wrong in selecting Frank M. Richter for an award in geophysics or geochemistry.

So it is with great pleasure that I join the Geophysics Division in congratulating Frank on his selection as the 1999 George P. Woollard Awardee.

Response by FRANK M. RICHTER

Given Don's very kind words and overview of my career to date, I could be forgiven for doing nothing more than expressing my gratitude to the selectors of the Woollard awardee and thanking Don for making their selection seem so plausible. But I hesitate to violate the traditional rules for an acceptance speech, which state that one should not only thank the selectors and the citationist, but all persons who had a role in shaping one's career and, furthermore, establish some connection, however remote and implausible, to the person after whom the award is named.

I will try to satisfy these rules by telling a brief story that could be called The Accidental Geophysicist.

Accident 1 involves Fidel Castro, who came to power while I was still in high school in Havana, Cuba. I had always intended to come to the United States for my university studies, but in the aftermath of the Cuban revolution, I would only be allowed to do so if I were to study a subject needed by Cuba, but not taught there. Geophysics was on the approved list, and you can imagine how rapidly I developed a passion for geophysics. By gaining acceptance to the Colorado School of Mines, I was allowed to leave Cuba.

Accident 2 involves Bill Heinz. By the time I graduated from the Colorado School of Mines (with a less than distinguished record), the United States and Cuba had broken diplomatic relations, so I stayed in the U.S. employed as an exploration geophysicist by the Anaconda Company. Bill Heinz, then a professor at Michigan State (now at Purdue), was an Anaconda consultant who often helped me design and interpret aeromagnetic surveys. Bill encouraged me to consider graduate school, and he was kind enough to get me admitted to Michigan State without my having to file a formal application, which would have disclosed my dismal undergraduate record. My time at Michigan State was very productive indeed. I courted and married Theresa Webber who has been Theresa Richter ever since. And thanks to Bill and his excellent connections to scientists at the Naval Research Labs, I was given an early and very persuasive exposure to seafloor spreading and plate tectonics. Bill is also my connection to George Woollard, in that Bill was a graduate student with Woollard at Wisconsin, and so you might say I am in fact George Woollard's academic grandson.

Accident 3 involves Bill Wood and Bob Miller. Bill Wood was a Bill Heinz graduate student whose thesis work involved coastal dynamics, and Bob Miller was a professor at the University of Chicago who was an external advisor and examiner for Bill Wood's dissertation. I first met Bob Miller at Bill Wood's thesis defense, and we became much better aquainted during the course of a long evening celebrating Bill Wood's success. After a few (maybe a bit more than a few) toasts, Bob Miller let it be known that he was the newly installed admissions councilor for the Department of the Geophysical Sciences at Chicago. A few more drinks and I was invited to apply; a few more, and I accepted. (Who would want to ruin a good party by saying no to so generous and spontaneous an offer?) And so, again without formal application and with nothing very specific in mind, I was off to the University of Chicago.

Accident 4 involves Joe Pedlosky. Having accepted me into the Ph.D. program at Chicago, Bob Miller felt a certain responsibility for finding me some sort of financial support. I can still see the twinkle in his eye as he came up with the idea that he would foist me on a newly arrived young professor, Joe Pedlosky. Joe, having just arrived from MIT, did not yet have any students, and I guess he figured, what the hell, I may as well give this unknown quantity a try. We were a pretty mismatched pair to start with, Joe being a fluid dynamicist working on baroclinic instability theory while I was, if anything, an exploration geophysicist who was still in state of utter confusion because geophysics at Chicago was so broadly defined as to include the behavior of fluids. In fact the Department of Geophysical Sciences was a relatively new creation at Chicago, having been formed by combining the departments of geology and meteorology. The name Geophysical Sciences was adopted to avoid any appearance of favoritism of one of the merged departments over the other, because nobody did geophysics sensu strictu at the time. Given my somewhat baffling new circumstances, the only thing that seemed to make any sense at all was that I should learn some fluid dynamics and apply it to what I knew at least a bit about, the solid Earth. And so, by a series of accidents, I became a mantle dynamicist at just the right time, given that the acceptance of plate tectonics clearly implied that Earth's mantle must behave in a fluid-like manner on long time scales. All sorts of new questions involving the fluid dynamics of the planetary interior just begged for an answer. Don has told you a bit about my involvement with some of these.

All but one of these accidents involved someone having greater confidence in me than I myself had at the time. I would like to thank them all, and I hope I have to some degree justified their confidence.

HISTORY OF GEOLOGY AWARD

presented to

DAVID ROGER OLDROYD

Citation by Ursula B. Marvin

When David Oldroyd entered Emmanuel College, Cambridge, in 1955, he spent almost as much time playing his cello as he did studying chemistry, his major subject, or geology, the one he enjoyed the most. After receiving his B.A. in 1958, he taught chemistry for four years at a school in Harrow.

In his second year there, he attended a teachers' conference at Oxford during the heady days of C. P. Snow's "Two Cultures." As speaker after speaker declared that the history and philosophy of science could serve as a bridge between the sciences and humanities, the thought struck David that, as a science teacher with musical proclivities, he, personally, might help to bridge the gap. His enthusiasm grew when he learned how interesting the history of science can be. Presently, David enrolled in evening classes at University College, London, to work toward an M.Sc. in history and philosophy of science—a tall order while teaching full time, playing the cello in orchestras and string quartets, starting a family, and rebuilding a house.

Then came 1962, the year his life would change dramatically. While walking past New Zealand House, David noticed a posting of teaching positions; with travel expenses paid, housing provided, and belongings transported. In due time, David and his wife, Jane, with their two young children, a fine 18th-century cello, and £50 in their pockets, sailed for the antipodes.

The following year, David passed the written examination for the M.Sc. at University College and selected a thesis topic he would have to work on in New Zealand without an advisor. The next seven years were BUSY. While teaching full-time, David began holding down a second teaching job and working on his thesis, which involved reading early texts and examining the geology of both the North and South Islands. He also took odd jobs harvesting crops and pruning pine trees. Meanwhile, Jane ran the household, looked after the children, and spent long hours cutting asparagus and picking beans and fruit. Later on, Jane earned an M.A. in English literature and now serves in an administrative position at Macquarie University in Sydney.

In 1967, David received his M.Sc. for his dissertation: *Geology in New Zealand prior to 1900,* which he now describes as very unsophisticated and excessively Whiggish. Be that as it may, it made him eligible for a university position, and in 1969 the Oldroyds moved to Australia, where David accepted a lectureship in the School of History and Philosophy of Science at the University of New South Wales. Once there, he chose a Ph.D. topic: "The Influence of the Chemical Revolution on Mineralogy." The head of the school approved, and recommended that he consult the work of T. S. Kuhn. David remembers looking up "Coon" in the library, but he soon straightened that out and embarked on a thesis that expanded to: "From Paracelsus to Haüy: The Development of Mineralogy in Relation to Chemistry," for which he received his doctorate in 1974.

In his teaching and writing, David Oldroyd has distinguished himself, internationally, for his remarkable breadth of interests and depth of understanding. He has written five books, two of which have been translated into Spanish, Italian, German, Turkish, and Chinese. He also has edited three books, written 11 book chapters, and served on the boards of five journals. He has published nearly 60 refereed articles, plus more than 130 essay reviews, book reviews, and encyclopedia articles, mainly on geology and chemistry but also on the history of music and other wide-ranging topics. His best-known work to date is *The Highlands Controversy* (1990). David was the first historian of science to be elected a Fellow of the Australian Academy of the Humanities.

I first became acquainted with David in 1976 at the International Geological Congress in Sydney. In 1995, as I was completing my term as secretary-general of the International Commission on the History of Geological Sciences, I discussed my possible successor with the other officers. We agreed that he or she should live in a far country and, given the economics of the situation, have access to a word processor and e-mail and, if possible, institutional support for mailings and travel to meetings. In addition, I hoped to find someone who would get as much fun out of the position as I had. No one seemed better fitted, so, with his permission, the INHIGEO Board nominated David. He was elected to the office in 1996.

Since then he has served as secretary-general with outstanding success. One of his first actions was to get an ISSN number for the annual INHIGEO Newsletters. By now he has issued three of these, packed with meeting reviews, book reviews, country reports, and much besides, each one filling nearly 80 pages.

David retired from his full professorship in 1995 to devote his time to research and writing. Since then he has published two books—*Thinking About the Earth: A History of Ideas in Geology* in 1996, and *Sciences of the Earth: Studies in the History of Mineralogy and Geology,* in 1998. He is currently researching the history of geology in Britain—delving into archives and visiting key outcrops in the field. We look forward to his next volume, *Fire, Water, and Ice: The History of Lakeland Geology,* scheduled to appear in 2001.

David has presented several named lectures and served as a Distinguished Visiting Scholar at Concordia University in Montreal. In 1993, he was the first member of the Faculty of Arts and Social Sciences to receive the degree of Doctor of Letters from the University of New South Wales. In 1994, he received the Sue Tyler Friedman Medal of the Geological Society of London. I understand that he still is getting much pleasure from playing his beautiful old cello at home and in concerts.

Response by DAVID ROGER OLDROYD

I greatly regret being unable to accept in person the award for which I have been so generously and unexpectedly, and I suspect undeservedly, named. The reason for my absence is rather extraordinary: a ride on a dromedary near the edge of the Gobi Desert along with a Chinese lady cellist friend of mine! Perhaps you may understand, then, why I pleaded a previous engagement when I was invited to Colorado to accept this award—an occasion that I should naturally be loath indeed to miss under normal circumstances.

But I'm not usually quite so extravagantly exotic. I wrote these lines from the charming town of Freiberg in Saxony, where INHIGEO was enjoying the wonderful hospitality of our German hosts, celebrating the 250th birthday of their patron saint, Abraham Gottlob Werner. For the past 15 years or more, I have restricted my intellectual work chiefly to the study of the history of geology; for this is the thing I love doing most. So an opportunity to visit Freiberg was not to be missed.

The point of it all for me is that it takes one to wonderful places and enables one to meet wonderful people—like, for example, Dr. Ursula Marvin, who has been immensely encouraging and wise in her counsel over the last few years. I do thank her so much, therefore, for her kind words. They are greatly appreciated, and I should say what a delight and an honor it has been to take over the baton from her in regard to the work of INHIGEO.

I seem to be getting into a peculiar situation these days, and one that I never dreamed of when, long ago, I had to make the easy career choice between science teaching, coal mining, or being a soldier for two years of national service after completing my degree. That is, I seem to have become the beneficiary of what the distinguished American sociologist R. K. Merton called the Matthew Effect: "Unto every one that hath shall be given, and he shall have abundance."

It is a happy state to be in, and naturally one may wonder how to get into it. It is quite simple: ask a good, informed friend to read anything you have written before you attempt to publish it. Always ask your friends to give your work thorough scrutiny. This formula I have found to be infallible. Thus, for example, an INHIGEO colleague, Kenneth Taylor, recently improved a paper of mine immeasurably by his careful reading of the text. Ursula Marvin did likewise with the typescript of my book *Thinking About the Earth,* saving me from some execrable solecisms about matters meteoritic. So, I suggest, having good friends is the secret of gaining acceptance of one's work in the world of academe. I commend everyone to cultivate good friends, and make use of them unashamedly! Among such friends I should mention, for example, Robert Gascoigne, David Miller, Kenneth Taylor, Gordon Herries Davies, Thomas Vallance, Hugh Torrens, David Branagan, Ursula Marvin, and many others besides.

However, I suppose there is something a little bit distinctive about the work I've done. Of late, it has always been an accompaniment to a holiday—in attractive parts of Britain. Thus, I have made for myself a modest cottage industry concerned with the history of geology in my home country, in northwest Scotland, in Wales, in the Inner Hebrides, and most recently in the Lake District. This self-indulgent practice started because I always had to get away from Australia during periods of study leave, to enable me to get on with my work undisturbed. Another consideration is the fact that distances in Britain are relatively short, the maps are excellent, and local experts are thick on the ground but not in the head. Thus, I believe that my historical work, such as it is, has a certain freshness because it grows from my own experiences and not just library or museum enquiries. Of late, I've been trying my hand at oral history, with what success remains to be seen.

My Australian friends do not approve. They complain that I don't write about the history of Australian geology. But for me, wandering in a desert does not have the charm of the conveniently placed cozy pub in the Lakes. And we only have one-humped camels, not the two-humped kind, in Australia. So, as you will gather, I'm a self-indulgent man in the matter of my chosen field of work. That it should attract the approbation of the Geological Society of America is, I confess, a matter of genuine surprise to me. However, I do have good friends, and this must surely be the explanation.

My warmest thanks, then, for your approbation and appreciation of my self-indulgent habits.

[David Oldroyd's statement was read in his absence by Kenneth Taylor, chair of the History of Geology Division.]

O. E. MEINZER AWARD
presented to
EDWARD A. SUDICKY

Citation by Carl A. Mendoza

It is both a pleasure and a privilege for me to introduce Dr. Edward Sudicky, from the University of Waterloo, as the recipient of this year's O. E. Meinzer Award. I graduated from Waterloo in 1993 and was Ed's third Ph.D. student. For me, Ed has been an outstanding friend and mentor. For the hydrogeological community at large, Ed has been an outstanding, and prolific, researcher in a number of areas.

First, some insight into Ed's personal life: He likes cars. When I was a grad student, Ed drove an old Mustang, but not just any Mustang. It was truly a muscle car, with high-performance tires, engine, and transmission. It got only about six miles to the gallon, which probably accounted for the fact that it had relatively low mileage when he finally sold it. Now that he has somewhat matured, reached the rank of full professor and volunteered to be chair of his department, Ed's taste in cars definitely has a European bent. Ed has four daughters, most of whom have been involved in figure skating. Ed spends a good deal of time driving his BMW from one rink to another for practices, coaching, and competitions. His wife, Nina, helps keep his personal life organized and on track. She has also graciously hosted a good number of grad students who "just dropped by for a beer," but stayed for many hours, usually talking about such mundane things as hydrogeology.

Ed's teaching abilities have influenced a large number of students. In Waterloo's porous media course, Ed's lectures on stochastic approaches to dispersion initially blew most of us away. However, once we sat down to think about it and work through some of the mathematics (that is, the math that we could), it actually made sense. He also teaches a course on solving hydrogeological problems with analytical techniques. His course notes were detailed and lucid. I still refer to them, along with his porous media notes, on a regular basis. To a large degree, the enthusiasm and ease with which Ed approached teaching led me to pursue an academic career. The same is true for others: five of the eight Ph.D. students that Ed has supervised have professorial positions, and another is pursuing a post-doc.

Ed is a terrific supervisor who cares deeply about his students. I recall several times that an M.Sc. student was having terrible troubles with a code, and the thesis deadline was approaching fast. In each case Ed stayed up until 5 or 6 in the morning to fix the problem. His students are first author on papers, and he strongly encourages them to present papers at conferences. There is always a large "Sudicky crowd," of current and former students, at GSA and AGU conferences. Ed also likes to have numerous research meetings and discussions; however, formality is not his strong suit in these cases. The preferred venue is the Grad House (the grad student pub). Ed always has a ton of ideas, and he freely shares them. A typical afternoon session when I was a grad student would result in three or four "things to try" the following day. Some failed, many worked, and my research has benefited greatly from Ed's suggestions.

Dr. Sudicky, the researcher, is a Fellow of AGU, editor of the *Journal of Contaminant Hydrology,* president of the IAHS Commission on Groundwater, and the 1994 Darcy Lecturer. He is also a likable, approachable guy who has a tremendous grasp of what is important and what is not.

A significant part of research requires knowing the history: what has been done before and by whom. Ed has an amazing system. His journals sit on a shelf and his collection of reprints are in a box on the floor. In 1992, the reprint stack was twice as high as the box. If asked about a specific topic or reference, Ed either directs you to an issue on the shelf, plus or minus a couple, or dives into the stack at a particular elevation. Invariably he is within a few papers of the intended reference.

Ed has published well over 70 journal papers in his short research career; however, the Meinzer Award is being presented for three particular papers coauthored with his students. His research interests include the development and application of models, both analytical and numerical, to describe groundwater flow, multiphase flow, and mass transport in heterogeneous porous and fractured media, subsurface remediation, groundwater–surface-water interactions, and quantification of model uncertainty. The papers he is cited for cover only a small part of this spectrum.

Burr, Sudicky, and Naff (*Water Resources Research,* v. 30, no. 3, 1994) provides a detailed look at the uncertainty associated with model predictions for reactive mass transport in heterogeneous media. The results call into question some of our conceptual ideas concerning the application of stochastic methods in such systems, compared to nonreactive cases. Ibaraki and Sudicky (*Water Resources Research,* v. 31, no. 12, 1995) examines the case of colloid-facilitated transport in fractured media. This paper provides important limits on the conditions under which colloid transport may lead to enhanced migration of sorbed solutes. Finally, Therrien and Sudicky (*Journal of Contaminant Hydrology,* v. 23, no. 1-2, 1996) addresses the complicated problem of flow and transport in variably saturated, discretely fractured media. Hydrogeologists have been plagued with understanding the behavior of such systems for decades. The results of this paper provide significant insight into the physical processes responsible for many misleading observations.

Please join me in congratulating Edward Sudicky, recipient of the 1999 O. E. Meinzer Award.

Response by EDWARD A. SUDICKY

Thank you very much, Carl, for those kind words, and thanks to the Meinzer Award Committee in selecting me for this honor on the basis of the three papers cited. When I first learned that I was to be this year's recipient of the Meinzer Award, you can't image how completely surprised and overwhelmed I was. I am indeed humbled that those three papers will be included in the impressive list of Meinzer Award papers. I have always believed that credit should be given where credit is due, and hence it would not be proper for me to be standing here without recognizing the major contribution of my coauthors. Darin Burr, Motomu Ibaraki, and René Therrien are all former graduate students who molded a few of my modeling ideas discussed over a beer into theses upon which the cited papers are based. Darin is now a consulting hydrogeologist in Canada, Motomu is a professor at Ohio State, and René is a professor at Laval University in Québec, Canada. Rich Naff of the USGS in Denver has probably forgotten more about stochastic transport theory than I'll ever know, and his mathematical prowess was critical to the analysis contained in the Burr et al. paper.

In fact, it was Rich's Ph.D. thesis work on macrodispersion, presented at the GSA meeting in Toronto in 1978, the first conference I ever attended, that gave me some of the stochastic mathematical tools used to interpret my natural-gradient tracer test conducted in the Borden aquifer. This tracer test, carried out in 1978 during the very early days of hydrogeological studies at Borden, formed the basis of my M.Sc. thesis on scale-dependent dispersion, under the tutelage of John Cherry. John, who continues to be one of my mentors and is a previous recipient of the Meinzer Award, has taught me the value of persistence and critical thought, and to always keep the "big picture" in mind. John also taught me the "amazing" filing system that Carl referred to, whereby reprints of papers are kept stacked high in unlabeled boxes scattered about the office. Since becoming chair of the Earth Sciences Department at Waterloo a couple of years ago, I've taken advantage of this system to file the many administrative memos and documents I receive on a daily basis. The one important change I've made to the system in this case is that most of these memos go into the so-called "circular file" instead of a box, and hence the pile never gets very high, owing to the nightly rounds by the janitorial staff.

I should perhaps give a little background as to how I ended up working in the field of hydrogeology. As an undergraduate, I studied civil engineering and originally focused on structural aspects. I soon became disenchanted with designing beams, because there was little challenge; material properties were known to the nth decimal point, and design recipes were well established from building codes. My course work then migrated toward water resources systems, mainly surface water, which I found to be much more fulfilling and challenging because of the uncertainty associated with natural systems. Then, in my senior undergraduate years, we were allowed to take a few optional courses from other faculties. I heard of this fourth-year course on groundwater, a topic of which I knew very little, being offered by Bob Farvolden in the Earth Sciences Department. I decided to take it. Bob was an amazing and inspirational lecturer, and I learned from him that there was even more uncertainty associated with this field of groundwater. In fact, Bob would deduct marks on an assignment if you calculated and reported a hydraulic conductivity value with more than two significant figures. This course was followed by summer jobs doing research for John Cherry, Emil Frind, and Bob Gillham. I'll never forget my first summer job with John. He asked me to set up and run a 2-D finite element model, in those days using punched cards, for a variety of cases to illustrate the effects of geologic layers and lenses on subsurface advective flow paths. Not knowing that particle tracking routines existed, I spent three solid months manually tracing particle paths from one finite element to the next on tracing paper overlaying the mesh, using a calculator and printouts of the velocity vector components for each element. The product of this tedious exercise led to Figure 9.8 in Freeze and Cherry's classic text, *Groundwater*, and an offer to do a master's degree with John when I graduated from engineering. This was in turn followed by a Ph.D. with Emil Frind because it was clear that I needed to upgrade my modeling skills.

Upon completing my Ph.D. in 1983, a time when sophisticated 3-D stochastic transport theories were emerging to explain scale-dependent dispersion, I thought it would be a useful exercise to go back into the field at Borden and test whether these theories made sense. At that time, the large-scale natural-gradient test was underway as a joint Waterloo-Stanford project. Following the Waterloo tradition of sampling overkill, many hundreds of permeability measurements were taken along numerous cores and analyzed geostatistically, and the results were inserted into theoretical expressions to predict dispersion parameters. The outcome of this exercise, which I published in *Water Resources Research* in 1986, proved to be fruitful from several perspectives. Stochastic macrodispersion theory seemed to make sense, it motivated other researchers to further test the theory at other sites, and the recognition it somehow brought me led to a faculty position at Waterloo in 1985. The latter point was particularly important to me because my wife Nina would keep reminding me that I had her and four young daughters to support and no real job.

Since joining the faculty, I have been particularly blessed to be associated with so many talented and hard-working graduate students. As Carl mentioned, many of my Ph.D. students have gone on to pursue productive academic careers supervising their own graduate students, and all of my former M.Sc. students are either making positive contributions in the consulting industry or have gone on to Ph.D. studies. During their studies, I try to provide a research environment that is stimulating, enjoyable, and rather informal. I encourage them to present their research on a frequent basis at major conferences such as GSA and AGU meetings, or I simply bring them along even if they are not presenting, just to meet the seasoned researchers they read about in the literature. They also become close friends of my dear and understanding wife, Nina, who likes to act as a surrogate mother whenever they drop by the house, which turns out to happen rather frequently. They also become extended family to my daughters, Nicole, Jennifer, Lindsay, and Meagan. Once in a while they even get to drive my prized car, to either drop off one of my daughters at the figure skating rink or to replenish the supply of beverages during a backyard barbecue.

Finally, I thank my father, Andrew, who, I am sad to say, passed away earlier this year, and my mother, Doris, for all their support and encouragement. Dad never received a formal education, but he was a very intelligent man who read books prolifically. He even read Freeze and Cherry in addition to the occasional journal paper on hydrogeology. I remember when I was still a graduate student and he paid one of his frequent visits to the university. While he was espousing his latest opinions about groundwater research directions in the presence of Bob Farvolden and me, Bob mentioned to him that he thought I was a pretty smart young student. Dad quickly turned to Bob and stated, "That's because I taught Ed everything he knows." Thank you very much, Dad, for that education, and thank you, GSA, for this honor.

G. K. GILBERT AWARD
presented to

SEAN C. SOLOMON

Citation by James W. Head

The G. K. Gilbert award is presented for outstanding contributions to the solution of fundamental problems in planetary geology in the broadest sense. It of course honors G. K. Gilbert, who more than 100 years ago recognized the crucial importance of a planetary perspective in solving geological problems. This year's recipient, Sean C. Solomon, has had a profound influence on our scientific thinking and on our understanding of the evolution of the planets and satellites, including Earth. His many accomplishments in seismology range from assessment of seismic attenuation and upper mantle structure (part of his Ph.D. thesis), to seismic discrimination and test monitoring, mid-ocean ridge and intraplate seismicity, and early development of ocean bottom seismometers. He has also analyzed the state of stress and absolute plate motions in oceanic crust and lithosphere, providing insight into intraplate stress and thermoelastic stresses, plate driving forces, and mantle rheology. Parallel research includes the crustal and thermal structure of mid-ocean ridges and oceanic transforms, and the assessment of upper mantle structure, much of this accomplished during his participation on nine oceanographic expeditions.

This body of work alone would have qualified Sean for the Gilbert award. But in addition, in the planetary geosciences field, Sean's contributions and influence have been enormous. His early work on the crustal and thermal evolution of the planets provided a firm basis for geologists to undertake a comparison of the nature and sequence of geological features to the predictions of these models. His sets of clearly stated predictions were a very important contribution to interdisciplinary studies between planetary geology and geophysics, two subdisciplines that unfortunately are more commonly on parallel or mildly tangential trajectories. In addition, his documentation and characterization of the concept of the Moon, Mercury, and Mars as "one-plate planets" did much to bridge the gap between disciplines and brought the planets into the realm more readily understood by Earth geoscientists. His Moon work, on the formation and evolution of the crust and the implications of the low density of the lunar crust for rising mantle melts, provided the basis for our current understanding of the magmatic history of that body.

His additional contributions to the thermal evolution of planets and satellites focused on the determination of the thickness of the lithosphere at different times in the history of these bodies. For example, using topography and the evolution of tectonic structures, he was able to determine the thickness of the lunar lithosphere in the first third of lunar history and how it varied areally. Using the topography and morphology of impact basins, he was further able to show the significant role of viscous relaxation and crustal flow in earlier lunar history and the distinctive nearside-farside difference in this behavior, and thus the existence and nature of variable thermal structure.

Sean applied similar principles to the thermal structure and history of Venus, posing questions about the mode of lithospheric heat transfer of Venus prior to the acquisition of high-resolution image data. With this as a basis, he created testable hypotheses for several different modes of heat transfer exhibited by Earth and the other planets and satellites, and these questions helped to frame the scientific thrust of the Magellan mission. He then used data from the Venus missions to assess the thermal structure of the planets and, as he did on several other planetary bodies, used the viscous relaxation of impact craters to assess the viscosity and thermal structure of Venus. This put major constraints on these values, helped to determine the very unusual evolution of Venus, and was a major factor in posing new geodynamic models to explain the observed geology and geophysics.

Furthermore, Sean has used the structure and nature of volcanic edifices to investigate the thermal structure of planets, the response of the lithosphere to growing volcanic loads, and the interactive influence of edifice loading and deformation on the growth and failure of the volcano. He has applied these basic principles to Earth, Mars, and Venus, producing important new insight into both thermal structure and planetary volcanism.

Most recently, in a paper in *Science,* Sean has used concepts about the influence of enhanced volatile input into the atmosphere, developed by David Grinspoon and Mark Bullock, to show that tectonic structure and sequence can actually be influenced by changing surface temperatures! This revolutionary concept is typical of Sean's contributions. He takes fundamental physical principles and uses extremely creative and rigorous thinking to provide basic new insights into the structure of the crust and lithosphere, and through this approach, achieves a much improved understanding of Earth and its planetary neighbors.

Sean's accomplishments do not stop there. He has made major leadership contributions to the planetary and marine geophysics communities through being a member and in some cases chair of many review and advisory committees and panels. Testimony of his stature in the community was his election to the presidency of the American Geophysical Union. His influence has also clearly been felt through his mentorship of more than 25 students in their advanced degrees at MIT.

Sean's scientific contributions are characterized by a diversity of interests, rigor, and extremely high quality. He has a laser-like ability to zero in on and provide fundamental contributions to the most significant scientific problems. These abilities, and the resulting contributions to the literature and through his students, surely qualify him as an individual who has made outstanding contributions to the knowledge of the planets and to the solution of fundamental problems in planetary geosciences.

Response by SEAN C. SOLOMON

Thank you, Jim, for your generous words. I am honored both to receive the Gilbert Award and to be numbered among those distinguished planetary scientists who received the award before me. This award holds particular significance to me, for two reasons. The first is that it is named after G. K. Gilbert, whose enormous impact on our science was achieved in large part because of his ability to integrate mechanics and planetary science with the geology of his time. The second is that the award is for planetary geology, a descriptor I would not have applied to my research field at the start of my professional career.

The path of G. K. Gilbert crossed that of my own institution at the beginning and again at the end of this century. Early in its history, the Carnegie Institution of Washington awarded grants in response to requests from American scientists at other organizations. Not one to miss an opportunity, Gilbert submitted his first proposal in 1902, the year the Carnegie Institution was established. In a remarkably prescient request, Gilbert asked for support for the drilling of a deep hole in plutonic rock, to determine heat flow as well as variations in thermal gradient indicative of past changes in global climate. In contrast to today's proposals, Gilbert's was two pages long, and he had his answer in 19 days. Some aspects of peer review, however, haven't changed much in nearly a century. Instead of the $50,000 Gilbert requested, he received $1,000 for a planning effort. Gilbert's plans, published two years later, specified a drilling area (near Lithonia, Georgia), a target drilling depth (2 km), and a revised cost ($110,000). Probably because of the expense, the plan was never carried out. That same year, Gilbert submitted a second proposal to the Carnegie Institution to investigate differential vertical motions in the Great Lakes region, but he later withdrew the application, citing increased responsibilities at the U.S. Geological Survey.

For the past 11 years, the Carnegie Institution has awarded a G. K. Gilbert Fellowship for postdoctoral work at the Geophysical Laboratory and the Department of Terrestrial Magnetism in the field of "seismic geology." The fellowship is supported by a fund established at the behest of Harry O. Wood, who stipulated the name of the fellowship as well as its scientific focus. Wood supervised a seismic network operated by the Carnegie Institution in southern California in the 1920s and 1930s, and he credited Gilbert with contributing to the ideas that led to the establishment of the network. Six men and women have held the title of Gilbert Fellow since the inception of the award, and most have worked on topics of planetary scale.

My own path toward planetary geology has been a gradual one. In retrospect, I can recognize five principal steps.

The first was my awakening to earth science as a discipline. Credit for directing my academic and career tracks to earth science belongs to Bob Sharp, the 1996 Gilbert Award recipient. In the fall of 1963, as a Caltech sophomore, I took Sharp's introductory geology class, which had the reputation of being so riveting and instructive that more than half the Caltech undergraduates took the course as an elective. Sharp had a host of techniques for engaging his students. In his lecture on volcanism, he bet the class a case of beer that an eruption somewhere on Earth would be reported in the *Los Angeles Times* before the end of the quarter. More self-confident than well read, the class accepted the challenge, ignorant of the fact that Sharp made this same bet every year and rarely lost. Earth more than obliged the wily professor with the eruption that fall not merely of a known volcano but of the brand-new island of Surtsey. Within nine months, with Sharp's assistance, I had secured a summer job at Caltech's Seismological Laboratory and enlisted as a geophysics major. I was hooked.

My second step toward planetary geology, spanning the second half of the 1960s, was my growing recognition that prominent earth scientists regarded planetary science as a field of serious intellectual endeavor. Such a viewpoint would be taken for granted today, but 35 years ago this perspective was not universally held. In the spring of 1965 I took a course from Don Anderson and Bob Kovach focused entirely on the physics of planetary interiors. The course emphasized the internal structure, constitution, and thermal histories of the planets and introduced us to most of the important papers then written on these topics. That summer, Mariner 4 flew by Mars, and along with many others I stood in front of the video monitors on the Caltech campus watching the images play out one line at a time. Anchoring the imaging team were three of my professors: Sharp, Bob Leighton (from whom I learned freshman physics), and Bruce Murray. One year later, when I moved to MIT for graduate work, my seismological mentors Frank Press and Nafi Toksöz were deeply involved in preparations for the Apollo seismic experiments. Toksöz enlisted me in studies of lunar internal structure and later lunar thermal evolution.

Step three, my planetary geological epiphany, came in 1974 with the inference by Bob Strom, Bruce Murray, and others on the Mariner 10 imaging team that lobate scarps on Mercury are the manifestation of an extended episode of global contraction. Through their work, I realized that geological features (or the absence of such features) constitute primary constraints on the interior evolution of the one-plate terrestrial planets, and that geophysical models in turn provide a context for understanding the geology.

The fourth step on my path was the acknowledgment by NASA that some of my research was beginning to be regarded as planetary geology. In 1976 I received a letter from Steve Dwornik, the Planetary Geology program manager, saying he'd heard from Clark Chapman of interesting work I'd been doing and inviting me to submit a proposal to his program. To save me Gilbert's disappointment of 75 years earlier, Dwornik even told me the maximum funding level I could expect.

The fifth and last step was acknowledgment by peers. Here my metric is the view of my citationist and most frequent collaborator. The watershed event occurred in 1983. Head was coauthor of a talk I gave at the Lunar and Planetary Science Conference on the banded terrain on Venus, identified from Don Campbell's latest radar images of Venus obtained at the Arecibo Observatory. Someone asked me after the talk why we thought that the banded terrain was compressional in origin. I don't remember my answer. What I do remember is that after I returned to my seat, Jim leaned over and said, "Good answer, Sean. That could have been given by a planetary geologist." Until this evening, that was the highest praise I'd heard from him.

My passage to planetary geology has been a wonderful experience. Through planetary geology, I've worked with a host of talented students and postdoctoral scientists, I've collaborated with many first-rate colleagues, and I met and married my best friend and life partner. And the journey continues. In partial repayment to the field, and in deference to the planet that influenced most strongly my embracing of planetary geology as critical to an understanding of the broadest issues in planetary evolution, I am pleased to be working on the MESSENGER mission, which will at last advance our knowledge of the geology of Mercury to the levels of the other inner planets.

The mission figures in a story that Gilbert might have appreciated. In October I gave a talk on MESSENGER at the Geological Society of Washington (of which Gilbert was a founder), held at the Cosmos Club (of which Gilbert was a member). One of my dinner hosts was Gene Robertson, a long-time staff member at the U.S. Geological Survey (of which Gilbert was one of the original geologists). Robertson asked me if I'd ever read a paper in the *Journal of Geophysical Research* by his nephew, Stephen Plagemann, on the thermal structure of Mercury. I replied that not only had I read it, I'd given an oral report on the paper as an undergraduate. But I didn't tell Robertson the whole story. The report was in a fall 1965 class on oral presentation of scientific material taught by Bruce Murray, and our assignment had been to give a talk on a recently published paper. After the talk, Murray asked me how I had chosen the paper. I replied that I did so because it built on material I'd learned in the Anderson-Kovach class. Murray said that while my talk was acceptable, the Plagemann paper was known to be wrong. At the time Plagemann's paper appeared in February 1965, Mercury was thought to be in synchronous rotation, a premise that strongly affected his thermal models. Four months later, Pettengill and Dyce announced in *Nature* that Mercury instead is in a 3:2 spin-orbit resonance, but caught up in my seismology research and my fascination with the Mariner 4 flyby I had missed their paper. I vowed thereafter that I would endeavor to keep up with all of the literature in whatever area I was working, and I've never forgotten how the planet Mercury can surprise.

I appreciate deeply the recognition that the Planetary Geology Division has bestowed with this award, by linking my name not only with that of G. K. Gilbert but with those of all Gilbert Award recipients past and future.

KIRK BRYAN AWARD
presented to
WILLIAM L. GRAF

Citation by W. Andrew Marcus

Professor William L Graf is the recipient of the 1999 Kirk Bryan Award for his remarkable publication, *Plutonium and the Rio Grande: Environmental Change and Contamination in the Nuclear Age,* published by Oxford University Press.

Plutonium and the Rio Grande documents and explains the distribution of plutonium, particularly plutonium from Los Alamos National Laboratory, in the river sediments of the northern Rio Grande. The simple question "where are the metals and why are they there?" takes Graf and his readers on a captivating geographic journey through the history, landscapes, and riparian environments of the Rio Grande. Along this journey, we delve into the atomic policies of World War II, look at the biogeography of semiarid riparian systems, examine the engineering works of the 20th century, reconstruct watershed-wide histories of climatic variation, sedimentation, and flooding, and develop and test theories of contaminant distributions at reach to watershed scales through clever use of modeling and an empirical database of epic proportions.

In simplest terms, *Plutonium and the Rio Grande* is a great read. Beyond that simple statement, however, four factors set *Plutonium and the Rio Grande* apart as a major work of research.

First, the empirical data set developed for the research is extraordinary, providing powerful backing for the conclusions in the study and a treasure trove of information for future work in the Rio Grande. Documenting historical changes of plutonium distributions in sediments and the variables controlling these distributions for a 72,000 km^2 drainage at local to watershed scales is an exceptional task. Yet Graf rises to this challenge, mixing and matching modeling with existing data, old and new mapping approaches, and dating techniques derived from a variety of different sources. As just one example, Chapter 6 reports on the sampling of 1,985 trees throughout the drainage to determine if trees can be used to discriminate channel form and sediment texture. The association of vegetation and sedimentary environments discovered by Graf is an efficient method for mapping fluvial landforms and local areas of probable plutonium accumulation. The development of this one technique required a major effort and is a contribution to geomorphology deserving of its own publication, yet it makes up only five pages of one chapter.

Second, the concepts laid out in *Plutonium and the Rio Grande* significantly advance our understanding of the temporal and spatial variability of contaminants in stream sediments. Geomorphologists have long known that geomorphic environment plays a primary role in controlling trace metal distributions in river sediments. The majority of work in this field has focused on qualitative descriptions of metal patterns in different depositional environments, the use of regression models to simulate downstream trends, documentation of the associations between tractive force and metal concentrations, or derivation of simple deterministic models that mimic watershed-wide trends in metal concentrations. No previous research has developed data sets or models that link and explain reach-scale to sub-basin-scale variations of metal concentrations in sediments, much less simulating these variations under different flow conditions and over different periods of time. In *Plutonium and the Rio Grande,* William Graf succeeds in this ambitious task.

Third, the study provides a comprehensive and useful guide to research approaches necessary to document and understand human impact on sediment contamination at watershed scales. Professor Graf outlines very specific guidelines for documenting and understanding metal distributions and impacts, and then leads by example with myriad case studies of how these concepts can be put into action. *Plutonium and the Rio Grande* thus provides a role model for future studies to follow.

Fourth, because of the clarity of writing, the findings are accessible to educated resource managers, environmental lawyers, and other interested parties, as well as geomorphologists. Professor Graf's research will allow managers to target potential hot spots for remediation in the Rio Grande, rapidly develop emergency sampling protocols for tailings or metals spills in similar fluvial systems, and evaluate the significance of future changes in plutonium in the Rio Grande. The book leads the way in demonstrating how geomorphology can inform policy and help society.

Plutonium and the Rio Grande represents the best that geomorphology can contribute to the earth sciences. Its author's geographic roots are apparent in the extensive use of maps as a tool of description and analysis, in the explicit examination of the spatial variability of human impacts, and in the focus on a region—the northern Rio Grande. The study also proudly displays its geologic roots, making wide use of historical documentation and dating techniques. And it is quintessential geomorphology, concentrating on process modeling of sediment and metal transport and explicitly focusing on geomorphic landform as the primary control on plutonium storage throughout the Rio Grande.

In his preface (p. viii), William Graf states:

> For me, there is a deep sense of pleasure in using science to analyze questions such as the issue of plutonium in the Rio Grande. It is much like the sense of pleasure a carpenter feels in using a finely made tool. And there is a sense of satisfaction in the scientific resolution of these questions, much like the satisfaction of the carpenter with a pleasing piece of woodwork. The science notwithstanding, I always return to this place, this landscape, these spirits, and I know again why this work is more than science. America has accomplished many great things, but preserving a quality of life as well as a quality environment is our greatest challenge for the twenty-first century. Efforts to understand places like the Northern Rio Grande in their entirety, with their human and natural histories, are the surest path to achieving this ambition of a quality national life.

With *Plutonium and the Rio Grande,* Professor Graf has achieved his goal. He has built an edifice that represents the best of what geomorphologists can contribute to science, but that also represents the best of what geomorphologists can contribute to society.

Response by WILLIAM L. GRAF

Thank you very much, Andrew, for your kind remarks. I'm not sure they are all true, but I'm grateful in any case for your support, and the support of the nominators and the Division Award Panel. I am truly honored by the Kirk Bryan Award and the recognition of the Geological Society of America. For more than a quarter of a century the members of the Quaternary Geology and Geomorphology Division have been my valued professional associates and personal friends, and I am delighted to acknowledge that whatever I have accomplished as an individual has actually taken place within the supportive context of these people. I also want to recognize Senior Editor Joyce Berry, of Oxford University Press, whose sound advice and good judgment immeasurably improved the book *Plutonium and the Rio Grande.* I am grateful to her and to Oxford University Press for their dedication to the production of a quality product, and for their willingness to undertake the additional expense and difficulties of publishing the basic raw data of the project.

The eight years of work that led to the publication of *Plutonium and the Rio Grande* reflect three important threads that are common to all modern earth science: the continuity exceeds the contributions of any one of us; the nature of our research connects us with other sciences; and answers we provide have true societal importance. My research into the environmental quality consequences for the Rio Grande of the Manhattan Project at Los Alamos, New Mexico, was a continuation of important work started by many others. The U.S. Department of Energy financially supported the research. Alan Stoker, a Los Alamos specialist in plutonium, undertook an initial accounting of the material released into the environment, at a time when he risked disapproval of some of his superiors. Leonard Lane, a Department of Agriculture hydrologic engineer, William Purtyman, a geologist, Thomas Hakonson, a radioecologist, Thomas Buhl, a health physicist, and Steven McLin, a hydrologist, all conducted and published research that was preliminary to my own. They worked closely with me in my own investigations and greatly contributed to my efforts. I also want to recognize Steven Reneau, a Los Alamos geomorphologist, who picked up the work where I left off, in a continuing effort to understand the dynamics of plutonium in the fluvial environment. It has been the easy cooperation among all these disparate researchers and personalities that has led to our progress.

No great and challenging research problem of interest to modern society is limited to a single discipline. While the great advances of science in the past two centuries have been largely made in the analytical arena, constantly reducing problems to their most elemental bits and pieces for study, there is now a great need for synthetic science. Approaches based on synthesis that seek scientific understanding of complex functional, interactive systems demand interdisciplinary efforts at the individual and team level of research. The unraveling of the story of plutonium in the Rio Grande would not have been possible without attention to such diverse (but actually closely related) topics as the physical chemistry of the element, geomorphology, hydrology, biogeography, water resource engineering, and the human history of the region. Almost a decade and half ago, one of our most revered division members, Charlie Hunt, decried in print the lack of such integrative approaches in modern geomorphology. I think he would be pleased with the progress we have made in recognizing the importance of these approaches to synthesis that are now much more common.

Plutonium and the Rio Grande is both basic and applied research, and I believe it emphasizes the fact that the division between these two labels is fast disappearing. As we enter the 21st century, the society that pays the bills for our research is demanding new levels of accountability for their investments in us. It is no longer acceptable for us to escape into the field, office, or laboratory and then argue that what we do advances science and is therefore worthy of support. Our theory must serve purposes that are recognizable to the educated layperson, and our applications in problem solving must be elegant and intellectually satisfying to the most demanding scientific critic. In this new era, basic and applied science are likely to be the same thing. The challenge for us is that we not only do good science, but that we do useful science.

My research at Los Alamos shows that in an effort to construct a weapon to protect our nation, we paid great environmental costs. The federal government has already spent heavily to rectify the problem, and eventually we are likely to invest ten times more in environmental restoration than we did in the original bomb project. This expenditure reflects our changing social values to recognize that Earth is the only home humanity is likely to have for a long time to come. As earth scientists, it is our responsibility to offer the experience, the intellect, and the will (as evidenced by this generous award) to contribute to the making of a quality environment for all future generations.

GILBERT H. CADY AWARD
presented to
ALAN DAVIS

Citation by James C. Hower

The GSA Coal Geology Division's Gilbert H. Cady Award is the highest honor in coal geology presented by a North American society. The outstanding contributions Alan Davis has made throughout his career as a coal geologist have led him here today; he is the 19th recipient of the award since its first presentation in 1973.

Over the course of his tenure at Penn State, Alan, along with students and other faculty, conducted research ranging from traditional aspects of coal geology to advanced microscopic techniques in the petrographic characterization of coals to the petrographic study of the products derived from coals. His fellow faculty members appreciated his ability to look beyond the immediate, traditional boundaries of coal petrology in order to find solutions to problems outside of geology. His students appreciated his guidance in their graduate studies. His guidance allowed us to develop independent lines of thought in the solution of our individual research problems. At the same time, he was never far away, ready to provide the necessary experience to keep us within bounds. As a former student, perhaps I perceive Alan's greatest legacy to be in the training of much of the current generation of organic petrologists. Many of his students have gone on to be leaders in the field. As someone who has continued to work with Alan, though, I have come to appreciate the continued guidance and research interaction. The transition from the advisor-student relationship to peers is not always easy. Once that transition is completed, both parties better appreciate the contributions of the other. With time, I think all of Alan's students have come to better comprehend the depth of the knowledge they gained from the years working with him.

Quoting from one of the supporting letters for the nomination for this award, I think we can all agree that "as a prominent leader in the international coal research community ... respected for the quality and value of his research ... it is truly fitting to honor this man, his long service to the scientific community, and his significant achievements by conferring this award."

Response by ALAN DAVIS

I am deeply indebted to the Coal Division of the GSA for selecting me to receive the Cady Award, being acutely aware of the stature of the previous recipients and the worthiness of so many of my contemporaries.

My bachelor's degree was obtained at Imperial College, London University. At that time, the emphasis there was in metalliferous mining geology; coal was mentioned only in passing, sadly an all-too-common situation at many universities even in the years when many geologists ultimately found their employment in that field. Something, however, sparked my interest in the subject, and during a geochemistry course I chose to write a paper on trace elements in coal.

After graduating, I was employed by John Taylor and Sons and later New Consolidated Goldfields at their Anglesey Prospect in North Wales. The work involved surface and underground exploration for copper, lead, and zinc at a site that had been worked since Roman times and which dominated world production of copper in the early 1800s. At a dance at a nearby village, I met Lorna Loader, whom I married eight years later.

The old miners had done a thorough job and very little was discovered during my time at the prospect. At that point I began my career in coal geology, joining the National Coal Board's Opencast Executive, prospecting for strip-minable coal on Lancashire's high moorlands.

I first became curious about coal petrology while mapping seam properties for the National Coal Board's Coal Survey Laboratory in Chester under J. O'N. Millot. I had heard about Pennsylvania State University and was persuaded to write to Professor William Spackman, and I was offered an assistantship. While I was crossing the Atlantic on the QE1, the death of Marie Stopes was announced over the P.A. system (because of her fame in fields other than the one upon which I was embarking). Russ Dutcher met me at the docks in New

York and drove me to State College. I was to write my master's thesis on the artificial coalification of wood. The Penn State faculty in the College of Earth and Mineral Sciences was outstanding, and I was especially inspired by William Spackman and E. G. ("Gene") Williams.

There was an enthusiastic group of students working in the little wooden house known as Ihlseng Lab, which was Bill's workshop. Many of my contemporaries rose to eminence in our profession as coal petrologists and palynologists. Three are prior recipients of the Cady Award. The famous in our field visited Ihlseng Lab, and Dr. Cady himself spent some time on the top floor, amazing us by tackling the petrology of anthracites.

Bill Berry, another colleague, laid the groundwork for my next position, at the University of Newcastle-upon-Tyne in England. The subject of my doctorate was the optical properties of carbonized vitrinites, undertaken with Duncan Murchison as my mentor. In 1964, while working in Newcastle, I attended my first ICCP meeting in Geleen, The Netherlands, and began a lasting appreciation of that organization's goal of uniform usage of terms and techniques.

The next year Lorna and I emigrated to Australia; I was to work for the Geological Survey of Queensland. This was an exciting challenge, not just because I was going to a new continent, but also because I had to design and equip the laboratory in which I would be working on the petrology of coals that were quite new to my experience. Those were very happy days because of the friendly scientists who made up the Coal Section, headed by Bill Hawthorne, and because our two children were born there.

Eventually I applied for a position at an Australian university. In his letter of recommendation, Bill Spackman wrote that if they did not employ me, he would. They didn't, and Penn State did, initially for a 6-month appointment, but I remained for almost 25 years. I owe a debt of gratitude to Bill for making this possible and for his wisdom and encouragement. During the 1970s it seemed to me as though Penn State was the center of the coal research universe. The oil embargo had created a tremendous resurgence in coal research, and at Penn State we covered the range of coal-related investigations, from origin and geochemistry, through mining and beneficiation, to utilization and environmental impact. The names William Spackman, Peter Given, and Phil Walker attracted students and research support, and I was able to benefit from this.

I am deeply pleased that you have recognized my contribution to coal petrology, but this would not have been possible without the dedication and acumen of my students. I was the beneficiary of the tough admission and curriculum standards in our Department of Geosciences. I cannot mention all of my students by name, but in recognizing me you are honoring them. The achievements for which you salute me read like a list of the titles of their theses. The subjects include the petrographic evaluations of coal hydrogenation and beneficiation processes; the interpretation of coal depositional environments and climates; the interpretation of the thermal, burial, and stress histories of coal and petroleum basins; coal systematics; automated microscopy; and the geological and chemical significance of maceral fluorescence properties.

I am also indebted to those fellow faculty members who understood very well the special role that microscopic studies can play in understanding the chemical and physical processes to which coal is subjected. In particular I value the several years of collaboration with the late Peter Given and Frank Derbyshire. I am also proud to have been associated with Gary Mitchell and Dave Glick, my coworkers in the Coal and Organic Petrology Laboratories for many years.

I have no doubt that even though the field of organic petrology is going through something of a decline in terms of the numbers of individuals working in the field and of funding opportunities, there has been a marked improvement in the quality of work being done. Our field is in the hands of very competent researchers, capable of integrating petrographic studies with other techniques to address complex geological and technological problems.

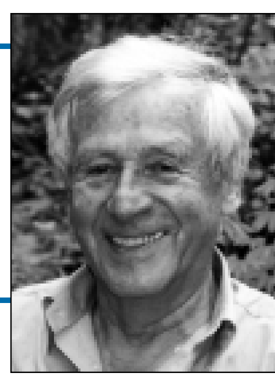
My acknowledgments would be incomplete without mention of some other scientists and friends around the world who have willingly shared their knowledge with me. I especially appreciate the interaction I have had with Alan Cook, Tom Calcott, Geoff Taylor, and Colin Ward in Australia; Marlies Teichmüller in Germany; Rosa Menendez and Javier Prado in Spain; Ralph Gray, Jim Hower, Jeff Levine, Rui Lin, Jeff Quick, Dave Bensley, and the late John Castaño; Jack Medlin, Bob Finkelman, Neely Bostick, and others at the USGS; and the coal geologists of the Pennsylvania Geological Survey.

The Coal Division has done so much in promoting our science through discourse in the conference room and field and through its encouragement of young researchers by means of its scholarships. I would in any case have been proud to have been a part of this impressive and friendly community of coal geologists, whose meetings I first attended in 1958. Now, I have further reason to be forever grateful. Thank you very much for this award, which I am pleased to share with my wife, Lorna.

STRUCTURAL GEOLOGY AND TECTONICS DIVISION CAREER CONTRIBUTION AWARD

presented to

HANS PETER LAUBSCHER



Citation by Robert D. Hatcher, Jr.

It is both a pleasure and an honor for me to present to you this millennium's last recipient of the GSA Structural Geology and Tectonics Division Career Contribution Award—Professor Hans Peter Laubscher. I have had the pleasure of knowing Hans for more than two decades; I first met him in 1978 at one of the Penrose Conferences we held at Helen, Georgia, in the southern Appalachians. Helen is billed as the "Swiss Alpine village of the Blue Ridge." We had several Swiss at that meeting, and none were able to see any similarities.

Hans was born near Basel, Switzerland, and was brought up with a love of the outdoors. He discovered geology after he entered the University of Basel and decided that there could be no better profession for someone who loved the out-of-doors. He received all of his university education at the University of Basel, completing the Ph.D. there in 1947 and conducting his research in an area where the Jura Mountains and Rhine graben interacted with each other. From 1948 until 1958 he worked for what is now Mobil Oil Company in Venezuela as a field geologist, a seismic interpreter, and then as a staff geologist. Here was loosed a fertile mind in a tectonically interesting region, where he also was able to discuss his embryonic ideas on material balance with mathematicians and petroleum engineers. These ideas were brought out in his early papers, but were perhaps best developed in some of his late 1980s papers on 3-D material balance in the Alpine lithosphere.

In 1958 he returned to the University of Basel to work as a faculty member in the Institute of Geology and Paleontology, becoming professor and head of the institute in 1966; he remained there until his retirement in 1989. He was a visiting professor of geology at the University of Illinois (1963–1964) and also has been a consultant in petroleum exploration, seismic hazard assessment, and radioactive waste disposal. He has since his "retirement" worked with the Swiss Geological Survey in computer-assisted analysis and synthesis of previously mapped areas; this position permits him to spend time in the field checking and remapping problem areas. Hans is a member of GSA, AGU, AAPG, SSA, and a number of European geological societies, including the

Geologische Vereinigung, the Swiss Geological Society, and the new European Union of Geoscientists, and he has been a recipient of the highest awards and medals of several of these organizations.

We know Professor Laubscher's work in numerous papers on the Jura and Alps, particularly several that establish basement controls and influence on thin-skinned structure developed in the cover rocks. He has also published important papers on the Venezuelan Andes and the Rhine graben. His 1962 *Eclogae Geologicae Helvetiae* paper "Die Zweiphasenhypothese der Jurafaltung" established him as one of the modern fathers of section balancing, and, in his 1988 GSA *Bulletin* paper, he extended balancing concepts to the third dimension of the Alpine lithosphere. He is also the father of the concept of the "tectonic lid," which he introduced in a paper in a 1983 GSA Memoir.

Hans Laubscher is truly one of the great geologists of our time. It would be unfair to describe him as one of the "grand old men of geology"; it is better to think of him as one who has generated great ideas and will continue to do so. If nothing else, perhaps we should anticipate an improvement on Hans's description of crustal balancing as being no more than "semiquantitative considerations of material balance." I present to you, our Society and Division, the 1999 recipient of the GSA SG & T Division Career Contribution Award: Hans Peter Laubscher, monumental scientist and honorable man.

Response by HANS P. LAUBSCHER

I was more surprised than probably anybody else at learning that I was chosen for this award. After my retirement 10 years ago, I concentrated on remapping the Jura south of Basel, publishing little, and then mainly in German for local consumption. There is a time in life when you expand, and then there is a time when you contract again. My drawers are full of unfinished work. I had to decide on priorities. For various reasons the Jura maps made the top of the list. One of the reasons is that as a young man, I had been an enthusiastic hiker and mountaineer and observer of nature generally. Botany was my first love.

While passing the final exams of my classical high school and wondering what I should do at the university, I read by chance about the adventures of a petroleum geologist in Borneo. Outdoors work, traveling, observing nature—a dream profession I had not known existed. My decision was made. Decades ago Bill Brace told me that was the Boy Scout Approach to Geology.

In the course of my studies, and particularly when working on my dissertation, I also found that geology presented those challenges to powers of observation, of inference, of combination, and, last but not least, of imagination that a young mind craves.

In spite of all the fascinations my years at the university offered, I had to rush through my studies in the shortest possible time, mostly for financial reasons.

In 1948 I began work for Mobil, then Socony-Vaccuum Oil Co., in Venezuela. My first assignment was that of a junior field geologist west of Lake Maracaibo, at that time still a wild jungle. The other members of the party were true professionals. We followed the rivers, making maps based on aerial photos and plane table measurements. I collected plants and snake hides, which earned me the comment: "Hans, you are not a geologist; you are a naturalist."

It was not going unnoticed, however, that I also studied mathematical texts, and because in many other ways I was not the typical American boy who easily fit into the party, but rather, a crazy Swiss, it was decided to put me into geophysics.

I worked for almost ten years in the Geophysics Department of Socony and after having missed the outdoors at first—my weekend hiking tours in the hills and mountains around Caracas were small consolation—I began to like the job more and more. I studied the physics of seismic wave propagation and similar things in my free time and found in the combination of clean physics and dirty geology a truly rewarding field of action.

It did not take me long, however, to realize that the earth was hopelessly chaotic, and that it had to be simplified almost beyond recognition to make it tractable by physical theory. This was before the arrival of computers in the earth sciences, but the problem remains even in these times of massively parallel computing. In discussions with reservoir engineers, I realized that material balance was that fundamental quantity close to a geological database that most effectively constrained kinematic reconstructions. Even more fundamental would be energy balance for dynamics, but first one must have a grasp of kinematics.

As to data and "facts," the lesson that most impressed me was the grading of geophysical data—good, passing, or poor. We used only these three categories in an infinity of shades. And it was fun and frustrating at the same time to realize how much subjective experience and intellectual temperament entered the game even at this early stage. A physicist working on the same data tended to smooth out the scattering of points statistically, whereas what intrigued me most was if aberrations did not have some geological significance.

After ten years of oil-finding in Venezuela, I returned to the University of Basel. By then, I had acquired a wife and four children, and the question of how to support them became more urgent by the day. I therefore accepted, after some reluctance, because I liked my job, an invitation by my old professor to join his staff with a view to succeeding him. After bringing myself up-to-date again on the newest developments of regional geology, particularly of the Alps, I had to reorganize teaching and research. I missed the goal orientation of exploration work and the satisfaction of interpretations being checked by drilling wells. In teaching quantitative tectonics I concentrated, after the most fundamental introduction to geodynamics, on aspects of material balance, first in the Jura and then in the Alps. One of the main challenges therein was the decision of how and how much to simplify the system.

Basel is the Swiss city that is geographically farthest from the Alps. Indeed people have noted that the Basel institute is the only one in Switzerland from which the Alps may not be seen. However, Basel has one great advantage. It lies at a point where contractional features such as the Jura join extensional ones such as the Rhine graben and its flanking elevations, the Vosges and the Black Forest. Working out the relationships of these apparently discrepant units presents quite a challenge, and for more than 100 years people have been debating them. Fundamental data were lacking until quite recently; it is possible only now to correlate events, as Tertiary stratigraphy has been refined by the study of mouse teeth, and events outside datable sediments have been more and more closely pinpointed by geochronology. It turns out that Basel is in the midst of Alpine structures; they are all an expression of the African-Eurasian plate collision. But don't expect everybody to agree on this.

When the railroad connection between the northern and the southern foreland of the Alps was built more than 100 years ago, geologists from the universities of the Upper Rhine graben began to discover the southern Alps. Ever since, the southern Alps have been a domain for research based in Basel. When I returned to Basel in 1958, I met Daniel Bernoulli, who was working on his thesis in the southern Alps. After a stint with Shell in the Mediterranean ranges, he returned to Basel, and a fruitful collaboration of almost two decades was the result. Daniel not only helped in unraveling what is now considered the complex African-Eurasian plate boundary zone. He, together with Hanspeter Luterbacher realized that the Mesozoic sediments drilled in the central Atlantic closely correlated with those in the Apennines. This was an important milestone in concretizing the plate tectonics concept.

Plate tectonics had become an article of faith for me in 1963, even before the term had been coined and the concept formulated, after I had talked to Runcorn about the newest results in paleomagnetism on my way to Urbana, where I spent the academic year 1963–1964 as a visitor, teaching structure and geophysics. The ophiolites that I had studied in the Zermatt Alps with my teacher and friend Peter Bearth in the late 1940s became the oceanic crust of the Piemonte ocean separating the sediments of the African margin as seen in the southern Alps from those of the European margin as seen in the Helvetic Alps. Today this seems almost self-evident, but in the 1960s it was difficult to find an Alpine geologist who did not sneer at such ideas.

Of course, it turns out that this simple concept does not do full justice to the truly chaotic nature of Earth in general and the African-

Eurasian boundary in particular. The work of the French in the Aegean basin revealed subduction roll-back with extreme crustal extension and block rotations at the splintered margins. This for me was a fundamental addition to the general concept of plate tectonics, similar to the metamorphic core complexes, the first glimpses of which I owe to Greg Davis. In 1976 he showed me those then puzzling outcrops on a marvelous field trip into the desert.

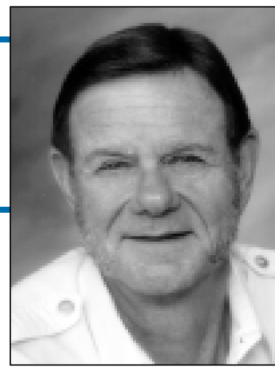
Subduction-related processes began to intrigue me from those early days on when Peter Bearth showed me the eclogitic pillow lavas in the Zermatt area, with their colorful red and green rims. The mechanisms and thermodynamics of deep subduction and later exhumation of surface rocks is still a fundamental issue in tectonics. So far as I see, the jury is still out on this.

From early on, kinematics in 3-D seized my imagination. It was conceived as an exercise in material balance in 3-D, and as a time series with changing configurations, beginning in the Jura and expanding into the arc of the western Alps and its join with the Apennines and the southern Alps, and then into other areas of the Alpine-Mediterranean system, and finally into some features in the Americas, particularly the northwestern corner of South America.

I have returned to mapping and 3-D kinematics in the Jura, and my time is fully occupied. Of the many exciting things that are going on in tectonics, I am a mere spectator, applauding here and frowning there. New fascinating perspectives are opening all the time, and old absurdities are repeated over and over again.

My gratitude goes to the many people who have helped me in my career. There was, of course, my mother, and there are the teachers, colleagues, friends, and students. There is, in particular, my wife, who shared my career and graciously took on the sometimes difficult life of a geologist's wife, and who enriched my own life with her sense of the beautiful and her own quest for truth. And last but not least, there are the members of the Structural Geology and Tectonics Division of GSA who have generously honored this career with your reward.

LAURENCE L. SLOSS AWARD
presented to
WILLIAM R. DICKINSON



Citation by Raymond V. Ingersoll

Bill Dickinson is richly deserving of the first Laurence L. Sloss Award for Sedimentary Geology, on the basis of his diverse contributions to knowledge and his lifetime of service to the Geological Society of America. The recognition of this combination of outstanding research and service to GSA is a fitting tribute to the memory of Larry Sloss.

Bill's contributions to knowledge are both broad and deep. The spectrum of his contributions ranges from global plate dynamics through facies analyses on the outcrop to microscopic details of sand grains in potsherds. The diversity of his interests reflects the diversity of the Division of Sedimentary Geology, which honors him today.

I first encountered Bill 27 years ago at Stanford, where he was providing a view of "The Big Picture" to an undergraduate Environmental Earth Science class. Cowboy Bill impressed me so much that day that I became his advisee, a decision I have never regretted in any way.

Bill received all his degrees at Stanford, and remained on the faculty from 1958 to 1979, when he shocked his Stanford colleagues and delighted his new Arizona colleagues by moving to the University of Arizona. In 1991, it was Tucson's turn to be shocked, as he "retired" at the young age of 59 in order to return to being a full-time geologist, going where he wants, when he wants, with his devoted field companion, Jackie.

Bill has received many honors, including election to the National Academy of Sciences, the Penrose Medal of GSA, a Guggenheim Fellowship, and numerous named lectureships. In addition to receiving the Sloss Award today, he is to receive the Twenhofel Medal of SEPM in spring 2000. Bill has held many positions in national and regional societies, including chair of the Cordilleran Section of GSA, vice president of SEPM, chair of the Board of Earth Sciences of the National Research Council, general chair of the 1987 GSA Annual Meeting, chair of the Department of Geosciences at the University of Arizona, chair of the National Research Council Panel on Geodynamics of Sedimentary Basins, and councilor and president of GSA, to name a few. He has been convener or speaker at more than 50 symposia, including convener of the famous Penrose Conference on plate tectonics in 1969.

Bill's research accomplishments have focused on the interplay of plate tectonics and sedimentation, but as broad as this field is, it does not capture the breadth of his interests and expertise. He has made major contributions to regional geology, especially in California, Arizona, the circum-Pacific region, and even the Ouachitas! He first became well known through work on andesites and subduction zones. He is the founder of a new school of sandstone petrology and petrofacies. He has made major contributions to Pacific archeology through his study of temper sands in prehistoric pottery. His bibliography exceeds 300 titles on many topics.

I would guess, however, that Bill's proudest achievement is his supervision of nearly 100 graduate students, both at Stanford and at the University of Arizona. As one of them, I can personally attest to the fact that his guidance and encouragement have been a common thread in his advisees' success. He imparts a rigorous delight to all his interactions. He has an infectious enthusiasm that is conveyed to undergraduates, graduates, and professionals alike.

Bill's major contributions to sedimentary geology include the following. His 1970 *Journal of Sedimentary Petrology* article "Interpreting detrital modes of graywacke and arkose" is the foundation of all petrofacies work on rocks both modern and ancient and at both local and global scales. The methods outlined in this paper are fundamental to all subsequent work, including his petrofacies work in the Great Valley with Rich, his remnant-ocean Ouachita work with Graham and Ingersoll, his synthesis of "plate tectonics and sandstone composition" with Suczek, and refinements thereof.

His two 1974 SEPM Special Publication articles "Sedimentation within and beside ancient and modern magmatic arcs" and "Plate tectonics and sedimentation" pioneered new ground. Derivatives of these classics include "Structure and stratigraphy of forearc regions," with Seely, "Plate tectonics and hydrocarbon accumulation," "Forearc basins," and "Remnant ocean basins," with Ingersoll and Graham.

Bill has contributed enormously to our understanding of the paleotectonics of the western United States. Building on early papers about eugeosynclinal sedimentation of Oregon, Bill and his students have applied plate-tectonic concepts to the interpretation of volcaniclastic sedimentation related to magmatic arcs, sedimentation related to the San Andreas fault system, Paleozoic and Mesozoic Cordilleran foreland and forearc basins, Laramide basins, and sedimentation related to Cenozoic detachment faults. His prolific contributions have continued during his so-called retirement, with major papers and monographs, such as "Tectonic implications of Cenozoic volcanism in coastal California," "Tectonic setting of faulted Tertiary strata associated with the Catalina core complex in southern Arizona," "Paleogene depositional systems of the Western Transverse Ranges and adjacent southernmost Coast Ranges, California," and "Kinematics of transrotational tectonism in the California Transverse Ranges and its contribution to cumulative slip along the San Andreas transform system." Every new contribution is rich with insight.

Bill Dickinson is probably best known as the person who placed sedimentary basins firmly within the context of the plate-tectonic paradigm. It is important to keep in mind, however, that more than anything else, Bill is a field geologist. Quite appropriately, he credits much of his success to the mentoring at Stanford of Bob Compton, author of the best-selling *Manual of Field Geology,* or *Geology in the Field.* Whether battling the brush and ticks of the California Coast Ranges, the heat of the Arizona desert, or the rigors of South Pacific beaches, Bill has always tested his models and gathered data primarily in the field. In this age of super computers, SHRIMPs and GPS, it is easy to create a virtual reality, devoid of direct connections with nature. A great sedimentary geologist must integrate diverse types of knowledge, attained in the field, the laboratory, and the library, in order to make significant contributions; Bill Dickinson is such a person.

And of course, from the field came many of his most memorable quotes, such as: "What's in a hole? There's nothing in a hole!"; "You can certainly sail where you like, but this idea is a big rocky shoal, in my view"; "Simple minds draw straight lines"; and, most revealing, "Whenever I hear one of those big arguments at a GSA meeting, I tend to trust the person who's seen the rocks."

It is my great pleasure to present to the Sedimentary Geology Division of GSA, Professor Emeritus William Richard Dickinson, first recipient of the Laurence L. Sloss Award for Sedimentary Geology.

Response by WILLIAM R. DICKINSON

After such a gracious and laudatory citation, emendations on my part would be unwise, for fear of spoiling the mood of high praise. There can be few moments in any scientific life more gratifying than to be the first recipient of a prestigious award named for as old and dear a professional friend as Larry Sloss.

The moment is especially sweet because sedimentary geology has been the engine at the core of my scientific soul for nearly half a century. Whenever I have strayed, never very far nor for very long, into affairs more tectonic or geomorphic, it has always been with insights derived from sedimentary geology as guide stars.

Yet the moment is bittersweet as well. I would cheerfully cast the award aside if doing so could bring Larry back to us. I hope those of you who knew him, and those who admired his career from afar, will take this occasion, as I do, to recall his memory and honor his achievements.

More than anyone I ever knew, Larry combined sustained intellectual vigor with a totally unpretentious approach to scientific and professional life. His unique personal style lent a special flavor to all his contributions, both to sedimentary geology and to geoscience as a whole. His refreshing and deft logic could swiftly deflate any stuffed shirt with a few well chosen words, often pointed but never cruel. As a recipient of that patented Sloss treatment on at least one occasion, I can attest to its salutary effect. I emblazon the name Sloss on my escutcheon with deep pride, and will do my best to live up to the high standards that Larry set. It will be far from an easy task.

Let me reach back now across a lifetime of experiences in sedimentary geology, and try to distill from them some guideposts for the future of the field, and for geoscience generally. The lessons I draw are partly complementary and partly contradictory, in keeping with the simultaneously collegial and dialectical qualities of any science.

1. Sedimentary geology, as we conceive it and practice it, is a convenient compartment but still an integral facet of geoscience as a whole. Our more important insights always have far-reaching implications, and our disciplinary borders must ever remain porous to the passage of ideas and people, both into and out from our field. Nothing could be more sterile than to restrict ourselves to research agendas that are inward-looking or exclusionary in concept. Even within the arena of sedimentary geology, think back on the fruitful interplay of such as paleoecology and geochemistry and basin analysis with classic stratigraphy and sedimentology.

2. Sedimentary geology is itself quintessentially multidisciplinary. No one, for example, can make do without understanding the struts of stratigraphy, for there is no context for sedimentary studies without them. I owe a personal debt to Si Muller for a thorough grounding in stratigraphic principles. For sedimentary petrology, there is no substitute for hands-on experience with igneous and metamorphic rocks, which serve as the ultimate source of most clastic particles, and Bob Compton led me by the hand in that direction. For sedimentation, some knowledge of fluid mechanics is essential, and I count among my lucky breaks the opportunity, as an engineering undergraduate, to study that tricky subject with John Vennard, one of the true masters of a thoroughly messy business. For a solid introduction to issues within sedimentology itself, it may surprise you that I credit an outstanding geophysicist, George Thompson, who taught the only sedimentology course I ever took

3. Perhaps the most persistent intellectual contribution of sedimentary geology to broader geoscience is made in common with geomorphology and consists of holding to actualistic principles for the interpretation of rock assemblages and ancient landscapes. Of course, geomorphology and sedimentary geology are but two faces of the same coin, for geomorphology fires the sediment bullets that we later perceive as sedimentary rocks. We contemplate the anatomy of limestone successions with the example of modern coral reefs and carbonate banks in mind. We apply knowledge of modern coastal and fluvial systems to the study of ancient counterparts. Few branches of geoscience have the opportunity to develop as many direct analogies in detail as we do. For example, ponder the hard lot of igneous and metamorphic petrologists who, except for volcanological aspects of their work, can never place their feet or lay their hands on active counterparts of the objects they study. The successes and failures of sedimentary geology warn them to constrain their inferences as adroitly as possible to avoid sliding into some imaginary hyperspace. In my own past work, the habits of actualism served as a springboard for analysis when plate tectonics hove upon the horizon.

4. At the same time, the history of sedimentary geology over the past half century warns us to be ever alert for processes we have overlooked, and attentive to those uncommon but powerful events that occur sparingly but dominate the evolution of many depositional systems. We must never stumble into the fallacy that we already know it all in terms of the framework and context of sedimentary processes. Recall that not so long ago we tried to understand marine sequences with no notion of turbidity currents, and recall how faulty our analysis of fluvial and coastal processes once was without taking into account the rare flood and storm events that override the effects of more mundane times.

5. A final lesson from sedimentary geology is the immense benefit of close collaboration between theoretical and practical geoscientists, geoscientists in academia and in industry, geoscientists with a focus on earth resources and those with a focus on the environment. How many times have we seen an idea born in one realm bear unexpected fruit in another? The world is a very complex place, and all of us need all the help we can get to make our way toward the light.

In my own case, the stimulus of working in tandem through the years with a long string of outstanding graduate students at Stanford and Arizona was a boon of inestimable value. It was they, more than anyone else, who inspired me to my hardest thinking and my best research. Giving a hand to those working their way up proves to be as beneficial to personal effort as getting a hand from those higher up the ladder. Behind me and beside me as I accept this award are a host of ex-students, as well as former and present colleagues, who have a perfect right to share the satisfaction I feel at the recognition that the Sloss Award represents. And right here with me, as always, is my wife, Jackie, who has been such a steady factor in my life for so many decades now that I cannot imagine doing the things I have done without her constant companionship and encouragement.

I thank one and all for the signal honor you do me, and for the opportunity, as the first recipient of the award that bears his name, to salute Larry Sloss. May his legacy never die!

Call For Nominations

National Awards for 2002

Deadline: April 30, 2000

Nominations for the national awards described below are being solicited for 2002. Each year GSA members have been invited to participate by recommending possible candidates.

Those who wish to make nominations are urged to do so by sending background information and vitae, and specifying the award for which the candidate is being submitted by April 30, 2000, to the GSA External Awards Committee, P.O. Box 9140, Boulder, CO 80301-9140, (303) 447-2020, fax 303-545-5307. The nomination process is coordinated by AGI on behalf of its member societies, and a roster of candidates will be finalized by the AGI Member Society Council at its spring 2001 meeting for nomination to the respective offices sponsoring the national awards.

William T. Pecora Award. The Pecora Award, sponsored jointly by NASA and the Department of the Interior, is presented annually in recognition of outstanding contributions of individuals or groups toward the understanding of Earth by means of remote sensing.

National Medal of Science. The medal is awarded by the President to individuals "deserving of special recognition by reason of their outstanding contributions to knowledge in the physical, biological, mathematical, engineering, or social and behavioral sciences."

Vannevar Bush Award. The Vannevar Bush Award is presented from time to time to a person who, through public service activities in science and technology, has made an outstanding contribution toward the welfare of mankind and the nation.

Alan T. Waterman Award. The Waterman Award is presented annually by the NSF and National Science Board to an outstanding young researcher in any field of science or engineering supported by NSF.

For complete descriptions and criteria, see www.geosociety.org/aboutus/admin/awards.htm.

Reminder: Call for Nominations

JOHN C. FRYE ENVIRONMENTAL GEOLOGY AWARD

To be awarded for an outstanding paper on environmental geology published by GSA or by one of the state geological surveys during the preceding three full calendar years. The award is a $1000 cash prize presented in cooperation with the Association of American State Geologists (AASG). Nominated papers must establish an environmental problem or need; provide substantive information on the basic geology or geologic process and relate it to the problem or need; suggest solutions, provide appropriate land-use recommendations, or resolve the problem or need based on the geology; and present the information in a manner that is understandable and directly usable by geologists. Nominator must include a paragraph stating the pertinence of the paper.

Nominations are due by March 31, 2000.

Send materials and supporting information to Administrative Offices, Geological Society of America, P.O. Box 9140, Boulder, CO 80301-9140. For more detailed information about the nomination procedures, refer to the October 1999 issue of *GSA Today*, or visit our Web site at www.geosociety.org/aboutus/admin/awards.htm.

Call for Applications and Nominations for GSA *Bulletin* Editor

The GSA *Bulletin* seeks a co-editor, beginning January 1, 2001. The new editor will replace the editor whose term ends in 2000 and will serve a four-year term. A phased transition should begin in the summer of 2000.

The GSA *Bulletin* has a 112-year history of excellence in publication of definitive works related to all aspects of geoscience. Part of GSA's mission is to bring together different earth sciences in a forum for scientific inquiry and discussion, and the *Bulletin* editors will be charged with continuing this tradition while helping Society staff find the best ways to provide comprehensive manuscripts in the electronic environment.

Editor Duties

1. Continue to maintain excellence of journal content through active solicitation of diverse and definitive manuscripts.
2. Ensure stringent peer review and expeditious processing of manuscripts.
3. Make final acceptance or rejection decisions after consideration of recommendations of reviewers and Associate Editors.
4. Correspond with authors regarding revisions and expeditious return of final manuscripts. Maintain active correspondence with current and potential contributors.
5. Select contents for each issue that will interest the broadest audience possible.
6. Select and maintain an active board of Associate Editors.
7. Report to the Committee on Publications on manuscript topic trends and issues specific to the *Bulletin*.

Editor Qualities

1. Broad personal background and active research in the geological sciences. Broad knowledge of geological research activities of scientists both nationally and internationally.
2. Interest in electronic publishing and in maximizing *Bulletin* content for print and electronic media.
3. Willingness to try new techniques to enhance author and reader satisfaction (e.g., theme issues).
4. Excellent organizational skills and ability to manage significant manuscript flow to ensure timely publication of papers. Ability to supervise editorial assistant to ensure that schedules are maintained.
5. Ability to remain tactful and helpful to authors, yet create and maintain stringent acceptance and rejection policies.
6. Willingness and capability to coordinate working schedules with a co-editor.
7. Willingness to invest about one day per week on *Bulletin*-related activities.
8. Objectivity and scientific maturity.

If you are interested in this opportunity to help guide the *Bulletin*, one of the premier geoscience journals, submit a resume and a brief letter describing relevant qualifications, experience, and objectives. If you are nominating someone, include a letter of nomination and the nominee's written permission and resume. Send nominations and applications to Peggy S. Lehr, Chief Operating Officer/Director of Publications, Geological Society of America, P.O. Box 9140, Boulder, CO 80301 by May 15, 2000. ■

Call for Comments and Guidance

Proposed North American Data Model for Geologic Maps

North American Data Model Steering Committee

The federal, state, and provincial geological surveys of the United States and Canada have begun building a data model to promote use of digital geologic maps. These agencies need guidance and comments from both producers and users of geologic maps, and ask for help by means of a poll, available on the Web at www.kgs.ukans.edu/AASG/poll.html.

Why a Data Model?

Geologic maps contain information that is crucial to a broad spectrum of societal concerns. The increasing use of geographic information systems (GIS) for decision support holds the potential for even wider and more effective use of geologic maps. Typically, however, each geologic map is unique. Widespread and effective use of map information depends on its format and content being familiar to a broad spectrum of users. If the information is unfamiliar in format or content, users tend to ignore it, especially if surrogates are available (soils or engineering data, for example). Therefore, some standardization in information structure will benefit the geoscience community, as we strive to provide users with more familiar, and hence more widely used, products. Standardization also can benefit map producers, because a larger pool of mappers using similar methods increases the efficiency of software written to support mapping, data capture, and database management.

To some extent, standardization is needed, for both the structure in which geologic map information is held in digital format and for the terms geologists use to describe earth materials. Efforts to develop standard data models that capture a map's complex information structure are underway in various geological surveys around the world. The degree of data-model standardization needed and desired by the North American geoscience community must be determined in order to address the burgeoning societal demand for GIS-compatible thematic maps.

Recent Evolution of the Data-Model Standards Effort in North America

A mechanism to explore and develop a data-model standard now exists for the North American geoscience community. In 1996, interested members of the U.S. Geological Survey, the Association of American State Geologists (AASG, representing the state geological surveys), and the Geological Survey of Canada met to discuss formation of various standards-development activities under the aegis of the National Geologic Map Database project (http://ngmdb.usgs.gov), a USGS-AASG cooperative effort that has a congressional mandate to develop standards. At a meeting in 1996, the AASG-USGS Data Model Working Group was formed (see data model standard, under http://ncgmp.usgs.gov/ngmdbproject/). Chaired by Gary Raines (USGS), the group, by mid-1998, developed a conceptual data model (version 4.3) for implementation in relational database systems (Johnson et al.), available at http://geology.usgs.gov/dm/.

To more fully develop the data model and to promote a broader discussion and understanding of it, the Working Group was superseded in 1999 by the North American Data Model Steering Committee (NADMSC). The NADMSC is composed of geologists and other technical and scientific staff from the federal, state, and provincial geological surveys of the United States and Canada. Additional representation from Mexican and Canadian geological surveys is being sought. Current members are: Dave Soller (USGS, committee coordinator), Brian Berdusco (Ontario Geological Survey), Tom Berg (Ohio Geological Survey), Boyan Brodaric (Geological Survey of Canada), Jim Cobb (Kentucky Geological Survey), Bruce Johnson (USGS), Rob Krumm (Illinois State Geological Survey), Jonathan Matti (USGS), Scott McColloch (West Virginia Geological and Economic Survey), Gary Raines (USGS), Peter Schweitzer (USGS), and Loudon Stanford (Idaho Geological Survey).

The NADMSC intends to provide a venue for broad participation in the data-model development process, through several mechanisms. First, the NADMSC sponsors a Web conference site (http://geology.usgs.gov/dm/), where interested parties may participate in data-model discussion and development. Second, the NADMSC is now forming various technical teams, to perform specific tasks needed for a useful data model (see http://geology.usgs.gov/dm/steering/). Finally, the NADMSC will conduct public forums to gather and/or to disseminate information. The opinion poll described here is a forum to provide vital information to the technical teams for structuring their tasks.

The Poll

Your opinions are important to NADMSC and will help guide its work on behalf of the geoscience community. The committee invites you to submit your comments and guidance through the form on the Web (see first paragraph for Web address). The committee will compile the responses and give them to technical teams.

The opinion poll questions are the following. On the Web form, choices are provided for each question.

1. If you are a geologic map user, how would you characterize yourself?
2. If you produce geologic maps, who is your intended audience?
3. What type of geologic map information is most important to you, as a map user?
4. What would you like to use a digital geologic map for?
5. Please characterize yourself as a computer user.
6. Describe your needs for exchanging digital geologic map databases with other producers/users/agencies.
7. Which standards do you follow, or expect to follow?

If you have specific questions or additional comments regarding this effort, please provide them to Committee Coordinator Dave Soller, drsoller@usgs.gov, (703) 648-6907, fax 703-648-6937. ■

Here's Your Chance To Review Proposed Standard for Geologic Map Symbols

The Geologic Data Subcommittee of the Federal Geographic Data Committee wants input on a proposed standard for symbol use on geologic maps. The standard contains descriptions, examples, cartographic specifications, and notes on usage for point and line symbols for geologic and related map features (e.g., geologic contacts, faults), patterns to represent areal features, and suggested map unit colors.

Why

The objective in developing this federal standard is to aid in the production of geologic maps and related products, as well as to help provide maps and products that have a consistent appearance. Although the Geologic Data Subcommittee coordinates geologic mapping standards only at the federal level, these standards could be more widely applied within the larger geoscience community.

Who

This draft standard has been developed by members of the USGS Western Publications Group and the National Geologic Map Database project (http://ncgmp.usgs.gov/ngmdbproject/). It draws heavily upon previous work by USGS geologic and cartographic personnel and their informal standards. The USGS also is working to develop digital "implementations" of the standard in commonly used formats suitable for digital map production; these implementations are intended to be released separately, during the public review period, as informal USGS products.

How

The subcommittee invites you to review this standard when it is released this spring. To request a copy of the document for review, contact Matilde Moss, mmoss@usgs.gov or (703) 648-6569. For questions regarding this standard or the public review process, please contact the standards coordinator, Dave Soller, drsoller@usgs.gov or (703) 648-6907. Comments will be addressed, and a revised standard, approved by the Federal Geographic Data Committee, will be issued. More information regarding the proposed standard is available at the Geologic Data Subcommittee Web site, http://ncgmp.usgs.gov/fgdc_gds/.■

GSA FOUNDATION UPDATE

Donna L. Russell, *Director of Annual Giving*

Engineering Geology Division Redirects Award Fund

GSA's Engineering Geology Division voted at its October meeting to change the purpose of the EGD Award Fund held by the GSA Foundation. The EGD Fund will now cover the expenses of the Richard H. Jahns Distinguished Lecturer. The distinguished lecture series was established in 1988 to increase student awareness of careers in engineering geology. Jahns, 1970–1971 GSA president, was well known for his work in engineering geology.

The nominee for the Jahns lectureship will be selected by a special committee appointed by the chair of the Engineering Geology Division and the president of the Association of Engineering Geologists. The appointment will be made annually and will be announced at the annual meeting of each organization.

Contributions to support the Jahns Distinguished Lecturer may be made directly to the Foundation office.

Digging Up the Past

Most memorable early geologic experience:

"In 1948, four of us hiked about 100 miles south of the newly opened Alaska Highway to pan for gold. After two months, an accident forced us to leave on a raft. Our 1:500,000 map didn't show rapids and falls, and we tipped over 18 times in one day, losing our gold and everything but a sleeping bag, a rifle, and an onion."

—D. W. Caldwell

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On behalf of the Foundation's Board of Trustees and staff, a heartfelt thank you to all our members who contributed to the Foundation in 1999. With your investment for Earth, Education, and the Environment, the Foundation was able to complete the Second Century Fund Campaign by raising over $1 million during the year. We offer our sincere appreciation to each of you for your continued support in the advancement of the mission and vision of GSA.

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BOOK REVIEW

Traces of Catastrophes: A Handbook of Shock-Metamorphic Effects in Terrestrial Meteorite Impact Structures. *By Bevan French. Lunar and Planetary Institute, Houston, Texas, 1998, 120 p.*

Impact cratering is capturing the attention of geologists in a broad range of disciplines, from petrographers, to geochemists, to structural geologists, and to geophysicists. This is being driven largely by the realization that the Chicxulub impact event was likely responsible for the mass extinction at the Cretaceous-Tertiary boundary and the growing realization that impact processes have, throughout Earth history, repeatedly perturbed the environment and affected the biologic evolution of our planet.

Despite the growing interest, few university courses introduce geology students to impact cratering. For example, impact crater formation and modification, which involves some of the most dramatic folding and faulting on the planet, is rarely taught in structural geology courses. Likewise, shock-induced mineral deformation, phase transformation, and melting are rarely taught in mineralogy and petrology courses. This partly reflects the lack of expertise among faculty, but it is aggravated by a lack of supporting texts. Until recently, the only substantive book on the subject was H. Jay Melosh's book *Impact Cratering: A Geologic Process*. That is why the new book by Bevan M. French, *Traces of Catastrophe: A Handbook of Shock-Metamorphic Effects in Terrestrial Meteorite Impact Structures*, is so welcome. While Melosh's book covers the theoretical underpinnings of the impact cratering process, French's volume explores the rock record.

In eight chapters, French deftly highlights the features of impact craters. He introduces the topographic nature of craters on planetary surfaces where they are better preserved than on Earth; discusses the impact cratering rate on Earth over geologic time; the excavation and modification of craters; shock-metamorphic effects produced by cratering, including impact melting; and how to determine if candidate structures are impact craters. French is particularly expert in the mineralogy and petrology of impact lithologies, as reflected in a very good set of thin-section photomicrographs. This is critically important information because microscopic features are used to unambiguously identify impact sites and record the magnitude of their effect on Earth's surface. These photomicrographs are augmented with a good selection of line drawings and tables that further illustrate impact cratering processes.

The book could perhaps be improved with a glossary; the handbook format lends itself to that type of section. However, new terms are at least flagged for the reader with boldface type. The book does not contain a lot of discussion about structural relationships in the field, but these are hard to convey with words and illustrations, particularly when the structures are very large or highly eroded craters. To learn about these aspects of impact cratering, it is difficult to beat field experience.

I highly recommend this volume for any student or professional geologist interested in learning more about the shock metamorphic features that are produced in the rock record by impact cratering processes. If you are interested in obtaining your own copy, contact the Lunar and Planetary Institute (Order Department, 3600 Bay Area Blvd., Houston, TX 77058-1113.) They can provide you with *Traces of Catastrophe* for the incredibly low cost of shipping and handling.

David A. Kring
University of Arizona
Tucson, AZ 85721

STUDENT NEWS AND VIEWS

Kyoko Ohashi, *State University of New York at Stony Brook*

Student News and Views provides GSA membership with commentary on matters relating to undergraduate and graduate students in the geosciences. The correspondent for Student News and Views welcomes comments and suggestions sent to stumatts@geosociety.org.

The Unknown

Although the focus recently has been on the word "millennium," a time span as short as a decade can leave the world in a drastically altered state. I am reminded of a conversation I had with my office mate a few years ago.

We were eating lunch in our office, on the wall of which was a map of the world. My office mate pointed to the map and exclaimed, "These countries—I've never heard of them!" I looked to where she was pointing and told her that those countries had gained independence after the collapse of the Soviet Union. She asked me when that had happened, and when I answered "1991," she thought for a moment, and said, "Oh, that's after I graduated from high school." I took that to mean that sometime in high school had been the last time she had studied world geography in a classroom setting. Having studied marine sciences in college and graduate school, she had never been required since high school to memorize the world map for a test. That in itself is, of course, common; as we progress in our education, we become increasingly specialized. What struck me, however, was how she said those words, as if to say, "If these countries came into existence after I took geography class in high school, I am not responsible for knowing about them."

That office mate has earned her Ph.D. and become a researcher at the national university in her home country. There is no doubt in anyone's mind that she is a researcher of very high caliber. Yet the fact that she had no qualms about not knowing of those countries lingered in my mind. I had been left with the impression that in her view, the world was divided into what she had to know and what she didn't have to know. This undoubtedly is an efficient way of dealing with knowledge. It is, however, the polar opposite of my approach, which is why her words have left an impression on me. I tend to like learning something I don't "have to" know. I remember, in junior high school, crossing out the name "Upper Volta" in my world atlas (which I had won in a school-wide geography contest), and writing "Burkina Faso" above it. I wasn't required to know about the name change of this small country in Africa, but it was fun for me.

If we only knew what we absolutely had to know, we would still be living in caves, subsisting on nuts and berries. When I was in elementary school, we were given a chart of the Dewey decimal system of classifying library books. Each category was represented by a picture of a prehistoric man and a question posed by him; world geography, for example, would have been "What other lands are out there?" To be curious about our surroundings—to venture out beyond our caves—may be a trait shared among many species, but we have had the various means to act on that curiosity more than any other species.

We have collectively accumulated a vast amount of knowledge—and "collectively," of course, is the key word here. None of us can hope to gain all the knowledge existing in the world today, to which more is continuously added—hence, specialization, in the form of choosing which AP classes to take, choosing a major, and so on. Specialization, however, has the inherent danger of not completing the loop—of our not being able to integrate whatever we have found into the context of what is already known. If a scientist makes a discovery in the forest and no one sees it, is it really a discovery? We need to be able to climb a tree, both to tell the world what we've found and to see how much is still unknown. ■

FUTURE GSA ANNUAL MEETINGS

2001 **Boston, Massachusetts, November 5–8**

2002 **Denver, Colorado, October 28–31**

2003 **Seattle, Washington, November 2–5**

FOR INFORMATION ON ANY GSA MEETING, CALL THE

GSA MEETINGS DEPARTMENT

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2000 GSA SECTION MEETINGS

Northeastern Section — March 13–15, 2000, New Brunswick, New Jersey. Regency Hyatt Hotel. Information: Robert E. Sheridan, Dept. of Geological Sciences, Wright Lab, Rutgers University, 610 Taylor Road, Piscataway, NJ 08854-8066, (732) 445-2015, rsheridn@email.rci.rutgers.edu.

Southeastern Section — March 23–24, 2000, Charleston, South Carolina, Westin Francis Marion Hotel. Information: Michael P. Katuna, Dept. of Geology, Charleston College, Charleston, SC 29424-0001, (843) 953-5589, katunam@cofc.edu.

South-Central Section — April 3–4, 2000, Fayetteville, Arkansas, Center for Continuing Education, University of Arkansas. Information: Doy L. Zachry, Jr., Dept. of Geosciences, 118 Ozark Hall, University of Arkansas, Fayetteville, AR 72701-1201, (501) 575-3355, dzachry@comp.uark.edu.

North-Central Section — April 6–7, 2000, Indianapolis, Indiana, Marriott Courtyard & the Indiana Government Center. Information: Robert D. Hall, Indiana University–Purdue University, 723 W. Michigan Street, Indianapolis, IN 46202-5132, (317) 274-7484, rhall@iupui.edu.

Rocky Mountain Section — April 17–18, 2000, Missoula, Montana, Missoula Community Theater. Information: Donald W. Hyndman, Dept. of Geology, University of Montana, Missoula, MT 59812-1019, (406) 243-2241, dhyndman@selway.umt.edu. *Preregistration deadline: March 10, 2000.*

Cordilleran Section — April 27–29, 2000, Vancouver, British Columbia, Canada, Robson Square Conference Centre. Information: Peter S. Mustard, Dept. of Earth Sciences, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6, (604) 291-5389, pmustard@sfu.ca. *Preregistration deadline: March 17, 2000.*

CALENDAR

Only new or changed information is published in *GSA Today*. A complete listing can be found in the Calendar section on the Internet: **www.geosociety.org.**

2000 Meetings

March

March 16–17, 16th Annual Mining and Land Resource Institute, Reno, Nevada. Information: American Association of Professional Landmen, (817) 847-7700, www.nvlandman.org/malri.htm.

April

April 9–12, Performance Confirmation of Constructed Geotechnical Facilities, Amherst, Massachusetts. Information: Donna Carver, (413) 545-9703, dcarver@ecs.umass.edu, www.ecs.umass.edu/cee/geohome/.

April 10–12, Australian Gold Conference, Perth, Australia. Information: www.conference.australiangold.org.au or enquiry@conference.australiangold.org.au, phone 61-8-9226-3280, fax 61-8-9226-1544.

April 14–16, Mid America Paleontology Society National Fossil Exposition XXII, Macomb, Illinois. Information: Allyn Adams, 612 West 51st St., Davenport, IA 52806, (319) 391-5443.

May

May 27–June 1, Mineral Surface Reactivity: EuroConference on Interaction of Mineral Surfaces with Organic and Inorganic Species in Aqueous Solution, San Feliu de Guixols, Costa Brava, Spain. Information: Sally Lewis, slewis@esf.org, www.esf.org/euresco/00/lc00154a.htm.

June

June 8–12, Geology of the Bahamas 10th Symposium, Bahamian Field Station, San Salvador, Bahamas. Information: Cindy Carney, Dept. of Geological Sciences, Wright State University, Dayton, OH 45435, (937) 775-3455, cindy.carney@wright.edu, www.geology.wright.edu/geology/events/symposium.html. *(Abstract deadline: April 1, 2000.)*

August

August 5–8, 2000, GeoDenver 2000, Denver, Colorado. Information: (800) 548-2723 or (703) 295-6300 (outside the US), fax 703-295-6144, www.asce.org/conferences/geo2000/.

September

September 6–8, 3rd Conference on Tectonic Problems of the San Andreas Fault System, Stanford, California. Information: http://pangea.stanford.edu/GP/seminars.html or kehoe@stanford.edu. (Abstract deadline: June 15.)

September 17–20, The Society for Organic Petrology (TSOP), 17th Annual Meeting, Bloomington, Indiana. Information: Maria Mastalerz, Indiana Geological Survey, 611 North Walnut Grove, Bloomington, IN 47405, (812) 855-9416, fax 812-855-2862, mmastale@indiana.edu. Further details: http://adamite.igs.indiana.edu/tsop.

October

October 11–13, RISK 2000, Computer Simulation in Risk Analysis and Hazard Mitigation, Bologna, Italy. Information: Karen Savage, Risk 2000/1479, WIT, Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK, phone 44-238-029-3223, fax 44-238-029-2853, ksavage@wessex.ac.uk, www.wessex.ac.uk/conferences/2000.

November

November 5–8, American Institute of Hydrology Annual Meeting and International Conference, Atmospheric, Surface, and Subsurface Hydrology and Interactions, Research Triangle Park, North Carolina. Information: AIH, 2499 Rice St., Ste. 135, St. Paul, MN 55113, (651) 484-8169, fax 651-484-8357, AIHydro@aol.com, www.aihydro.org.

GSA 2000 Annual Meeting & Exposition

Reno, Nevada • November 9–18

- Pre-Meeting Field Trips, November 9–12
- Short Courses & Workshops, November 11–12
- Exhibits Open, November 12–15
- Technical Program, November 13–16
- Post-Meeting Field Trips, November 16–18

Abstracts Deadline:

Paper—July 25, 2000
Electronic—August 1, 2000

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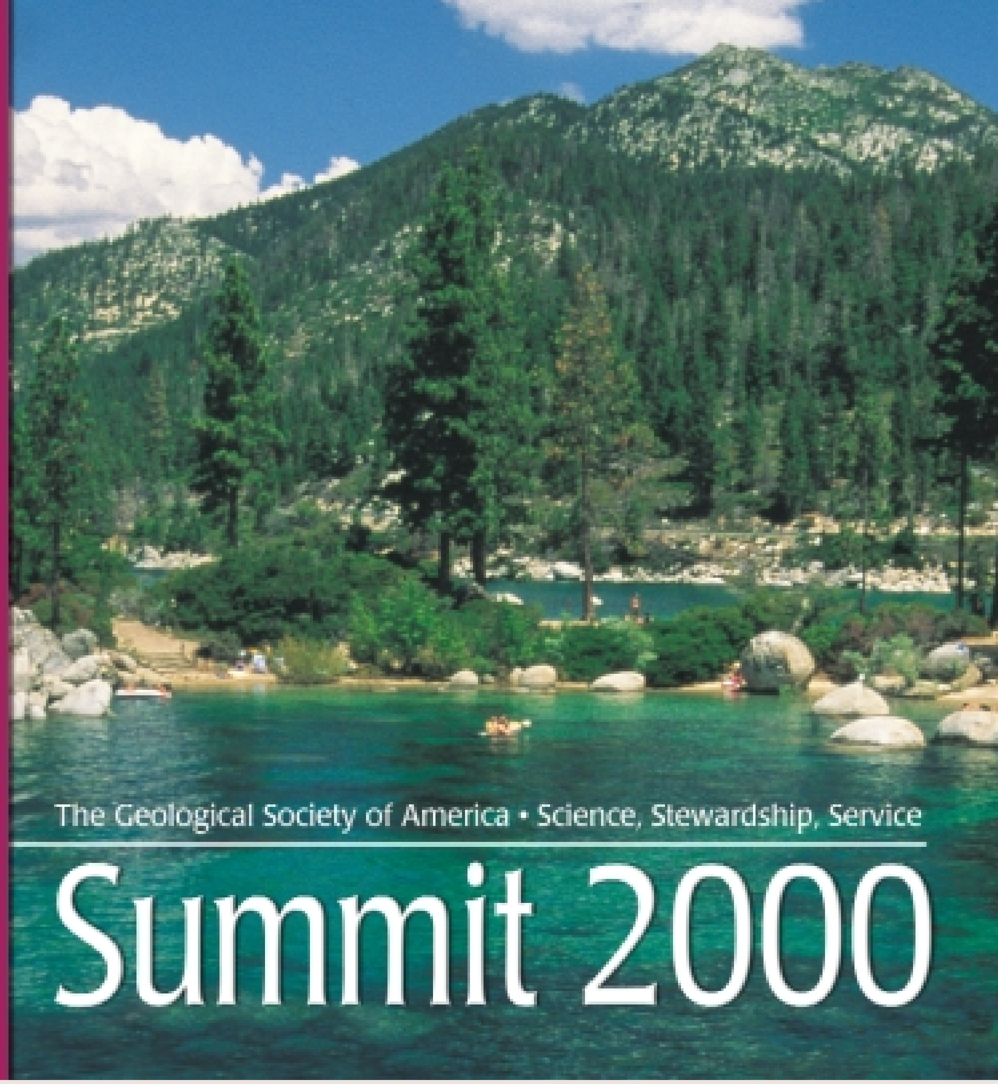

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The Department of Geology at the University of Southern Indiana invites applications for a full-time position at the Geology Instructor level, beginning August 2000 and renewable on a yearly basis. The Department seeks a creative and energetic geologist in any area of geology. The successful applicant will teach and develop introductory laboratory sessions (including field experiences) at the undergraduate level, conduct an evening lecture in Physical Geology, and will maintain and enhance the department's teaching collections and equipment. A master's degree in geology is required. The University is committed to excellence in teaching, scholarship and professional activity, and service to the University and community. Minorities and women are encouraged to apply. Please submit a letter of application including a brief statement of teaching experience and scholarly interests, a resume, and name/address and phone/email for three references for review beginning March 20, 2000, to: Dr. Paul K. Doss, Chairman, Department of Geology and Physics, University of Southern Indiana, 8600 University Blvd., Evansville, IN 47712. Additional information may be obtained from http://deepcnet.usi.edu/geology.

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BIOGEOCHEMISTRY
UNIVERSITY OF SASKATCHEWAN

The Department of Geological Sciences at the University of Saskatchewan invites applications for a tenure-track position in Biogeochemistry. We are interested in candidates with expertise in organic biogeochemistry, and a strong background in stable isotope or trace element analytical techniques. Applicants must hold a PhD, and previous teaching and research experience is preferred.

The Department has 15 full-time faculty, including two endowed research chairs in Geochemistry, and a well-equipped Analytical Geochemistry Facility. Further details are available on the Department web-site http://www.usask.ca/geology/.

Applicants should send a full resume and names of three referees to: Dr. James Basinger, Head, Department of Geological Sciences, 114 Science Place, University of Saskatchewan, Saskatoon, SK, S7N 5E2, Canada. Email: jim.basinger@usask.ca. Fax: 306-966-8593. Application deadline is April 30, 2000.

The University is committed to Employment Equity. Members of Designated Groups (women, aboriginal people, people with disabilities and visible minorities) are encouraged to self-identify on their applications. This position has been cleared for advertising at the two-tier level. Applications are invited from qualified individuals, regardless of their immigration status.

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UNIVERSITY OF SASKATCHEWAN

The Department of Geological Sciences at the University of Saskatchewan is seeking applicants for a tenure track position in applied geophysics. The successful applicant will have demonstrated research ability, a strong commitment to undergraduate teaching and must hold the PhD degree.

The Department has fifteen faculty, including three in the area of geophysics, and two endowed research chairs. We offer BSc, MSc and PhD degrees in geophysics, geology, environmental earth science paleobiology. The Department has a well-equipped seismic lab, supported by a full-time technician.

Applications should be received no later than April 30, 2000. Initial enquiries to jim.basinger@usask.ca. Fax: 306-966-8593. Further details are available on the Department website http://www.usask.ca/geology/

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STABLE ISOTOPE RESEARCH SCIENTIST
THE UNIVERSITY OF ALABAMA

The Department of Geological Sciences at the University of Alabama is seeking an outstanding candidate to fill the position of Research Scientist in the area of stable isotope mass spectrometry. The initial appointment is for 3 years assuming satisfactory performance.

Qualifications for this position include an M.S. or Ph.D. degree in geochemistry or a related field and experience in stable isotope mass spectrometry. The successful applicant will be expected to set up, run, and maintain a new Finnigan MAT Delta+ recently purchased by the Department of Geological Sciences. Therefore, preference will be given to candidates with extensive experience in a mass spectrometry laboratory and a record of research in this area. The successful applicant will collaborate with a group of researchers in biological, geological, and marine sciences with a wide range of externally funded projects. For more information about some of our programs visit our web sites: http://www.geo.ua.edu/ and http://www.as.ua.edu/cfs/.

Please send curriculum vitae, bibliographies, names of 3 references, mass spectrometry lab experience, and research interests to Dr. Stowell, Department of Geological Sciences, Box 870338, University of Alabama, Tuscaloosa, AL 35487. Review of applications will begin March 1, 2000 and applications will be accepted until position is filled.

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TENURE-TRACK POSITION, GEOLOGY DEPARTMENT
BRIGHAM YOUNG UNIVERSITY

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Starting salary and rank will be commensurate with degree and experience. Review of applicants will begin on 1 May 2000.

Applicants should send a letter of application, curriculum vitae, and the names and e-mail addresses of three references to: Dr. Scott M. Ritter, Faculty Search Commit-

DIRECTOR
INSTITUTE OF GEOPHYSICS AND PLANETARY PHYSICS
University of California, RIVERSIDE

igpp

Applications are invited for the position of Director of the University of California, Riverside (UCR) Institute of Geophysics and Planetary Physics (IGPP). The Director is the scientific and administrative head of the Institute. He/She should be eligible for a joint appointment as a tenured professor of the University of California, Riverside in the department of the candidate's discipline.

The Institute of Geophysics and Planetary Physics is a major Multi-campus Research Unit (MRU) of the University of California with branches at UCLA, UCR, UCSC, UCSD, LANL and LLNL. Research at the different IGPP branches includes astrophysics, climatology, geochemistry, geophysics, paleobiology, physical oceanography, and planetary and space physics. Research at UCR includes tectonics and geodynamics, environmental geophysics, solid and fluid geophysical systems, mineral physics, high-energy astrophysics, plasma physics and archaeometry. Applicants in complementary areas and especially in the fields of high-energy astrophysics, tectonics and geodynamics, and the physics and chemistry of solid-fluid interfaces are encouraged to apply. More information can be found at http://cnas.ucr.edu/~igpp/home.html. The IGPP at UCR has a staff of about 25 faculty, professional researchers and postdoctoral researchers.

The Director should be an active internationally distinguished researcher with a demonstrated ability for administrative and scientific leadership especially in an interdisciplinary setting. He/she is expected to have a strong commitment to graduate student education and teaching and for promoting extramural research funding. Salary is commensurate with experience and the level of appointment in the tenured professor series of the University of California and will include an administrative stipend for the directorship.

Applications should include a curriculum vita, a list of publications, statement of research interests and names and addresses for at least three letters of recommendations. Applicants should be willing to submit additional references on request. Materials should be sent to: **Chair, IGPP Director Search Committee, CNAS Dean's Office, 311 College Building North, University of California, Riverside, CA 92521.**

Full review of applications will begin on 10 April 2000 with an appointment date as early as 1 July 2000. Applications will be accepted until the position is filled. Requests for additional information regarding the position can be directed to lisa.arth@ucr.edu.

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tee, Department of Geology, Brigham Young University, Provo, UT 84602 (scott_ritter@byu.edu)

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RALPH E. GRIM PROFESSORSHIP IN GEOLOGY
UNIVERSITY OF ILLINOIS, URBANA-CHAMPAIGN

The Department of Geology at the University of Illinois, Urbana-Champaign, invites applications for a tenured appointment as the R.E. Grim Professor of Geology. The successful applicant will have a distinguished record of scholarship in mineral science or sedimentary geology and will have demonstrated strong disciplinary leadership through establishment of a vigorous, internationally recognized research program. The successful applicant must also demonstrate an ability to promote excellence in education. Rank (associate or full) and salary will be commensurate with experience. Applicants should submit a curriculum vita, a record of research funding, a list of publications, a description of research and teaching interests, and the names of at least four referees to: Dr. Stephen Marshak, Search Committee Chair, Department of Geology, University of Illinois, 1301 West Green Street, Urbana, IL 61801. Questions about the position can be directed to Dr. Marshak (217-333-3542; Fax: 217-244-4996; smarshak@uiuc.edu). Nominations of potential candidates can be transmitted by e-mail. The search will remain open until the position is filled, but for equal consideration, applicants should submit materials no later than March 21, 2000. The University of Illinois is an Equal Opportunity/Affirmative Action employer. Women and minorities are encouraged to apply.

POSTDOCTORAL POSITIONS IN UCLA
ION MICROPROBE LABORATORY

The W.M. Keck Center for Isotope Geochemistry at UCLA is seeking several Ph.D. scientists to undertake isotopic investigations using our high resolution ion microprobe in the areas of (1) early solar system evolution; (2) low temperature geochemical phenomena in petroleum reservoirs, geothermal systems, and mineral deposits; (3) paleoclimatology; and (4) astrobiology. Candidates could have a background in any of the four areas enumerated above, in isotope geochemistry, or in SIMS. The positions are available immediately for an initial term of one year with the possibility of renewal for subsequent years. Salary is commensurate with experience. UCLA offers excellent benefits. Interested candidates should consult our web page (http://oro.ess.ucla.edu/ionprobe/home.html) for further information and complete the application form found there. Consideration of applications will begin immediately. The University of California is an equal opportunity employer.

GEOSCIENCES - FULL-TIME TENURE-TRACK
MONROE COMMUNITY COLLEGE

Master's Degree or higher in geology, geography, or related earth science fields required. Ability to teach geology or geography courses required. Ability to teach several courses in different geosciences areas preferred. Please see course listing and descriptions in Geology or Geography in MCC catalog or at http://www.monroecc.edu. Please send letter of application, resume, list of three references, official transcripts., and statement of philosophy regarding teaching or regarding the role of today's community college to: Dr. Sherry Ralston, Director of Human Resources, Monroe Community College, 1000 E. Henrietta Rd., Rochester, NY 14623. AA/EOE/SUNY

GRADUATE TEACHING ASSISTANTSHIPS
GEOLOGY AND GEOCHEMISTRY
NEW MEXICO INSTITUTE
OF MINING AND TECHNOLOGY

The Geology/Geochemistry Program of the Department of Earth and Environmental Science has graduate teaching and research assistantships in support of M.S. and Ph.D. candidates in the area of geology and geochemistry. The assistantships will be available in Fall 2000. The Geology/Geochemistry program has active research programs in many areas including carbonate diagenesis, economic geology, crustal evolution, environmental geology, environmental geochemistry, structural geology, surficial processes, sedimentology, soils, Quaternary geology, hydrogeology, Ar/Ar dating, and volcanology.

The Department of Earth and Environmental Science (http://www.ees.nmt.edu) at New Mexico Tech (http://www.nmt.edu) comprises 18 full-time faculty, 26 adjunct faculty, and approximately 90 graduate students. We enjoy a high-desert climate, small-town setting and cheap living, with numerous outdoor recreational opportunities, including biking, rock climbing, skiing, hunting, and hiking. Socorro is located approximately 1 hour south of Albuquerque. For further information, contact Dr. Philip Kyle, Department of Earth and Environmental Science, N.M. Tech, Socorro, NM 87801 USA; Tel. 1-800-428-TECH (8324) (domestic calls) or 1 505-835-5995, e-mail gradapps@dutchman.nmt.edu

THE JUDSON MEAD GEOLOGIC FIELD STATION
INDIANA UNIVERSITY

The Judson Mead Geologic Field Station of Indiana University is seeking applicants for two visiting faculty positions for Summer 2000. These include: (1) a full time, 7-week position in G429, Geology of the Northern Rocky Mountains; and (2) a 2-week position in G329, Introduction to Environmental Field Science. Comfort and/or familiarity with teaching in a field setting are considered essential. The new faculty members will work with other faculty and associate instructors. For G429, any specialty will be considered, though a training in environmental geology and hydrology is most needed. For G329 we are looking for someone with a knowledge of surficial processes and hydrology. Additional information about the courses and program can be found at http://www.indiana.edu/~iugfs. Applicants should send letter of interest and resume to: Director, Judson Mead Geologic Field Station of Indiana University, 1001 E. 10th, St., Bloomington, IN 47405. Indiana University as an Equal Opportunity/Affirmative Action Employer encourages the candidacies of women and minorities.

FACULTY - EARTH SCIENCE
UTAH VALLEY STATE COLLEGE, OREM, UTAH

Candidates are currently being sought for an anticipated tenure-track faculty position to begin August 2000 to help support a growing Earth Sciences program at Utah Valley State College in Orem, Utah. Requires graduation from an accredited college or university with an earned Ph.D. with a

Classifieds *continued on p. 55*

GeoTrip

Geology of the Grand Canyon—Lee's Ferry to Pierce Ferry

April 7–14, 2000 • 8 days, 7 nights

Participants of a GSA river trip socializing at the end of the day in the Grand Canyon. Photo by Ivo Lucchitta.

Scientific Leader: Ivo Lucchitta, U.S. Geological Survey, Flagstaff, Arizona

Ivo Lucchitta's interests include continental extension (from the perspective of Colorado Plateau–Basin and Range interface); history of Grand Canyon and Colorado River; and Quaternary geology and geomorphology, especially as applied to southwestern drainage systems.

Description

Explore the classic stratigraphy of one of the world's most fascinating and accessible geologic records, including Tapeats Limestone, Bright Angel Shale, and Vishnu Schist. Although millions have traveled the Colorado River's erosional path through the Kaibab plateau, GSA's trip offers a rare combination of expert geological leadership and stimulating intellectual companionship. Emphasis will be on the interaction between geology and people.

Fees and Payment

$1,750 for GSA Members; $1,850 for nonmembers. A $300 deposit is due with your reservation and is refundable through February 1, less a $50 processing fee. The total balance is due *March 1, 2000.* Minimum: 14. We are holding 14 spaces. Any additional spaces will be based on availability. Included: Guidebooks to the river; geologic guide; transportation to and from Las Vegas and the river; waterproof bags for clothes; life jacket; camping gear, including two-person tent, sleeping bag and pad, and eating utensils; continental breakfast before put-in on day 1 and all river meals; soft drinks on the river. Not included: Airfare to Las Vegas, lodging and meals in Las Vegas, and alcoholic beverages.

GeoTrip

Deformation, Dinosaurs, and Darwin

Salta, Argentina • July 24–August 13, 2000 • 21 days, 20 nights

View of the Neogene Cordillera Oriental from the Cuesta del Obispo in Salta Province, Argentina. Photo by James H. Reynolds.

Scientific Leaders: James Reynolds, Magstrat, LLC, Webster, North Carolina, and Brevard College, Brevard, North Carolina; Dorothy L. Stout, Cypress College, Cypress, California

Jim Reynolds has spent the past 15 years investigating the uplift history of the Andes. Using magnetostratigraphy, Jim and his colleagues are developing a relatively precise chronostratigraphy across the many tectonic provinces that we will visit. In addition to his work at Magstrat, LLC and Brevard College, he holds an adjunct position at the University of Pittsburgh.

Dottie Stout has been leading geological expeditions around the world since 1978, exploring China, South America, Africa, Europe, Indonesia, Australia, and Russia. Dottie is past president of the National Association of Geology Teachers, is currently on GSA Council, and is temporarily on leave as a program director at the National Science Foundation.

Description

This thousand-mile journey down the east side of the Andes encompasses a variety of the tectonic provinces associated with variations in the Nazca plate subduction angle that range from subhorizontal to moderately steep. The trip begins in Salta and Jujuy provinces in northwestern Argentina, where Proterozoic, Paleozoic, Mesozoic, and Cenozoic strata and structures are spectacularly displayed. Other sites to be visited: (1) The Train to the Clouds, Parque National de Reyes—a jungle excursion renowned for its animals and birds; environmental geology problems caused by active alluvial fans in the Quebrada de Humahuaca; and new interpretations and connections of Grenville rocks. Cambrian-Ordovician strata with North American affinities will be examined, as will views of a porphyry copper complex on the 20,000-ft-high Sierra de Famatina. (2) Valle de la Luna National Park, the area in which the oldest known dinosaurs were discovered, includes views of Aconcagua; a bus ride to Los Penitentes ski area along the route that Darwin took when he traversed the Andes from Valparaiso, Chile (weather dependent); Buenos Aires; and Iguazu Falls.

Fees and Payment

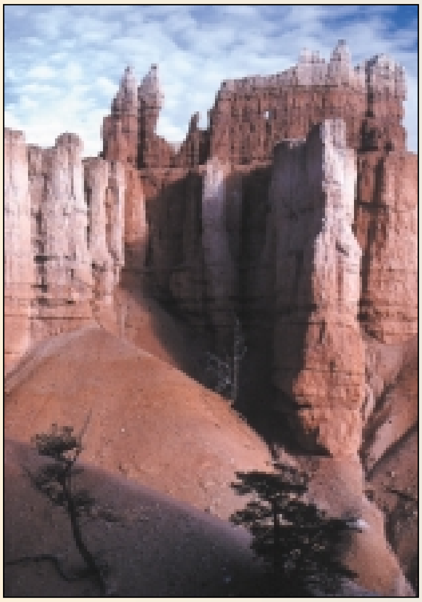
$3,900 for GSA Members; $4,000 for nonmembers. A $300 deposit is due with your reservation and is refundable through June 1, less $50 processing fee. The total balance is due *June 1, 2000.* Minimum: 20; maximum: 30. Included: Guidebook, ground transportation, lodging for twenty nights, based on double occupancy, and meals for 21 days. Not included: Airfare to Argentina and alcoholic beverages.

2000 GeoVentures

GEO HOSTEL

Valley of Fire in Southern Nevada, Toroweap Valley of the Grand Canyon, Zion and Bryce Canyon National Parks of Southern Utah

Dixie College, St. George, Utah • June 10–15, 2000 • 5 days, 6 nights



Eocene Claron Formation, Bryce Canyon National Park, Utah. Photo by Martin Miller.

Scientific Leaders: Spence Reber, Chevron USA (retired); Janice Higgins, Dixie College, St. George, Utah

Spence Reber spent 37 years as a petroleum geologist for Chevron USA. He was the field trip leader for Chevron's Structural Geology Seminar for 22 years, during which he traversed the areas to be visited. Spence has remained active in geology. He is a groundwater consultant for most cities and towns in southwestern Utah, and teaches geology at the Institute for Continued Learning at Dixie College in St. George.
Janice M. Higgins received both her bachelor and master degrees in geology from Brigham Young University in Provo, Utah, and a secondary teaching certificate from Metropolitan State College in Denver, Colorado. She has worked as an exploration geologist in the oil industry and as a physical and earth science teacher in Colorado and Utah. She is currently a project geologist with the Utah Geological Survey mapping program, producing geologic maps and the accompanying text for 7.5 minute quadrangles. Janice is also an adjunct instructor of geology at Dixie College in St. George, Utah.

Description

This GeoHostel will be of interest and challenging to the professional geologist or geophysicist, yet understandable and fascinating to others. The structure and stratigraphy of the region are exceptionally well exposed, and each field trip stop will display elements of both. The participants will be housed in dorm facilities at Dixie College, located in historic St. George, Utah. St. George is a thriving community of more than 50,000, nestled in a valley surrounded by picturesque hills and mountains. It was ranked 6th in a recent survey of the 10 most popular and desirable retirement communities in the United States. The field trips planned for each day will begin and end in St. George. A brief show-and-tell with handouts will be given in the morning before going out into the field. All of the field trips will be on hard surface roads, and walking will not be strenuous. The weather in the region is generally warm and sunny, with daytime temperatures ranging from 70 to 90 °F and nighttime temperatures ranging from 50 to 60 °F. Bring your camera and binoculars for this GeoHostel.

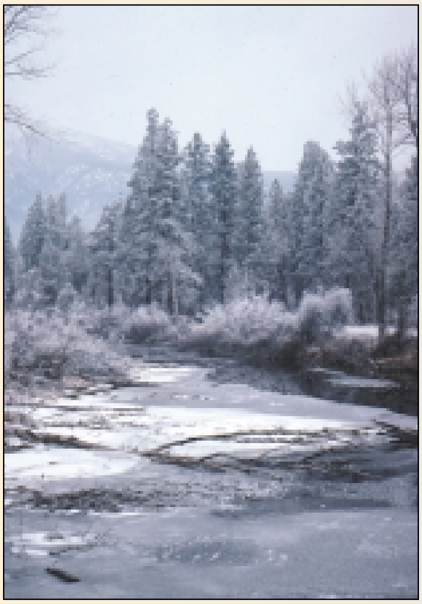
Fees and Payment

$800 for GSA Members; $900 for nonmembers. A $100 deposit is due with your reservation and is refundable through May 1, less $20 processing fee. The total balance is due *May 1, 2000.* Maximum: 32. Included: Classroom programs and materials; field trip transportation; lodging for six nights (single occupancy, or double for couples); breakfast and lunch daily, and welcoming and farewell events. Not included: Airfare to and from St. George, Utah; transportation during hours outside field trips; and other expenses not specifically included.

GEO HOSTEL

Geology of the Lewis and Clark Expedition: Lost Trail Pass to the Columbia River

University of Montana, Missoula, and Sacajawea Select Inn, Lewiston, Idaho • July 15–20, 2000 • 5 days, 6 nights



Along the Lewis & Clark Trail in the Bitterroot Valley, Montana. Photo by Rob Thomas.

Scientific Leaders: Rob Thomas and Sheila Roberts, Western Montana College, Dillon, Montana

Rob Thomas is currently an associate professor and chair of the Department of Environmental Sciences at Western Montana College in Dillon. He developed an interest in the geology of the Lewis and Clark Expedition as a result of 13 years of research and teaching in southwestern Montana. His focus has been on the origin and timing of extensional tectonism in southwestern Montana, the dynamics of carbonate platform development and destruction, Cambrian mass extinctions, and field-based geoscience program development.
Sheila Roberts is currently an associate professor of geology in the Department of Environmental Sciences at Western Montana College in Dillon. Her focus has been on Pleistocene paleoclimates recorded in saline lacustrine sediments. Sheila is also a strong advocate for service learning in the geosciences, and has mentored her students on several community service projects along the Lewis and Clark trail in southwestern Montana. A native Montanan, Sheila is a knowledgable guide to the history and geology of the Lewis and Clark Expedition.

Description

From 1804 to 1806, Meriwether Lewis and William Clark journeyed through the recently acquired Louisiana Territory on the order of President Thomas Jefferson. From August to October of 1805 they traversed the continental divide, traveled down the Bitterroot Valley, over the Bitterroot Range, and on to the Columbia River. This trip will be a geolog-

GeoVentures *continued on p. 54*

2000 GeoVentures

GeoVentures continued from p. 53

ical and historical tour of that famous landscape. The expedition will have two base camps, Missoula, Montana, and Lewiston, Idaho. The geological component of this GeoHostel will include field trips to see Proterozoic and Phanerozoic sedimentary rocks; Mesozoic compressional structure; Mesozoic igneous rocks and mylonites of the Idaho batholith; and Tertiary volcanics of the Challis arc and the Columbia Plateau. Side trips will investigate accretionary terranes and the John Day Formation. The historical component will include stops at important landmarks from the Lewis and Clark expedition such as the Lost Trail, Traveler's Rest, Lolo Pass, and Nez Perce villages.

Fees and Payment

$900 for GSA Members; $1,000 for nonmembers. A $100 deposit is due with your reservation and is refundable through June 1, less $20 processing fee. The total balance is due *June 1, 2000*. Maximum: 32. Included: Classroom programs and materials; field trip transportation; lodging for six nights (single occupancy, or double for couples); breakfast and lunch daily, dinner on Sunday, and welcoming and farewell events. Not included: Airfare to and from Missoula, Montana; transportation during hours outside field trips; and other expenses not specifically included.

See the December 1999 issue of* GSA Today *for information on accommodations, age requirements, health recommendations and special needs, and cancellation procedures, or check GSA's Web page: www.geosociety.org.

REGISTER TODAY!

Send a deposit to hold your reservation; please pay by check or credit card. You will receive further information and a confirmation of your registration within two weeks after your reservation is received.

	Deposit Per Person	No. of Persons	Total Paid Deposit
GT001—Grand Canyon	$300	____	$________
GT002—Argentina	$300	____	$________
GH003—Utah	$100	____	$________
GH004—Montana	$100	____	$________
	TOTAL DEPOSIT		$________

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

☐ VISA ☐ MasterCard ☐ American Express

Credit Card # Exp. Date

Signature

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

MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
2000 GSA GeoVentures, Member Services
P.O. Box 9140, Boulder, CO 80301
fax 303-447-1133 or 303-443-1510

MAKE CHECKS PAYABLE TO: GSA 2000 GeoVentures

COMING ATTRACTIONS ...

FIELD FORUM

Correlating Volcanic and Plutonic Perceptions of Silicic Magma Chamber Processes: Evidence From Coastal Maine Plutons

Ellsworth, Maine

September 14–19, 2000

Leaders: Robert Wiebe, Franklin and Marshall College, RWeibe@Acad.FandM.edu; David Hawkins, Denison University, hawkins@cc.denison.edu; Donald Snyder, University of Michigan, donsnyd@umich.edu; Tod Waight, Danish Lithosphere Centre, Copenhagen, twe@dlc.ku.dk

Cost: $630

GEOTRIP

Ireland: Giant Steps Through Time

Dublin, Ireland

September 16–October 1, 2000

Leaders: John Morris, Barry Long, Brian McConnell, Conor MacDermot, and Pat O'Connor, Geological Survey of Ireland, Dublin; Patrick McKeever, Ian Mitchell, and Terry Johnston, Geological Survey of Northern Ireland.

Coordinators: Enda Gallagher, Geological Survey of Ireland, gallaghe@tec.irlgov.ie; Jay M. Gregg, Dept. of Geology and Geophysics, University of Missouri—Rolla, greggjay@umr.edu

Cost: $4,300 (member); $4,400 (nonmember)

See the April issue of* GSA Today *for information regarding registration, daily itineraries, and accommodations, or check GSA's Web page: www.geosociety.org.

Classifieds *continued from p. 51*

strong component of mineralogy, petrology, and/or geohydrology, plus teaching experience at the undergraduate level. Applicants must submit: a letter of application, a curriculum vita, copies of transcripts/diplomas showing degrees awarded, and three letters of recommendation. To be considered in the first screening all materials must be received by 5:00 p.m. on 03-10-2000. For a complete position description, contact Human Resources at (801) 222-8207 or visit our web page at www.uvsc.edu/hr/employ. E-mail information requests to bartlena@uvsc.edu. UVSC is an accredited college serving 18,000 students. UVSC is an Affirmative Action/Equal Opportunity/Equal Access employer. Minorities, women, and individuals with disabilities are encouraged to apply. AA/EOE

STATE GEOLOGIST, NEW HAMPSHIRE DEPARTMENT OF ENVIRONMENTAL SERVICES

New Hampshire Department of Environmental Services (DES) is seeking to fill this spring, the position of State Geologist for the State of New Hampshire. In that capacity, the State Geologist serves as the chief scientific advisor for DES and for the State on geologic and hydrogeologic issues, and is responsible for continuing the development of the geologic resources program for the state. The ideal candidate will possess exceptional written and oral communications skills, and the ability to develop and maintain strong working relationships with many programs within DES and the public.

Minimum qualifications include Master's degree with a major study in geology, hydrology, hydrogeology or a related water resources or earth science degree and ten years' experience in the fields listed in the educational requirements, three years of which shall have been in a supervisory capacity. One additional year of approved work experience may be substituted for the Master's degree required by this class specification.

The salary range is $46,722.00 - $56,238.00. For further information on the responsibilities of the position, contact Donna Jenkins at (603)271-4974 or e-mail at djenkins@des.state.nh.us.

DES offers an attractive benefits package including fully paid health and dental for yourself and dependents. A state application can be obtained in the following ways: to download, go to our website at www.des.state.nh.us; request via e-mail at hr@des.state.nh.us; call Sue Lang at (603)271-1496, or for hearing impaired at TDD Access: Relay NH 1-800-735-2964. Please return a completed application along with a copy of your college transcripts to Human Resources, DES, 6 Hazen Drive, Concord, NH 03301. Closing date for submission of applications is: March 24, 2000. EOE.

GEOLOGICAL ENGINEERING FACULTY UNIVERSITY OF MISSOURI-ROLLA

The Department of Geological and Petroleum Engineering at the University of Missouri-Rolla invites applications for a tenure-track position in geological engineering. Rank will depend upon qualifications and previous experience in an area considered critical to the mission of the program. A Ph.D. in Geological Engineering or a related field is required and registration as a professional engineer or the qualifications to become registered are strongly desired. Appropriate areas of expertise include: engineering geology and geotechnics, groundwater hydrology and contaminant transport, GIS and remote sensing applications in geological engineering, applied geomorphology, or geo-environmental and geo-materials engineering. Other areas of geological engineering that compliment the mission and ongoing strengths of the program will be considered. The successful candidate should possess a strong commitment to undergraduate and graduate teaching and advising and the successful candidate must demonstrate or show potential for scholarly accomplishments and the ability to obtain external research funding.

The University of Missouri-Rolla offers B.S., M.S., and Ph.D. degrees in geological engineering. It is located in scenic south-central Missouri about 100 miles southwest of St.Louis. Outdoor activities and recreational opportunities are plentiful and Rolla is characterized by good public schools, medical facilities, and a relaxed, pleasant mid-western lifestyle. Additional information about the department and UMR may be obtained by visiting www.umr.edu.

Interested candidates should submit a curriculum vitae; a statement of teaching interests and research accomplishments; and the names, addresses, and telephone numbers of at least three professional references. The deadline for receipt of applications is May 1, 2000, although the selection process will begin immediately upon receipt of applications. Starting date will be September 1, 2000.

Send application materials to: Human Resource Services, Reference Number R50743, University of Missouri-Rolla, 1202 North Bishop, 1870 Miner Circle, Rolla, MO 65409-1050. The University of Missouri-Rolla is an equal opportunity employer.

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Opportunities for Students

Graduate Student Support Opportunities in Earth Sciences, Lehigh University—The Department of Earth and Environmental Sciences of Lehigh University has Graduate Student Fellowships for highly qualified individuals. The department has active research programs in tectonic studies (geochronology, stable isotope geochemistry, low temperature geochemistry, seismology, high resolution geophysics, structural geology, paleomagnetism) and surficial processes (low temperature geochemistry, fluvial and tectonic geomorphology, glacial geology, hydrology, and limnology). Please contact Prof. D. Morris, Dept. of Earth and Environmental Sciences (dpm2@lehigh.edu) or see our Web page for more details (http://www.ees.lehigh.edu).

Graduate Assistantships Available, University of Akron: The Department of Geology, University of Akron, has multiple graduate assistantships in our MS program available for Fall 2000. Students with a GPA of 3.0 or above are invited to apply for 9-month assistantships valued at $9,500 with a full remission of tuition and fees. Research interests of our twelve faculty range from the traditional areas of geology and geophysics to a specialization in Quaternary Research covering such topics as hydrogeology, paleoclimate reconstruction, glacial geology, ancient lake systems, surficial processes, karst systems, aqueous geochemistry, and GIS. Akron is undergoing a cultural resurgence marked by new construction across campus and the adjacent downtown area. The city is located adjacent to extensive green spaces in neighboring Cuyahoga Valley National Recreation Area. Prospective students can request an information package or learn more about the graduate program and current research opportunities by visiting the departmental website (http://www.uakron.edu/geology/) or can contact the Graduate Advisor, Department of Geology, University of Akron, Akron, OH 44325-4101 for additional information.

Summer Research - Each year the M.U.S.T. (Minority Undergraduate Scholarship and Training) Program at Old Dominion University, in Norfolk, Virginia, places ten undergraduate scholars with faculty mentors for a summer research experience. Scholarships are available in many areas of Biogeochemistry including chemical tracer studies, biogeochemical cycles of nutrients, trace element cycles in freshwater, estuarine and coastal environments and microbial biogeochemistry. Due to the interdisciplinary nature of the field, rising juniors and seniors from the marine, biological, geological and chemical sciences are preferred. Please contact Dr. Robyn Hannigan at 1-757-683-4101 or by e-mail: rhanniga@odu.edu or visit our web page at http://web.odu.edu/reu. ■

The Swiss Federal Institute of Technology (ETH) and the University of Zurich invite applications for the position of an

ETH ZÜRICH

UNIVERSITAS TURICENSIS MDCCC XXXIII

Assistant Professor for Crystalline Geology

The successful candidate will lead a strong research and teaching program combining geological field investigations of crystalline rocks with quantitative data from experimental and theoretical studies of deep earth materials.

The new professor should have a prime interest in the basic physical and chemical processes of crust/mantle interactions, magma generation, regional metamorphism and orogenesis. The new professor is expected to establish a vigorous field-based program dealing with the petrology of crystalline rocks which includes the Alps and other areas where crust and mantle rocks are exposed. On the longer term, the successful candidate is expected to develop a new program in experimental determination of chemical and physical properties of rocks, minerals and melts, as a basis for understanding the formation and the mobility of magmas and crystalline rocks in the Earth's crust and mantle.

The professor will have overall responsibilities for some of the key experimental and analytical infrastructure serving the Department as a whole.

Co-operative teaching at the undergraduate level, and research collaboration with colleagues at ETH and University Zurich is encouraged and expected, especially with the fields of tectonics and rock deformation, solid-earth geophysics, crystallography, theoretical petrology and geochemistry.

Applicants should submit a detailed curriculum vitae, a statement of research interests, a list of publications, and the names of three potential referees to the President of ETH Zurich, Prof. Dr. O. Kübler, ETH Zentrum, CH-8092 Zurich no later than April 10, 2000. Our schools specifically encourage female candidates to apply with a view towards increasing the proportion of female professors.

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Colorado and Adjacent Areas (1999 Annual Meeting, Denver)

David R. Lageson, Alan P. Lester, Bruce D. Trudgill

FLD001, 208 p.

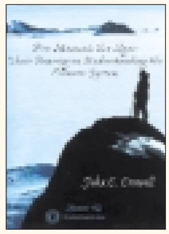
0-8137-0001-9
List price $25.00,
Member price $20.00

Planetary Petrology and Geochemistry (The Lawrence A. Taylor 60th Birthday Volume)

G. A. Snyder, C. R. Neal, W. G. Ernst

IBS002, 277 p.
0-9665869-1-3
List price $89.95
Member price $71.96

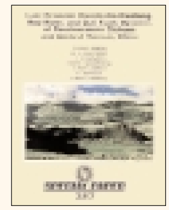
Pre-Mesozoic Ice Ages: Their Bearing on Understanding the Climate System



John C. Crowell

MWR192, 112 p.
0-8137-1192-4
List price $46.00
Member price $36.80

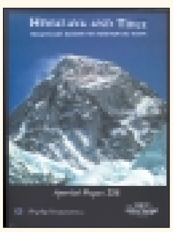
Late Cenozoic Xianshuihe-Xiaojiang, Red River, and Dali Fault Systems of Southwestern Sichuan and Central Yunnan, China



Erchie Wang, B. C. Burchfiel, L. H. Royden

SPE327, 114 p.
0-8137-2327-2,
List price $41.00
Member price $32.80

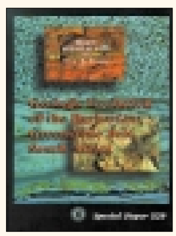
Himalaya and Tibet: Mountain Roots to Mountain Tops



Allison Macfarlane, Rasoul Sorkhabi, Jay Quade

SPE328, 336 p.
0-8137-2328-0
List price $70.00
Member price $56.00

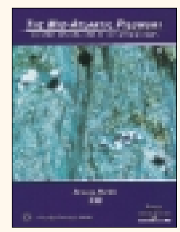
Geologic Evolution of the Barberton Greenstone Belt, South Africa



Donald R. Lowe, Gary R. Byerly

SPE329, 324 p.
0-8137-2329-9
List price $60.00
Member price $48.00

The Mid-Atlantic Piedmont: Tectonic Missing Link of the Appalachians



David W. Valentino, Alexander E. Gates

SPE330, 146 p.
0-8137-2330-2
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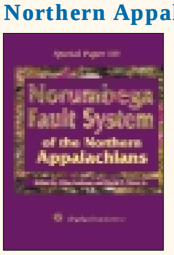

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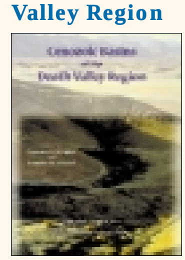

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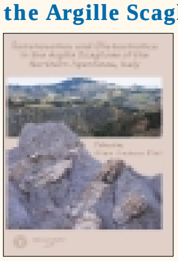

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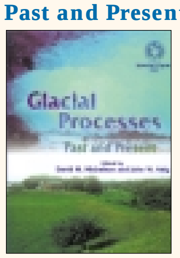

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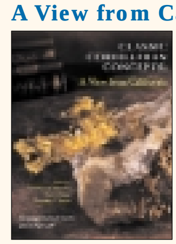

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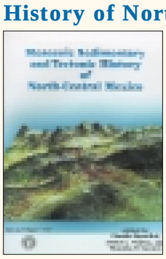

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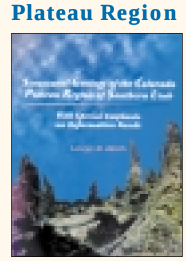

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