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INSIDE

Debating the Environmental Factors in Hominid Evolution

Craig S. Feibel, *Department of Anthropology, Douglass Campus, Rutgers University, New Brunswick, NJ 08903-0270*

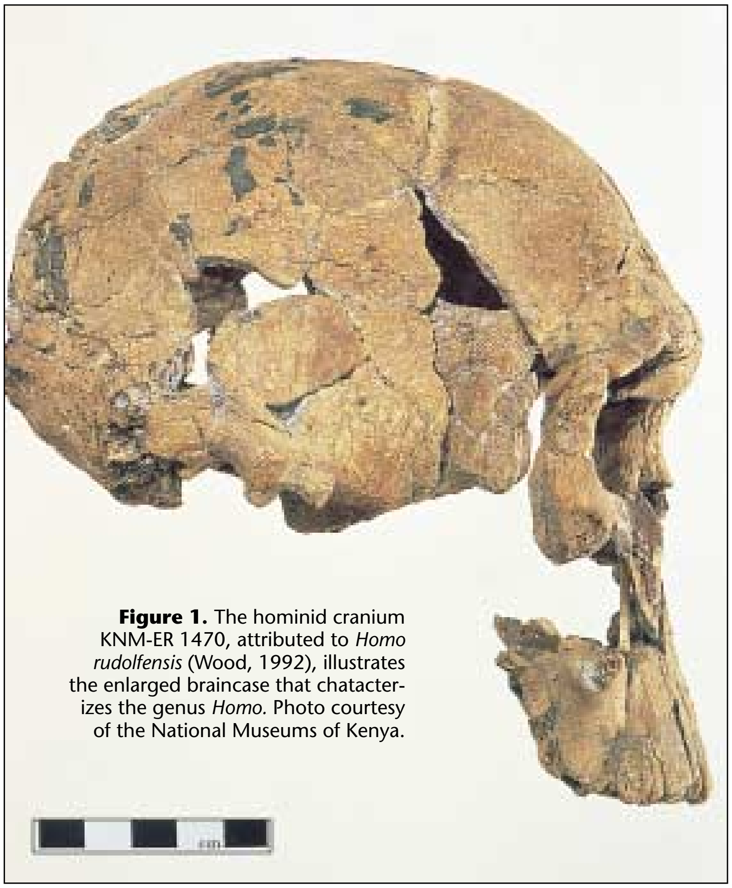

Figure 1. The hominid cranium KNM-ER 1470, attributed to *Homo rudolfensis* (Wood, 1992), illustrates the enlarged braincase that chatacterizes the genus *Homo.* Photo courtesy of the National Museums of Kenya.

Figure 2. Hominid footprints at Laetoli, Tanzania. The origin of bipedalism, graphically illustrated here, still lies shrouded in the uncertainty of a gap in the fossil record. Further investigations may resolve the issue of whether this event is linked to global environmental change at the end of the Miocene.

ABSTRACT

Environmental factors, particularly climatic fluctuations, are widely viewed as important controls on the path of evolution. The broad coincidence of two adaptive transitions in hominid evolution with major climatic milestones supports models in which these evolutionary shifts are climatically driven. In the first, the origin of the Hominidae is tied to the Messinian desiccation of the Mediterranean. A second, more convincing case, involves the origin of the genus *Homo* and the first appearance of stone-tool technology, which occur in broad contemporeneity with the onset of Northern Hemisphere glaciation in the Pliocene. Detailed analysis, however, encounters difficulties in tying large-scale forcing phenomena to the terrestrial evidence for hominid evolution, and in resolving the effects of interacting environmental factors. The influences of climate, tectonics, volcanism, and community evolution all act at varying scales, and are reflected in different ways in the geologic record. Current research is tying detailed studies from the African continent to records of global change, and to better understanding of the interactive effects of various environmental factors with human evolution.

INTRODUCTION

The prospect of global-scale environmental change is currently driving an intensive interdisciplinary research effort on the effects of wide-ranging processes including climatic forcing, tectonics, volcanism, and community evolution. How these and other factors will affect the future of humankind is one of the great mysteries in scientific research today. Just as the future of our species will depend upon responses to environmental factors, our past is marked by a long record of adaptation to environmental conditions and change. As details of our evolutionary past emerge from the fossil record, related investigations are forging a picture of the environmental context through which we evolved, and raising questions on the nature of adaptive responses to a dynamic Pliocene-Pleistocene environment.

Paleoanthropology has long suffered from a paucity of evidence detailing both the array of hominid lineages and the world in which they evolved. But discoveries over the past several decades have greatly expanded the direct fossil evidence of our family, the Hominidae, and a focus on interdisciplinary investigations has strengthened the basis for assigning ages and reconstructing the communities and ecosystems in which they developed. In parallel with these advances has been an explosion in data on global-scale phenomena through the later Cenozoic, and particularly on the evolution of Pliocene-Pleistocene climate and tectonic history. Now, hard questions of cause and effect are being posed, as scientists try to relate the major adaptive shifts in our lineage to

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environmental controls and episodes of change.

Paleoanthropology is still very much a discovery-driven science. Thus, each new fossil can greatly augment the available evidence and alter perceptions of hominid ancestry (e.g., Kimbel et al., 1996). In contrast, the data relating to geological context and the environmental setting for hominid evolution is extensive and diverse, with new discussions and publications appearing regularly. Most recently, a lengthy compilation of papers on climate and hominid evolution has been published (Vrba et al., 1995), a conference in Malawi sponsored by the Wenner-Gren Foundation addressed questions of biogeography and evolutionary theory as they relate to hominids (Sikes and Wood, 1996), and the 1996 GSA Annual Meeting in Denver hosted a debate on the climatic control of hominid evolution. Environmental influences and the driving forces behind hominid evolution have also been examined in the popular literature (Stanley, 1996; Potts, 1996a). As more and more data accumulate, there has been a trend away from simplistic, single-cause scenarios, and toward a more integrative approach to environmental factors. The result is a more balanced assessment of problems and an increasingly geological perspective to some major questions in hominid evolution.

RADIATIONS OF THE HOMINIDS

Although there are many difficult questions remaining in the reconstruction of a phylogeny for the hominid family, the main features of that story are now becoming clearer. There are two primary adaptive transitions in the hominid record: a shift to a full upright bipedal mode of locomotion (which characterizes the family), and a dramatic increase in the size of the brain (associated with the genus *Homo;* Fig. 1).

The record of bipedalism in the Hominidae is most graphically preserved in the fossil trackways at Laetoli, Tanzania (Fig. 2), where the 3.6 Ma footprints of three individuals were uncovered by Mary Leakey's excavations in 1978–1979 (Leakey and Hay, 1979). Fossil specimens

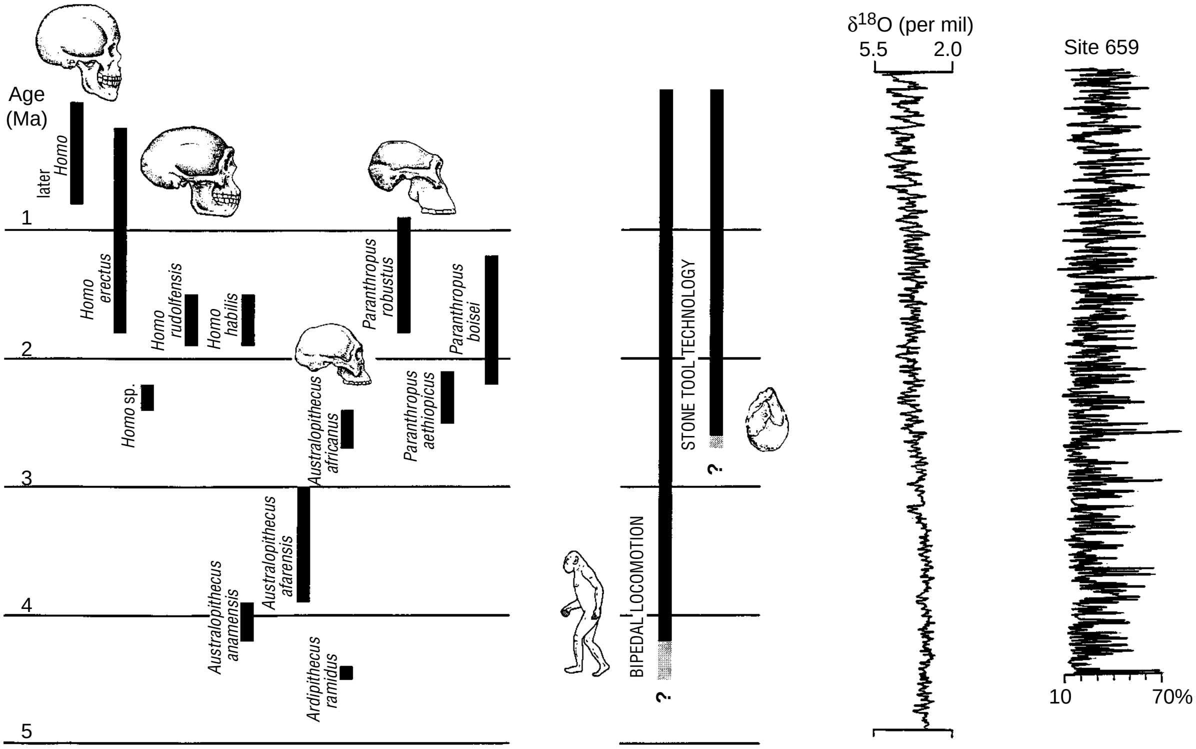

Figure 3. Correspondence of evidence for hominid evolution with global climatic proxies. Ranges of commonly accepted hominid taxa are shown at left, with evidence for bipedal locomotion and stone-tool technology. At right, are oxygen isotope records (compilation adapted from Shackleton, 1995) and an example of a terrigenous dust record (from deMenocal, 1995).

from Laetoli are attributed to the taxon *Australopithecus afarensis,* which is also well represented in the collections from Hadar in Ethiopia, ranging down to near 3 Ma (Johanson et al., 1978; Kimbel et al., 1994). The record of hominid bipedalism can be extended back to 4.2 Ma (Leakey et al., 1995; see Fig. 3). At that time another species, *Australopithecus anamensis,* already had features suggestive of specialized bipedal locomotory abilities. The development of hominid bipedalism was thus an adaptation that occurred even earlier than *A. anamensis*. The sparse fossil record prior to 4.2 Ma, however, leaves the timing and context of this transition uncertain.

The second major adaptation in the hominid lineage, and the one that sets our line apart from the australopithecines, is an increased cranial size relative to body size. This trait is already established in the oldest securely dated cranial specimens of the genus *Homo* at 1.9 Ma, and thus likely entered the hominid repertoire of adaptations in the 2–3 Ma interval. The oldest specimen attributed to the genus *Homo* is the 2.4 Ma maxilla recently reported from Hadar, Ethiopia (Kimbel et al., 1996). Possibly associated with the increase in brain size is the adoption of stone-tool technology as a behavioral adaptation; its earliest record is at 2.5 Ma (Semaw et al., 1997). Within the genus *Homo,* there is a dramatic radiation of species at about 1.9 Ma. At least three species are present in the record close to this time, *Homo habilis, H. rudolfensis,* and *H. erectus* (see Fig. 3). On the basis of the available material, it is difficult to assign earlier material to species.

Parallel to the diversification of the *Homo* lineage is a radiation that includes a gracile hominid, *Australopithecus africanus* appearing between 2 and 3 Ma, along with a robust form, *Paranthropus aethiopicus.* The robust lineage is represented by two further species, *P. boisei* and *P. robustus* in the interval between 2 and 1 Ma.

The origins of bipedalism remain poorly understood, as few fossils or localities of the appropriate age are currently known. The origin of the genus *Homo,* however, and the radiations in both the *Homo* and *Australopithecus* lineages occurred in times that are well represented in the geologic record of Africa, and both fossil evidence and details of context are abundant.

GLOBAL CLIMATIC CHANGE

Nearly every discussion of hominid evolution includes a link to global change. While there is no question that important global climatic changes were underway through Pliocene-Pleistocene time, it is less clear that (1) individual "events" can be identified in the global record or in the records associated with hominid fossils, (2) that climatic effects were sufficiently strong to affect low-latitude Africa, particularly those parts inhabited by hominids, or (3) that climatic effects can be uniquely implicated among interacting environmental factors.

Connections between global climate, particularly temperature-precipitation shifts, and steps in hominid evolution have long been used to explain the major adaptive shifts recognized in our ancestry (e.g., Brain, 1981; Laporte and Zihlman, 1983). For example, the origin of the Hominidae is often related to drying in the Messinian, and the splitting off of the *Homo* branch to the onset of Northern Hemisphere glaciation. As already noted, there is currently insufficient evidence to evaluate the Messinian-hominid connection, but they do appear to be broadly contemporaneous. More can be argued about the connection between Northern Hemisphere glaciation and the origin of *Homo.* The influential paper by Shackleton et al. (1984) aroused tremendous interest in the paleoanthropological community, placing the onset of major Northern Hemisphere glaciation at 2.4 Ma. This corresponded well to theoretical perceptions for the record of *Homo,* but until recently there has been little fossil evidence to support such an antiquity for the genus. The existence of stone tools in the record back to 2.4 Ma, however, was taken by many to be trace-fossil evidence for *Homo* of that age. It is important to note that very little of adaptive significance is known about earliest *Homo;* thus, arguments relating to this evolutionary event are highly speculative. What is known is that this event probably occurred in the interval between 2.5 and 3 Ma, and is thus roughly coincident with important high-latitude events marking the development of Northern Hemisphere glaciation. This makes it fair

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game for consideration as a consequence of climatic forcing.

A recent summary of the climatic argument for hominid evolution is deMenocal's (1995) synthesis of evidence from the marine realm which shows convincingly that the dramatic oscillations driven by orbital periodicities, which characterize the high-latitude record of the Pliocene-Pleistocene, were clearly felt in low-latitude Africa. He analyzed marine dust records off both the east and west coasts of Africa, and combined this data set with oxygen isotope results (Fig. 3) to show both long-term trends and variations in frequency of climatic oscillations. Four features of this data set are significant here. There is a long-term trend over the past 4 m.y., marked by increasing dust and heavier $\delta^{18}O$ values, documenting a shift toward cooler and drier conditions. Oscillations in both data sets reflect changing dominance in orbital parameters, from a precessional (23–19 ka) mode prior to 2.8 Ma, to an obliquity (41 ka) pattern between 2.8 and 1 Ma, and finally to an eccentricity-dominated (100 ka) periodicity after 1 Ma. The dust record provides direct evidence that these global climatic oscillations affected terrestrial ecosystems in at least the northern part of low-latitude Africa. Although the timing of shifts in dominant periodicity can be quantified, it is unclear whether these represent the sort of "events" sufficient to trigger evolutionary response in terrestrial communities.

Two other questions remain to be answered. The first concerns how much of the continent provided the signal recorded in the marine dust records. Present-day dust flux off Africa is derived primarily from already arid regions around the Sahara, and Holocene variations have been attributed to shifts in the extent of that arid belt. The signals recorded in the marine dust record do not necessarily imply threshold changes in wetter habitats on the continent, and thus may not have directly affected organisms there. The impact of periodicities and their shifts must be directly measured in the environmental record of individual sites and basins associated with the record of hominid evolution in order to establish that link. The second question concerns the ability to discriminate among various interacting environmental factors and to uniquely identify climatic signals. While the large-scale response across northern Africa recorded by deMenocal (1995) calls for large-scale controls such as climate, when we begin evaluating the record directly associated with hominid evolution, more local- and regional-scale phenomena may obscure such signals. It is also important to consider that global climate in the Pliocene-Pleistocene was affected not only by orbital factors, but also by tectonic developments and changes in oceanic circulation, other very large-scale phenomena. The Pliocene-Pleistocene ice ages were ultimately driven by major tectonic events including the uplift of the Tibetan Plateau and the closing of the Isthmus of Panama (Stanley, 1995, 1996; Stanley and Ruddiman, 1995).

Figure 4. Fossiliferous sediments like this fluvial channel and overbank couplet at Koobi Fora in the Turkana Basin have yielded a detailed record of steps in hominid evolution and the environmental context in which it took place.

COMPETING HYPOTHESES

Most hypotheses put forth to explain patterns in evolution include environmental influences in either an active or passive role. Three hypotheses that have been proposed to relate the evolutionary record of the Hominidae to climatic fluctuations are: (1) the long-held "savanna hypothesis," in which a relative shift toward cooler and drier conditions causes a change from more forested to more open vegetation; (2) the "turnover-pulse hypothesis" (Vrba, 1996a), with more specific conditions and implications; this relates broad-based faunal turnovers to environmental (here specifically climatic) events; and (3) the "variability selection hypothesis" (Potts, 1996a, 1996b), focusing not on individual events or shifts, but rather on the repetitive nature of environmental oscillations through time. Each of these has its adherents, and its strengths, as discussed below.

Lurking in the background of discussions on hominid evolution for decades has been the savanna hypothesis. Although commonly invoked (e.g., Klein, 1989), it does not seem to have been explicitly stated or clearly defined. As a basis for reference, the idea has been summarized recently by Potts (1996a). In this hypothesis, cooling and drying leads to a decrease in forests and a spread of grasslands, in either a gradual or abrupt fashion. The idea's beauty is in its simplicity, and it has been applied to explain a wide range of evolutionary trends, from the origin of the Hominidae to the origin of the genus *Homo,* and other events as well.

The turnover-pulse hypothesis attempts to link temporally restricted clusters of speciation and extinction events with climatic shifts. In a sense, it uses the same process as the savanna hypothesis, but applies it in two directions (that is, cooler and drier trends or warmer and wetter trends) and over varying scales. As applied to the record of hominid evolution, it has become the focus of interest in tying a climatic "event" associated with the onset of Northern Hemisphere glaciation to the appearance of *Homo* and of stone tools (Vrba, 1996b; Semaw et al., 1997). The two difficulties in testing this hypothesis center on how an "event" is defined and on the treatment of data showing significant levels of speciation and extinction (see below). Other workers, including Prothero (1995), have argued that as a generalization the hypothesis does not work. In test cases in the early Cenozoic, prominent climatic signals do not herald major speciation or extinction events among mammals.

The most recent addition to the field is the variability selection hypothesis of Potts (1996a, 1996b). This relates speciation to repeated shifts in selection over time, as environmental oscillations are reflected in fluctuations of landscape characteristics. The variability hypothesis focuses on the overall pattern of changes in environmental parameters, not on individual shifts. In this sense it takes into account what is perhaps the most distinctive feature of Pliocene-Pleistocene environments, their regular oscillations. It can also be accommodated by the documented record of climatic effects for Africa (deMenocal, 1995) without the need to identify specific individual "events."

These and other models are now being used to test patterns in the fossil record and environmental clues associated with hominid localities. In studies of the development of bipedalism and early hominids, many workers are questioning the validity of the savanna hypothesis (Hill, 1987; Andrews, 1992, 1995; see also Shreeve, 1996). The evidence from many fossil sites is beginning to imply more wooded conditions for the early Pliocene and more open forests in the Miocene. The contrasts between forest and savanna are dwindling in this interval, and with them the underpinnings of this theory. Detailed studies of mammalian faunas are also calling into question the "pulse" in the turnover-pulse hypothesis, amid questions of what patterns are really preserved in the fossil record (Behrensmeyer et al., 1996; see also Kerr, 1996). This debate exposes some of the complexities encountered in the interpretation of even the best available data sets.

TURKANA BASIN: A TEST CASE

Probably the most tightly controlled and extensive collection of data for hominid evolution comes from the Turkana Basin (Fig. 4) of northern Kenya and Ethiopia. Research over nearly three decades has established a detailed framework of isotopic dates and tephrostratigraphic correlations (McDougall, 1985; Brown and Cerling, 1982; Brown et al., 1985; Brown, 1996) that have been applied to the fossil record of more than 450 hominid specimens (Feibel et al., 1989) and over 70,000 other vertebrate fossils. Studies of the context of these fossils has revealed a wealth of data on environmental character and change through nearly 4 m.y. in this basin (Feibel et al., 1991; Bonnefille, 1995).

Although Vrba (1988) argued that the East African record of mammalian evolution, and in particular the Turkana Basin record, supported her view of a turnover pulse near 2.5 Ma, a detailed review of all environmental indicators, including the mammalian data, found changes near 2 Ma, but could not substantiate a 2.5 Ma pulse. Recently, Behrensmeyer and coworkers (1996; see also Kerr, 1996) looked in detail at the Turkana Basin mammalian faunas, and saw a significant long-term turnover between 2–3 Ma, but again not a pulse. While an increase in open-habitat forms was present, there was likewise a persistence of forest, woodland, and bush-adapted taxa. There are methodological differences between the two studies, particularly with respect to the treatment of rare taxa. Vrba (1996b) emphasized the significance of rare forms, often known from only a single specimen, as they demonstrate the presence of immigrant forms predicted in the turnover-pulse hypothesis. But the rarity of these taxa makes it impossible to evaluate whether an occurrence represents a first appearance (as an immigrant) or simply an artifact of collecting or taphonomic biases against rare forms that were, however, present earlier. It is also possible that the faunal transition recorded for 2–3 Ma occurred as several pulses, which may even have differed in relative magnitudes. This argument highlights one side of the problem in linking evolution and environment, that of discerning the character of evolutionary patterns from fossils.

Beyond these problems of interpreting the mammalian data looms a more intractable problem of separating the effects of multiple environmental factors acting on an ecosystem. Geological investigations in the Turkana Basin have led us to recognize a diverse array of environmental factors, acting over different time periods and with different intensities (Feibel, 1995). Because of its large size and predominantly fluvial nature, the Turkana Basin is influenced by two climatic regimes: a relatively wet seasonal regime in its Ethiopian Highlands catchment area, and a semiarid seasonal regime in the lower elevation depositional basin. At present, these regimes are out of phase, such that the rainy season in the catchment occurs during the dominant dry season of the lower basin. Similarly, two aspects of volcanism affected the basin in the past: occasional proximal events in the form of lava flows, and more common influxes of tephra from distal sources in the Ethiopian Highlands. Tectonics also played a major role in complicating the environmental picture, with a history of uplift and subsidence on a series of alternating half graben and marginal blocks. Interdependent upon these factors were changes in landscapes related to depositional settings, vegetation patterns, and soil development which also propelled change in the basin's communities.

Geologic evidence commonly points out which of these factors are dominant at a given time—for example, an influx of volcanic ash is quite conspicuous—but it is more difficult to evaluate the interactions among these factors. A high sedimentation rate due to volcanism can cancel out the effects of increased subsidence, but climatic interactions are more difficult to assess. There are now numerous examples in which a dominant factor obscures our perspective of what's happening with another. A case in point is the Omo micromammal record.

Micromammals are generally regarded as excellent indicators of local habitat and environmental conditions. In a study of such faunas from the northern part of the Turkana Basin, in the Omo Valley, Wesselman (1984, 1995) documented a dramatic local change from primarily mesic (requiring moderate amounts of water) to dominantly xeric (low water need) forms. He interpreted this purely in terms of a climatically driven system, using his evidence to support a climatic shift at ca. 2.5 Ma. Geologic evidence, however, points to other possible causes for the observed patterns. Beginning around 2.5 Ma, the Stephanie uplift, a basement-cored structural block that now borders Lake Stephanie (Chew Bahir) in Ethiopia, began to develop. This uplift shed coarse volcanic detritus off its southern margins, and coarse metamorphic debris farther north. This metamorphic debris entered the Omo sedimentary record at this time, and became the raw material utilized in early stone-tool manufacture there (Merrick, 1976; Howell et al., 1987). The sediments display a shift from a large meandering river to a shallow braided system. What this likely represents is a displacement of the axial, meandering river by a clastic wedge of basin-margin alluvium. The axial system was a large perennial river fed by the highlands catchment, and the marginal system was composed of short ephemeral streams draining the arid local margin (Feibel et al., 1991). The shift in character of the micromammal assemblages could thus be explained simply as a product of tectonic activity and sedimentary response, or as a product of tectonics and other factors. But in this case, what is certain is the tectonic effect; the contribution of climate here remains unclear.

Similar arguments can be made for the influence of explosive volcanism and the influx of voluminous tephra into the sedimentary basin. These events have the ability to transform the landscape, and to rearrange floral and faunal communities, effects that mimic climatic signatures. The record of tephra influx into the basin is cyclical; three cycles are recorded, spanning 4.2–3.4 Ma, 3.4–2.5 Ma, and 2.5–1.6 Ma. Each increased in intensity through time, and subsequent cycles exceeded the magnitude of precursors. Although single eruptions were no doubt dramatic, their individual effects seem to have been short-term. However, the cumulative effects at the peaks in eruptive cycles were enough to disrupt depositional systems and dramatically alter the pattern of communities across the landscape (Rogers et al., 1994). This effect is most clearly seen around 1.6 Ma, but the coincidence of the 2.5 Ma activity peak with global climatic shifts implies that whatever signal we find in

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evolutionary patterns, it is unlikely to be a purely climatic signal.

MIXED SIGNALS

The common theme that unites nearly all of the studies on the context of hominid evolution is the complex mix of often conflicting environmental signals. There are two aspects of scale involved here: spatial scales of variability in terrestrial systems, which may vary dramatically on a scale of meters to tens of meters, and temporal scales of sampling, where data may represent fossils accumulated over a few years or a suite of assemblages representing hundreds of thousands or even millions of years. These data must somehow be integrated with a regional and global data set that records effects on many different scales.

The adjective often employed for habitats of Pliocene-Pleistocene terrestrial systems in Africa is "mosaic," in which complex ecotones separate forest, woodland, bushland, and grassland in a landscape not only spatially heterogeneous, but also temporally dynamic. Such complexity is probably the norm in terrestrial ecosystems through much of time, and it cannot be ignored in attempting to tie together the adaptive responses occurring on a dynamic landscape and the interacting environmental signals that mold that system.

The major adaptations that molded the hominid lineage took place in Africa within a context of environmental change: climatic swings, tectonic upheaval, volcanism, and evolving faunal and floral communities. As new discoveries of fossil remains resolve details along the hominid trajectory, far-ranging investigations of environmental characteristics raise questions of both the context and the driving forces behind this evolutionary story. While the global pattern of climate change through the Pliocene-Pleistocene is well documented from high-latitude localities, and even in certain low-latitude settings, it is unclear how directly these influences affected early hominids.

It may be that, as in any good mystery, there is more than one culprit at work, and no doubt as we continue to delve into the record of hominid evolution and its context, new primary suspects will emerge.

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Hominids *continued on p. 7*

WASHINGTON REPORT

Bruce F. Molnia

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

Building Knowledge for a Nation of Learners: A Framework for Education Research

"Building Knowledge for a Nation of Learners" marks the Department of Energy's "first attempt to develop a single comprehensive vision of the nation's future needs for knowledge about education, and to set clear priorities for educational research geared to meeting those needs."

Early this year, the Department of Energy released a new National Priorities Plan entitled "Building Knowledge for a Nation of Learners: A Framework for Education Research." The report, the first in a new series of biennial reports, establishes national priorities for education research. These priorities are based on a recognition that the nation is strengthened by a population that values and pursues a lifetime of learning, and that a critical prerequisite for meeting this goal is an investment in education research to improve the achievement of all learners. The report presents an education research agenda for the 21st century. It is meant to serve as an agenda for supporting the development of knowledge about how to improve teaching and learning in the nation's schools.

More than 500 parents, teachers, education researchers, and representatives of business and community organizations were consulted in preparing the agenda, which was developed by the department's Office of Educational Research and Improvement and a 15-member National Educational Research Policy and Priorities Board, co-chaired by Southern Illinois University president and former Education Under-Secretary Ted Sanders and Stanford University education professor Kenji Hakuta.

As defined by the report, the National Priorities for Research in Education are:

1. Improving learning and development in early childhood so that all children can enter kindergarten prepared to learn and succeed in elementary and secondary schools;
2. Improving curriculum, instruction, assessment, and student learning at all levels of education to promote high academic achievement, problem-solving abilities, creativity, and the motivation for further learning;
3. Ensuring effective teaching by expanding the supply of potential teachers, improving teacher preparation, and promoting career-long professional development at all levels of education;
4. Strengthening schools, particularly middle and high schools, as institutions capable of engaging young people as active and responsible learners;
5. Supporting schools to effectively prepare diverse populations to meet high standards for knowledge, skills, and productivity, and to participate fully in American economic, cultural, social, and civic life;
6. Promoting learning in informal and formal settings, and building connections that cause out-of-school experiences to contribute to in-school achievement;
7. Understanding the changing requirements for adult competence in civic, work, and social contexts and how these requirements affect learning and the futures of individuals in the nation.

The priorities are focused on early childhood learning, student learning, effective teaching, strengthening schools, student diversity, learning beyond the classroom, and adult competence.

The report includes the chapter "Putting the Priorities to Work," which challenges Americans from all walks of life to get involved in the process of educational improvement and to take greater responsibility for results. State and local decision-makers and educators can get more involved by accessing and using the research through a nationwide system of regional education laboratories, national research and development centers, and clearinghouses. Other sections include "An Open Letter to the American People" and a prologue, "What Do We Need to Know?"

Because public participation is invited, the earth science community may wish to closely follow this process to see that our discipline is included in the evolving agenda and to provide input so that our nation's educated citizens of the 21st century are earth science literate.

The report is available in DOE's "Online Library" Web site at http://www.ed.gov/offices/OERI/RschPriority/plan/. ■

Hominids *continued from p. 6*

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CORRECTION

CORDILLERAN SECTION MEETING

The cost of Cordilleran Field Trip 3—**Petrology and Volcanology of Maui,** lead by Sinton and Rowland has been increased from $150 to $400. This includes, in addition to all previously stated information, air fare from Honolulu to Maui and from Maui to Kailua Kona. It does not include transportation from the Kona airport to the hotel.

GPS TO GEOCHEMISTRY

B. HOFMANN-WELLENHOF and
H. LICHTENEGGER, University of Technology, Graz, Austria, and
J. COLLINS, GPS Services, Rockville, MD

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The new edition of this very popular reference and textbook explains recent advances in the technology of Global Positioning System (GPS) – such as Differential GPS (DGPS), ambiguity resolution, real-time kinematic (RTK) techniques, the International GPS Service for Geodynamics (IGS) and the combined adjustment of GPS and terrestrial data. The authors show, clearly and comprehensively, how GPS works and how it can be used for precise measurements (i.e. surveying) as well as for navigation and attitude determination. While much new material has been added, the overall structure of the book remains the same as the earlier popular editions. The authors explain in detail the practical use of GPS as well as the basic mathematical models for various modes of GPS operation, with examples of different applications and types of projects. For novice GPS users, they describe proper project planning, execution, data reduction and coordinate computation.

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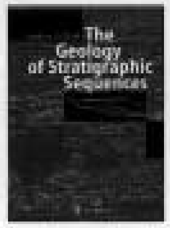

A.D. MIALL, University of Toronto, Ontario, Canada

THE GEOLOGY OF STRATIGRAPHIC SEQUENCES

The Geology of Stratigraphic Sequences represents a new paradigm in geology. The main theoretical basis for this model is the supposition that global stratigraphic architecture is controlled by eustatic sea-level changes. This premise is still under debate and has obscured a significant positive development: stratigraphic research guided by sequence models has brought fundamental improvements in our understanding of stratigraphic processes and controls of the basin architecture. This research has demonstrated the importance of processes other than eustasy for the generation of cyclic sequences, including tectonics, and orbital forcing of climate change. The book is an excellent introduction for graduate students and a valuable reference for professional geologists in industry and at universities.

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H.F. DIAZ and **R.S. PULWARTY,** University of Boulder, CO (eds.)

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Hurricanes of the North Atlantic Ocean have left their imprint on the landscape and human cultures for thousands of years. In modern times fewer lives have been lost due to the development of modern communication systems, and to an improved understanding of the mechanisms of storm formation and movement. However, the immense growth of human populations in coastal areas – which are at greatest risk from hurricanes – has resulted in very large increases in the amount of property damage sustained over the last decade in the Atlantic, Gulf of Mexico and Caribbean Regions. This volume provides a comprehensive review of the dangers of hurricanes, their influence on insurance policies, and recent scientific findings of hurricane research. It will be of great interest to climatologists and meteorologists as well as a valued source of information for policymakers and emergency management planners.

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J. HOEFS, University of Göttingen, Germany

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In this volume, Hoefs has written an excellent introduction to the use of stable isotopes in the field of geoscience. The book is divided into three parts: theoretical and experimental principles, fractionation of mechanisms of light elements, and the natural variations of geologically important reservoirs. In this updated fourth edition, many of the chapters have been expanded to include recent results and new developments, especially those on techniques and mineral deposits. For students and scientists alike, the book will be a primary reference with regard to how and where stable isotopes can be used to solve geological problems.

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MERCURY FROM GOLD AND SILVER MINING: A CHEMICAL TIME BOMB?

Mercury contamination from gold mining is a major environmental problem, comparable to mercury contamination from industrial sources. Deteriorating socio-economic conditions and increasing gold prices in the late 1970s resulted in a new rush for gold by individual entrepreneurs for whom mercury amalgamation was a cheap and easily carried out operation. Even after the present-day mining areas are exhausted, the mercury left behind will remain part of the biochemical cycle of the forest for years to come. This volume reviews the latest information on mercury contamination from gold mining, its cycling in the environment and its long-term ecotoxicological impact.

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SAGE REMARKS

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

Educational Opportunities and Resources for Geoscience Educators, Researchers, and Students

1997 Workshop, Conference, and Funding Opportunities for Geoscientists

EARTH AND SPACE SCIENCE TECHNOLOGICAL EDUCATION PROJECT

The Earth and Space Science Technological Education Project (ESSTEP) is bringing together undergraduate faculty from two- and four-year institutions with secondary school faculty, professional societies, businesses, and government agencies in a partnership to provide faculty in grades 8 through 14 with: (1) hands-on experience in state-of-the-art data acquisition, manipulation, and presentation technologies for the earth and space sciences, (2) innovative strategies for using technology in classrooms and laboratories, (3) internship opportunities in earth and space science technology fields, and (4) improved access to a wide variety of technology-based education resources. More specifically, ESSTEP workshops will assist faculty in exploring ways that technologies such as the Internet, Geographical Information Systems, Global Positioning Systems, multimedia, image processing, and virtual reality can be used to enhance student learning, promote science and technology careers, catalyze the development of new courses and materials, and better articulate the grades 8–14 earth and space science curricula. ESSTEP will focus on the integration of computer-based technologies, field-based research, and "best" educational practices. The ultimate project goal is to enhance and improve student learning.

Audience: ESSTEP is targeted at teams of two to four community college, secondary, and other undergraduate faculty who teach earth, space, or environmental science, technology, geography, mathematics, and/or physical science.

Workshops: During July 7–19 and August 4–16, 1997, ESSTEP will conduct two workshops for 20 participants each in Boulder, Colorado.

Participant Support: Participants who attend all workshop sessions will receive $550 stipend, room and board, software, and technical support as well as the opportunity to participate in internships with businesses and government agencies.

Applications: Please contact Ed Geary at (303) 447-2020 or egeary@geosociety.org. Applications for 1997 are due March 15. ESSTEP workshops will also be offered in 1998 and 1999.

ESSTEP is sponsored by the Geological Society of America, Cypress College, and the Space Science Institute, with support from the National Science Foundation.

WORKSHOP ON COURSE DESIGN AND INNOVATIVE TEACHING

(sponsored by the National Association of Geoscience Teachers and funded by the NSF Division of Undergraduate Education)

During the workshop, each participant will:

- redesign a course that he or she has taught previously, working with other participants and with one of the instructors as a mentor;
- learn about a variety of innovative and effective teaching and assessment techniques aimed primarily at increasing active learning in the classroom;
- develop a concrete plan for revising the course to make it more effective in terms of actively engaging students.

Expectations: Each participant must bring to the workshop a syllabus and textbook from a course he/she wants to revise, work during the workshop on a plan to revise the course, offer the revised course during 1997–1998, and submit a report on the results.

Eligibility: Participants in this workshop must hold a faculty teaching position at a two- or four-year college or university and have responsibility for teaching undergraduate geoscience courses.

Cost: The workshop itself is FREE, thanks to a grant from the NSF Division of Undergraduate Education. The grant covers the operational costs of the workshop plus room, board, and workshop materials for the participants. Participants or their home institutions must provide transportation to and from the workshop.

Application and selection criteria: Application materials for 1997 were due February 18, but if you are interested in this workshop, please contact Heather Macdonald. For more information, contact Heather Macdonald at (757) 221-2443 or rhmacd@facstaff.wm.edu. The workshop is limited to 25 participants. The final list of participants will be established with the goal of assembling a group representing a wide range of experiences and educational environments.

Facilities: The workshop will be held at the College of William and Mary in Williamsburg, Virginia. Participants will be housed in double rooms in the dormitories on campus and will eat meals in the University Center.

Getting there: Participants may fly in to Newport News, Norfolk, or Richmond. We will provide transportation to and from Newport News Airport only. Participants flying to Richmond or Norfolk must arrange their own transportation to Williamsburg.

IMPROVING DELIVERY IN GEOSCIENCE (IDIG): TECHNIQUES AND STRATEGIES IN UNDERGRADUATE GEOSCIENCE TEACHING FOR ALL STUDENTS

In 1997, a one-week IDIG conference will be held from July 19 to 25 at the Colorado School of Mines in Golden, Colorado. In 1998, a one-week IDIG conference will be held during the summer at the University of South Carolina, and in 1999 it will be at Cypress College in California.

IDIG conferences have been designed to assist geoscience faculty to:

- Explore reform-based teaching strategies appropriate for introductory geoscience courses and adaptable for implementation in other courses for systemic implementation;
- Assess and utilize state-of-the-art instructional technology and up-to-date measurement and data collection and evaluation mechanisms;
- Examine and evaluate alternative assessment strategies for introductory undergraduate courses;
- Investigate ways to integrate geoscience with other academic disciplines;
- Assess ways to use local resources to build and maintain a network among K–12 schools, industries, colleges, and universities.

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SAGE *continued from p. 9*

Workshops: IDIG workshops are for teams of undergraduate faculty and K–12 teachers in the geosciences and related academic fields. Undergraduate institutions (including two- and four-year schools) are invited to assemble teams of three to five faculty members who would like to design or revise an introductory geoscience course. For each conference, participants will be eight to ten teams of three to five faculty, resulting in a working group of approximately 40 faculty. The participants will learn a variety of ways to utilize alternative teaching strategies, incorporate state-of-the-art instructional technology, and employ a selection of assessment tools. Combining what they have learned with their existing experience, the members of each team will receive assistance as they begin to design or revise a geoscience course that meets a specific need in their institution and could serve as a model for the design of other courses.

Financial Support: This program will provide complete on-site support for each workshop, including room and board for the participants, but each team's home institution(s) will be expected to fund the travel to and from the workshop.

Applications: The deadline for application requests was February 28, 1997; applications must be submitted by April 28, 1997. To receive application materials or additional information about this program, contact: Improving Delivery In Geoscience (IDIG), American Geological Institute, 4220 King Street, Alexandria, VA 22302-1502, (703) 379-2480, fax 703-379-7563, ehr@agiweb.org, http://www.agiweb.org/IDIG is sponsored by AGI ,the Colorado School of Mines, the University of South Carolina, and Cypress College, with financial support from the National Science Foundation.

SECOND INTERNATIONAL CONFERENCE ON GEOSCIENCE EDUCATION: LEARNING ABOUT THE EARTH AS A SYSTEM

The Second International Conference on Geoscience Education will be held from July 28 to August 1, 1997, at the University of Hawaii—Hilo. Subthemes of the conference include:

- earth science education for all students at all levels of education;
- the role of business, industry, and government agencies in supporting informal and formal education efforts; and
- the need for public literacy in the earth sciences.

Conference activities will include pre- and postconference field trips, keynote speakers, interactive poster sessions, an instructional materials exposition, social events, and family activities. For further information contact the conference co-conveners, John Carpenter, Center for Science Education, University of South Carolina, Columbia, SC 29208, or Victor Mayer, College of Education, Ohio State University, Columbus, OH 43210.

STUDENT OPPORTUNITY: The Southwest Earth Studies Program (SESP)

SESP is an NSF-funded 8-week research experience in philosophy and the earth sciences. It will be held from June 9 to August 1, 1997, in Durango, Colorado.

SESP will be composed of two professors and ten students, half from the earth sciences, half from the humanities. The purpose of this program is for science students to gain proficiency in the philosophic (e.g., ethical and epistemological) implications of scientific issues, and for humanities students to gain an understanding of the role that scientific information can and should play in philosophic and public-policy debates.

The topic for the summer of 1997 will be the scientific, philosophic, and public-policy issues surrounding acid mine drainage in the San Juan Mountains of southwest Colorado. Students will engage in original scientific research under the direction of the professors. Scientific, philosophic, and public-policy issues will be integrated at every possible level of analysis.

Participant Support: Students will receive 6 hours of college credit, 3 hours each in philosophy and the earth sciences, as well as tuition, room and board, and a $125/week stipend. A limited amount of travel money is also available.

Requirements: Students must be highly motivated self-starters committed to an interdisciplinary approach to environmental problems. Students must have had a previous course in both the earth sciences and philosophy. Participants must be willing to work on topics outside their area of expertise, and to both learn from each other and teach together. Students must have achieved junior standing before the program begins and must not have finished their undergraduate degree. Students must be comfortable in outdoor and wilderness settings, willing and able to camp and hike significant distances (6–12 km/day) at high altitude (above 10,000 ft.)

Applications: Send transcripts, two letters of recommendation from professors, a 500-word statement of purpose explaining your interest in this program and how it fits into your future goals, and an address and telephone number where you can be reached to: Robert Frodeman, Director, Southwest Earth Studies Program, Fort Lewis College, Durango, CO 81301, (970) 247-7326, E-mail: frodeman_r@fortlewis.edu.

FUNDING OPPORTUNITY: RESEARCHERS PLEASE TAKE NOTE!

The Informal Science Education Program at the National Science Foundation has announced a new program that we would like all GSA members to be aware of. Supplements of up to $50,000 will be made to active research grants to support a wide range of activities that in some way promote public science literacy. The program announcement can be found on the NSF Web site at http//red.www.nsf.gov/EHR/ESIE/resawrd/Ise-supl.htm.

TECHNOLOGY RESOURCES FOR EDUCATORS AND STUDENTS

New software products and World Wide Web sites are being created everyday. Below we list a few products and Web sites you may want to examine for possible classroom use. No endorsement by the Geological Society of America or me is intended by this listing. Additional SAGE Remarks columns will describe other software products and Web sites. Please let me know about other geoscience education software or Web sites that you use or would like more information on.

UK Earth Science Courseware Consortium Modules: A series of interactive, multimedia courseware modules on a range of earth science subjects. Module topics range from Crystallography, Optical Mineralogy, Geochemistry, and Petrography to Structural Geology, Geophysics, Paleontology, and Geological Mapping Skills. Designed primarily for undergraduate students of earth science. For a price list and ordering form, contact: UK Courseware Consortium, Central Unit, Department of Earth Sciences, University of Manchester, Manchester M13 9PL, UK. Telephone is 44-161-275-3820 or 3838, fax 44-0161-275-3947, E-mail: ukescc@man.ac.uk. Minimum requirements: PC: Windows 3.1, 4 Mb RAM, a VGA color monitor, and a 386 processor. Macintosh: 4 Mb RAM, color monitor (14").

Astronomy Village: A nicely done multimedia package that engages students in the scientific process as applied to astronomical research. Examine binary stars and black holes, or search for earth crossing objects. Grades 9 and above. Available from NASA CORE, Lorain County JVS, 15181 Route 58, South Oberlin, OH 44074, (216) 774-1051, ext. 293. Price: $5; $5 for the teacher's guide; $14 for the introductory video. Minimum requirements: Mac LC llll, System 7; 5 Mb memory, 20 Mb on a hard drive, color monitor, CD-ROM drive, and Hypercard 2.1.

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SAGE *continued from p. 10*

WEB SITES

Volcano World
http://volcano.und.nodak.edu/

Volcano World brings modern and near real time volcano information to specific target audiences and other users of the Internet. Volcano World draws extensively on remote sensing images and other data collections. Each image is related to geologic processes, and users are encouraged to analyze images with provided algorithms. Easy to use, Hypercard-like interface.

The Virtual Museum of Paleontology (University of California at Berkeley)
http://ucmp1.berkeley.edu/

The Museum of Paleontology at the University of California at Berkeley (UCMP) has created a "virtual museum" accessible to anyone who can log onto the Internet. Students of any age can enter the Hall of Dinosaurs, explore the Geologic Time scale, examine the writings of Charles Darwin, learn about the earliest fossil finds, or simply wander through the ever-changing exhibits.

National Earthquake Information Center (NEIC)
http://wwwneic.cr.usgs.gov/

The NEIC is operated by the U.S. Geological Survey, Golden, Colorado. This site has extensive information on seismology and earthquakes around the world along with many seismograms and moment tensor solutions. Of particular interest is the collection of education material.

Windows to the Universe
http://www.windows.umich.edu

Windows to the Universe is a user-friendly learning system for the general public. It presents innovative, engaging, and current information about the earth and space sciences. On-line resources include documents, images, movies, animations, and data sets that explore scientific knowledge about our solar system, universe, and the physical sciences. It also highlights the historical and cultural ties between science, exploration, and the human experience. ■

Research Grants Available

The Colorado Scientific Society invites graduate students to apply for research grants to be awarded by the Society in early May 1997. Applicants must be enrolled in a master's or Ph.D. program at an accredited private or state college or university. About eight grants ranging from $500 to $1000 each will be awarded for field-oriented earth-science thesis projects in Colorado and the Rocky Mountain region. Also, one or more grants of $500–$1000 will be awarded for engineering geology theses (with no restriction on the geographic area of interest) and for studies of the Heart Mountain fault in northwestern Wyoming. Interested students can obtain application forms and grant information directly from the Web at http://rainbow.rmi.net/~css/ or by mail from the Chairman of the Memorial Funds Committee, Colorado Scientific Society, P.O. Box 150495, Lakewood, CO 80215. Deadline for applications is *April 7, 1997.*

More GSA Representatives Needed

In the mid-1980s, GSA launched a new representative program targeting companies, agencies, and consultants throughout the country. The purpose was to broaden GSA's representation to include all employment sectors. The program was modeled on the successful campus representative program that began in 1979 and now includes 552 representatives at colleges and universities throughout North America.

We now have 139 company, 92 agency, and 45 consultant GSA representatives. However, we need more volunteers. Our goal is to designate a representative at all major company offices and governmental agencies throughout the country. We want to develop a similar liaison with GSA members who are self-employed and serve as consultants. They would also represent major cities and geographic regions.

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

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

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 SIXTH 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 $500 is made possible as a result of support from the Donald and Carolyn Biggs Fund.

NOMINATION PROCEDURE: For nomination forms write to Edward E. Geary, Coordinator for Educational Programs, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

DEADLINE: Nominations and support materials for the 1997 Biggs Earth Science Teaching Award must be **received by April 30, 1997.**

LETTER

In a letter in the December 1996 issue of *GSA Today* (v. 6, no. 12, p. 17), George Klein comments on an earlier message (*GSA Today,* September 1996, v. 6, no. 9, p. 1) by Eldridge Moores calling for contributions to the Second Century Fund. In particular, Klein discusses what Moores called the "apparent end of the 'social contract' between society as a whole and science." Klein refers to this as a "renegotiation" rather than an "end."

Klein correctly claims that government funding for science, including geology, is now being aimed at those functions (research and education) that "improve America's economic competitiveness in the global economic marketplace." Klein suggests that economic security, as more narrowly defined today, is the only driving force supporting the social contract with science. Basic research, which he claims was once supported as a result of "economic security considerations of those times" (more than a century ago) and broadly interpreted military security, should, he says, no longer be funded by government. He seems to suggest that, because of the large number of colleges and universities now in existence and the advanced industrial situation in the U.S., the research, education, and service funding system of the Morrill Act is no longer required.

Indeed, one could argue that, on the basis of current market realities in the U.S., only those aspects of science which can produce immediate or short-term economic advantage are of interest to the people of the United States. Thus, there is no need for any government support. If science really can produce immediate or short-term economic advantage, it should be up to the industry or business benefiting from this economic advantage to fund the research. We should rely on industrial research centers and consultants for research, compilation and interpretation of data, etc. Klein cites the petroleum and mining industries as places where geology can move into the mainstream of this new "amended social contract emphasizing economic security." And, indeed, these are industries not needing government subsidies. This means, of course, that we will also rely on the industrial research centers and consultant positions for employment opportunities.

I don't really believe this but it does, unfortunately, seem to be the trend in the U.S. today. Long-term, basic research, whether in biodiversity, paleontology, traditional geology, or other fundamental science, seems to be out of favor and underfunded. In the long term, this will do the U.S.—and its citizens—a real disservice.

Klein ignores the aspects Moores cited where geology is of crucial importance to society. These aspects do not deal with basic research nor those that produce "economic security." They are down-to-earth and impact the average citizen. Yet, in spite of their importance, because they don't improve corporate bottom lines, they are ignored. They are not seen as part of the "social contract."

If we can't convince our colleagues, the public, or elected officials that basic research, education (at all levels), and service ARE important and worth funding, many of us involved in basic research and education might as well quit and drop out.

GSA and geologists in general have much to contemplate as we approach the beginning of a new century and as we face new realities in the U.S. As fewer and fewer young people have an adequate grounding in science, public support for science will continue to decline. GSA, through programs such as SAGE, is moving in the right direction, but the task is monumental.

Richard Leary
Illinois State Museum
Springfield, IL 62703 ■

1997 Penrose Conferences

April

April 24–30, **Paleocene-Eocene Boundary Events in Time and Space,** Albuquerque, New Mexico. Information: Spencer Lucas, New Mexico Museum of Natural History, 1801 Mountain Road NW, Albuquerque, NM 87104, (505) 841-2873, fax 505-841-2866, E-mail: lucas@darwin.nmmnh-abq.mus.nm.us.

September

September 10–15, **Faults and Subsurface Fluid Flow: Fundamentals and Applications to Hydrogeology and Petroleum Geology,** Albuquerque and Taos, New Mexico. Information: William C. Haneberg, New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, 2808 Central Ave. SE, Albuquerque, NM 87106, (505) 262-2774, fax 505-255-5253, E-mail: haneberg@nmt.edu. For more information, see http://www.nmt.edu/~haneberg/Fluids.html.

September 23–28, **Tectonics of Continental Interiors,** Cedar City, Utah. Information: Michael Hamburger, Department of Geological Sciences, Indiana University, Bloomington, IN 47405, (812) 855-2934, fax 812-855-7899, E-mail: hamburg@indiana.edu.

CALL FOR NOMINATIONS REMINDERS

Distinguished Service Award

The GSA Distinguished Service Award was established by Council in 1988 to recognize individuals for their exceptional service to the Society. GSA Members, Fellows, Associates, or, in exceptional circumstances, GSA employees may be nominated for consideration. Any GSA member or employee may make a nomination for the award. Awardees will be selected by the Executive Committee, and all selections must be ratified by the Council. Awards may be made annually, or less frequently, at the discretion of Council. This award will be presented during the annual meeting of the Society. Deadline for nominations for 1997 is **MARCH 3, 1997.**

John C. Frye Environmental Geology Award

In cooperation with the Association of American State Geologists (AASG), GSA makes an annual award for the best paper on environmental geology published either by GSA or by one of the state geological surveys. The award is a $1000 cash prize from the endowment income of the GSA Foundation's John C. Frye Memorial Fund. The 1997 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in Salt Lake City.

Nominations can be made by anyone, based on the following criteria: (1) paper must be selected from GSA or state geological survey publications, (2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper.

Nominated papers must establish an environmental problem or need, provide substantive information on the basic geology or geologic process pertinent to the problem, relate the geology to the problem or need, suggest solutions or provide appropriate land-use recommendations based on the geology, present the information in a manner that is understandable and directly usable by geologists, and address the environmental need or resolve the problem. It is preferred that the paper be directly applicable by informed laypersons (e.g., planners, engineers). Deadline for nominations for 1997 is **March 31, 1997.**

National Awards

The deadline is **April 30, 1997,** for submitting nominations for these four awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, Alan T. Waterman Award.

GEOLOGICAL SOCIETY OF AMERICA

MEDALS AND AWARDS FOR 1996

PENROSE MEDAL
presented to
JOHN R. L. ALLEN

Citation by JAMES A. HELWIG

It is my honor to present to you John R. L. Allen, the 1996 Penrose Medalist. Today our Society recognizes a lifetime of dedicated research that has endowed the earth sciences with a rich lexicon to read the record in the rocks. As with previous Penrose Medalists, J. R. L. Allen epitomizes the remarkable diversity of productivity of a truly creative mind. As John Steinbeck wrote, "Ideas are like rabbits. You get a couple and learn how to handle them, and pretty soon you have a dozen." John Allen's rabbits are everywhere.

Like a grain of sand, Professor Allen's journey began at an outcrop of Precambrian, worked its way into the Old Red Sandstone, was transported and resedimented in fluvial sequences, continued to saltate over numerous bedforms, and has arrived in a tidal channel of coastal marsh. Doctor Allen has been seen in other clastic depositional environments from time to time, perhaps due to changes in sea level, or more likely to the stimulation of the many students, colleagues, and applied scientists inspired by his work.

He has published on topics from the well-known and superb studies of bedforms and sedimentary structures, to the analysis of Romano-British wetlands reclamation, to the preservation of human footprints in the geologic record. John's analysis of the relationship between flow parameters, sand transport, bedforms, and cross-stratification is a major achievement, forming a cornerstone of modern sedimentology. By use of equations, experiments, models, and outcrops he has built a model for the conduct of research itself, as well as an elegant system for reading the geologic record of past processes and environments.

His work includes laboratory experiments in physical sedimentation, numerical models of sedimentary successions, and a host of observations of outcrops, fossils, geo-archeology, and even windblown trees. As John Muir observed, everything is hitched to everything else. As John Allen observes, one can use sedimentology to understand the distribution of pollutants or to analyze Roman practices of wetlands reclamation; or, conversely, one can use pollutants and Roman ruins to understand sedimentology. In like manner, John has practiced that most enviable of abilities as a scientist, the capability to move smoothly from observation to experiment to theory, and to connect the whole of earth science.

I first met John Allen in 1964 when I, a lowly graduate student, heard him lecture in John Imbrie's course at Columbia University. This week I meet him again for the second time—a lot of grains of sand have gone down the channel—and during the intervening years Professor Allen has continually demonstrated my first impression of a man of remarkable scientific acumen, asking significant questions, and totally dedicated to understand the workings of nature. In these pursuits, Lyell's dictum and Sorby's approach have served him well. I have a well-worn copy of his 1970 classic book, *Physical Processes of Sedimentation,* which is but one of his benchmark publications that mark major advances in sedimentology. Although he may be classified as a sedimentologist, the record shows that he is a master craftsman who has broadly affected geology in research, education, and applied earth science. And as the mark of his continuing contribution, today he is exerting his talents on the study of the interaction between man and his environment. He has truly earned the company of the Penrose Medalists.

John Allen has enjoyed a long academic career at the University of Reading, where he is currently the Research Professor of Sedimentology. His awards and honors are numerous and include Fellow of the Royal Society, the Lyell Medal of the Geological Society of London, the Twenhofel Medal of SEPM, and the Sorby Medal of the International Association of Sedimentologists. John Allen has picked up the Old Red Sandstone where the Reverend Hugh Miller left off, and absorbed the intellect of Sorby. Gaining ground, he then led us on a steep climb to a higher plateau of geology—or perhaps a deeper channel. Always moving forward, always looking back, he is a student of the planet and a scientist in four dimensions. It is a great pleasure to present to you the 1996 Geological Society of America Penrose Medalist, John Robert Lawrence Allen.

Response by JOHN R. L. ALLEN

Never was I more astonished and surprised in my life than to learn that the Geological Society of America wished me to be the recipient of its Penrose Medal for 1996. This is an exceptional and most unexpected honor, which I am proud to accept.

This honor is most unexpected because the geological research I have managed to complete—with its emphasis on understanding sedimentary processes in terms of general physics—has always given me the greatest excitement and pleasure. It is perhaps reward enough that, through the encouragement of many people to whom I shall always be indebted, and not least my wife, who is with me today, I have been able to enjoy such enormous fun.

The honor you have conferred upon me is exceptional because, in awarding me the Penrose Medal, you have placed my work in the same sphere as that of Walter Bucher, Philip Kuenen, William Rubey, my countryman Ralph Bagnold, Francis Pettijohn, Robert Sharp, Harlen Bretz, and Luna Leopold; all scientific giants of whom I have stood in awe and for whose leadership and contribution to our understanding of earth-surface processes I have great admiration and respect. The honor is for me doubly exceptional because you have as well given me life Fellowship of your distinguished Society, of which Richard Penrose, whose name you give to this medal, was in 1930 your president. I feel greatly privileged to have been invited in this way to enjoy the warmth and friendship of your scientific family, and thank you all from the heart.

My researches began in Britain in 1955. It seemed to me at the time that the opportunity to pursue geological science in a university was the next best thing to the possession of a private income. Geological science then was rightly expected by the general public to contribute to human good, but the need to foster and fuel creativity—the "dreaming of dreams" that leads us in new, fruitful, and unexpected directions—was also fully and openly recognized and widely supported. Today, in 1996, forty years on, I find myself and my fellow-researchers in a very different, postacademic world. In that world, science itself is under scrutiny and attack, and scientists are held increasingly "accountable" and their activities ever more closely monitored by their public and private patrons. Throughout the developed world as a whole, we witness the "anti-science" of the right in politics and the "pseudo-science" of elements on the religious right. On the political left, there are those who would persuade us of the sociological relativism of science, and that its findings do not represent any kind of objective, universal, and timeless truth about our material world. On all sides the demand is that scientific research—to be funded grudgingly—must be socially and economically relevant. What has become of knowledge for its own sake?

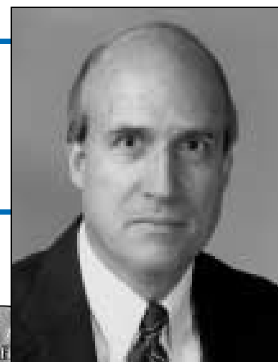
The challenges we as geological scientists face today are therefore many, and exacting. If science is not to be misunderstood and misrepresented, the public at large needs to be much better educated in the content and particularly the processes of science; each and every one of us can contribute toward this goal. We need to work more effectively and persuasively with policy-makers in setting priorities for geological research which, while affordable and adding to human good, continue to include that necessary room for dreaming and the fulfillment of dreams. To shrink now from political acts will harm the future. We need continually to review our ways of working so that, as geological problems become more complex, calling for team activity, the burning creativity of young researchers can continue to shine out.

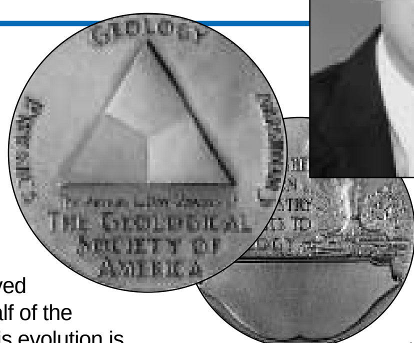
I come back to the person whose name is attached to the medal you have bestowed upon me, and to his example. Richard Penrose was a distinguished and practicing economic geologist. He was therefore in no doubt about the wealth-creating capability of our discipline but, as his celebrated bequest to this Society forcefully demonstrates, recognized also with equal clarity that the free and sufficient exercise of the scientific imagination fueled the future.

DAY MEDAL

presented to

ROBERT A. BERNER





Citation by JOHN W. MORSE

Robert Arbuckle Berner has been chosen to receive the 1996 Day Medal in recognition of his outstanding contributions to the field of "low-temperature" geochemistry. This field has evolved dramatically during the second half of the twentieth century, and much of this evolution is directly attributable to Bob's vision and leadership. Through his many innovative papers, scholarly books, and dedication to teaching he has had a major intellectual impact on a whole generation of geoscientists. His outstanding research has contributed substantially to the study of low-temperature geochemical processes blossoming into a wide range of subdisciplines that include chemical oceanography, sedimentary geochemistry, environmental geochemistry, biogeochemistry, and the geochemistry of global cycles. His many accomplishments are reflected in the fact that he is a past president of the Geochemical Society, was made a member of the National Academy of Sciences at a relatively young age, and is a recent recipient of the Huntsman Medal of the Bedford Institute of Oceanography (Canada), the Murchison Medal of the Geological Society of London, and the V. M. Goldschmidt Medal of the Geochemical Society, the recipient of an honorary doctorate from the University of Aix-Marseille (France), and among the most frequently cited members of the earth sciences community in the scientific literature.

Bob was born in Erie, Pennsylvania, and grew up in, among other places, Michigan, where he received his B.S. and M.S. degrees at the University of Michigan. Bob obtained his Ph.D. at Harvard under the advisership of Ray Siever, and a long-lasting personal and professional association with Bob Garrels was begun there.

While at Harvard, Bob married Elizabeth Kay and started his study of iron sulfide minerals. He subsequently went to Scripps Institute of Oceanography as a Sverdrup Postdoctoral Fellow in 1962, followed by a brief time on the faculty of the University of Chicago. In 1965, he joined the faculty at Yale, where he is now the Alan M. Bateman Professor of Geology.

In the 1960s, Bob's research was primarily on processes associated with the early diagenesis of sediments, with particular emphasis on the formation of pyrite. This research revealed the complexity of interrelationships among physical, chemical, and biological processes occurring near the sediment-water interface, resulting in his mathematical models for diagenesis. Many of these ideas were brought together in his two books on the early diagenesis of sediments. Bob's innovative work on sediment diagenesis continued though the mid-1970s to 1980s and came to include studies of the formation and behavior of methane, development of the G model for sedimentary organic matter, investigation of iron mineral and phosphate diagenesis, and demonstration of the utility of sedimentary C/S ratios as indicators of paleodepositional environments. During this period, Bob also became involved in research on silicate weathering reactions, in which he introduced X-ray photoelectron spectroscopy (XPS) to the study of the surface chemistry of silicate minerals undergoing dissolution. In recent years, he has put much of his effort into modeling the global carbon cycle and the role it plays in controlling atmospheric oxygen and carbon dioxide, and global climate over Phanerozoic time. He is continuing to evolve his GEOCARB model and is particularly interested in how the evolution of land plants may have influenced global weathering rates and the carbon cycle.

Bob has a unique talent for not only educating, but also inspiring those around him to push themselves to do the best they can and to maintain the highest scientific ethical standards. He stands out as a shining example of how "small," curiosity-driven science can produce big results. He has not been an empire builder, but has preferred to work with modest funds, relatively simple equipment, and small groups of individuals.

Bob's wife, Elizabeth (Betty) Kay Berner, also is a fine geologist, having attended graduate school at Harvard with Bob and co-authored books on the global water cycle and environment with him, and who is now teaching geology at the University of Connecticut. I think Bob would agree that Betty's love and support have contributed substantially to the incredible career he has enjoyed. Those of us who have worked with Bob also thank Betty for making us feel part of the family and putting up with the many late- to all-night get-togethers at their home.

It is for these many accomplishments, along with the inspiration, guidance, and friendship that he has provided to so many of us, that we honor Robert A. Berner with the 1996 Day Medal.

Response by
ROBERT A. BERNER

Well, here I am at another annual GSA meeting. I have now attended 32 of them. My first meeting was in 1958 when, as a 22 year old, I presented the results of my master's research at the University of Michigan on a cross-bedding study of sediments from Huerfano Park in southern Colorado. What a disaster! I discovered the night before my talk (needless to say, I was very nervous) that I had brought the wrong slides with me—pictures of my mother, dog, etc.—instead of the intended scientific pictures of outcrops, maps, etc. I stayed up all night preparing posters in lieu of slides (there was no Federal Express then) and just finished the posters in time for my afternoon talk. I marched in with the posters and put them on the stage (there were no poster sessions then), but because everyone else had used slides, the lights were never turned up during my 10-minute talk. Thus, I was pointing to the posters in the dark and nobody could see them. Thus began my auspicious career at the GSA.

I started coming regularly to GSA annual meetings in 1962. (Since then I have missed only four of them.) During that time I have listened to almost a thousand talks and have seen the abstract book grow from a small pamphlet to a volume so large that it heavily weighs down my briefcase. (An idea of how the size of the abstract book has grown since 1958 is shown in Figure 1.) I have also given many talks myself on subjects ranging from iron sulfide mineralogy and crystallography, to the carbonate chemistry of oceans and sediments, to the surface chemistry of silicates, to biogeochemical studies of diagenesis, to the kinetics of weathering, and more recently to the evolution of atmospheric CO_2 and O_2. I even talked once about the chemistry of rotting fish! (Some joker on the GSA staff changed the wording of my abstract, from a high *mass* ratio [of fish to seawater] to a high *mess* ratio). Besides giving talks and listening to them at these 32 meetings, I have witnessed numerous award ceremonies, but this is the first time I have ever been on *this* side of the podium.

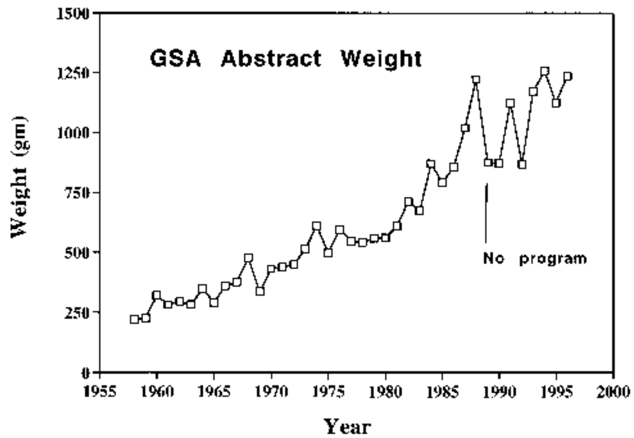


Figure 1. Plot of weight of the abstract book (in grams) for the annual GSA meetings for 1958–1996. This is one indicator of the growth of the Society. Note that starting in 1989 the program of talks was issued separately from the abstracts, thus accounting for a drop in weight from the previous year. (Note also that this drop was made up in just 5 years by natural growth of the abstract book.)

My presence here would have been impossible without the timely advice I received from my advisers as a graduate student. That includes Lou Briggs at the University of Michigan, who insisted that I go on for a Ph.D. and do it at Harvard, even though I really wanted to take my master's degree and start working for an oil company. Lou was the one who turned me into a lover of sediments and sedimentary rocks. At Harvard I was greatly influenced by Bob Garrels and Ray Siever (not to be confused with the great radio comedy team of Bob and Ray). Bob taught me how to apply physical chemistry to sedimentary problems, and Ray taught me that squeezing water out of mud could provide a wealth of important chemical diagenetic information. I started my Harvard Ph.D. research studying the sediments of Barnstable Harbor on Cape Cod under the tutelage of Alfred C. Redfield, who was a famous physico-bio-geo-chemical oceanographer—in other words, a naturalist. Redfield impressed on me the importance of constant self-education and the need to solve any given problem by applying whatever method is available, which can entail entering fields far from one's own specialty. Ever since then, this Redfield approach has been my scientific philosophy.

I credit Bob Garrels for much later guiding me, actually pushing me, into the study of global geochemical cycles, both during the annual "cycle rallies" we had at GSA meetings and while he was a frequent visitor at Yale. Without him there would not have been any BLAG, GEOCARB, etc. I also give credit to a virtually unknown early pioneer of geochemical cycles, J. J. Ebelmen. Ebelmen was a chemist who worked at the Ecole des Mines in France, and whose two papers in 1845 and 1847 on geochemistry are totally hidden in the multitude of old dusty reports of that organization. As I have pointed out in a recent short note in *Geochimica et Cosmochimica Acta,* Jacques Ebelmen deduced the basic fundamental processes that control atmospheric O_2 and CO_2 on a long geologic time scale. This includes the weathering and sedimentary burial of both organic matter and pyrite as they affect O_2; and volcanic-metamorphic degassing, the weathering of Ca-Mg silicates, and the weathering and burial of organic matter as they together affect CO_2. He also deduced that there has to be a close balance between input and output fluxes for atmospheric CO_2 because there is so little atmospheric CO_2 compared to the large fluxes. His ideas are still correct today. (He was only a century ahead of his time!) He was one of the first persons to write chemical reactions, using the then newly devised chemical notation system that is still in use. As an outstanding example, he wrote a balanced reaction showing that the burial of sedimentary pyrite should result in the production of atmospheric oxygen. This is a complex argument that was subsequently independently rediscovered, but only after 120 years had passed. Ebelmen's pronouncements on the atmosphere were based partly on his chemical analyses of rocks and associated soils. He was one of the first to show how the elements are fractionated between soils and solution during the chemical weathering of silicates and how growing plants accelerate this weathering.

At this point I want to say a few words about the future of our science. The Day Medal is for contributions to geology via the application of physics and chemistry. I hope that some day doing geology automatically will involve geophysics and geochemistry. I even look forward to the day when the terms "geophysics" and "geochemistry" are dropped and that geology is viewed in its broadest sense to include the application of physical and chemical, as well as biological, principles to the study of the whole earth, including its liquid and gaseous portions. As is obvious, I am a strong supporter of the concept of earth system science.

In closing I express my thanks to the many students, postdocs, and colleagues with whom I have had the pleasure of working over the past three decades. I am especially proud of my former students, ranging from my first student, John Morse (who has just fed you much exaggeration about me) up to some of the young Yale student faces in this audience. I especially thank my wife, Betty, an excellent geologist in her own right, who has been an inspiration and constant companion and whose patience with my behavior is legendary. Finally, I want to thank the GSA for the past 35 years of intellectual excitement. It doesn't seem fair to get a prize for all of this fun. But thank you anyway. I am greatly honored to receive the Arthur L. Day Medal for 1996.

YOUNG SCIENTIST AWARD (Donath Medal)

presented to

PAUL R. BIERMAN

Citation by ALAN R. GILLESPIE

Paul Bierman's scientific contributions focus on the rates and processes by which Earth's surface changes: how long landforms are stable; how rapidly hillslopes erode; the flux of sediment through basins. His most recognized work involves measurement of cosmogenic nuclide concentrations to quantify rock weathering and basin-scale erosion rates, the timing and rate of withdrawal of the Laurentide ice sheet, and long-term faulting rates. His results have drawn attention to the powerful tool presented by cosmogenic isotopes for geomorphic studies, in addition to their use in surface dating.

Paul received his undergraduate training at Williams College, training that whetted his appetite for glacial geology and geomorphology. His graduate study was at the University of Washington, where he came to grips with quantitative studies of surface processes. Paul's research is broad in scope, yet remarkable for the clarity with which it is defined and the rigor with which it is executed. It is characterized by intensive field observation, meticulous laboratory measurement, and an acute awareness of the limitations of his data and interpretations. His scientific communications—written and spoken—are concise and lucid. Paul's contributions to geology and geomorphology extend beyond his research. He has led GSA field trips and taught a short course on cosmogenic isotopes. He is a consummate teacher, both in the classroom and as a mentor to his graduate students, one of whom received the Mackin Award last year. Paul is the kind of person who by his critical analytical skills and infectious joy and enthusiasm for geological research raises the performance level of all around him.

Paul Bierman is a most worthy recipient of GSA's prestigious Young Scientist Award.

Response by PAUL R. BIERMAN

Thank you for this medal; it is an unexpected honor. You have given me this medal for research achievements; yet as Vermont summer turned to fall, I became more and more certain that this award is really about education—more specifically, about the intense, individual mentoring I have been so lucky to receive. So I will use this platform not only to thank those who have enabled me to climb these stairs but to suggest that the future of our science, geology, demands that we ourselves are successful, dedicated mentors—training our students to be rigorous, critical thinkers.

Of course, my first and in many ways most important mentors were my parents. It is they who encouraged me to pick up rocks, to ask why and to ask how everything worked. At every point in my life, it was my parents who encouraged me to continue my education.

As an undergraduate at Williams College, I was surrounded by an atmosphere of academic intensity and a Geology department that was home. I learned geology by doing, by pursuing a field-based senior thesis rooted in unpublished, turn-of-the-century work of USGS geologists and by typing on what must have been the first IBM PC. It was at Williams that I met David Dethier, whose red pen, subtle humor, and endless hours of edits enabled me to complete a senior thesis and author my first publication.

I went to the University of Washington nearly a decade ago, a decision made after a three-hour discussion with Tom Dunne and Steve Porter at a GSA alumni gathering. At the University of Vermont, I have adopted Tom's tradition of evening seminars at home with my students and also seem to have carried with me Tom's predilection for moist field trips. At Washington, I met Alan and spent six great years in the Remote Sensing Laboratory and in the Owens Valley of California—two of the best places to do geology. From Alan I learned how to laugh at science while, as Alan would say, climbing every mountain, whether in the field, in the lab, analyzing data, or writing a paper. For those of you who don't know Alan, this means it's dusk, you've been hiking all day over Sierran granite boulders, lunch was a jar of Chileno peppers, you ran out of water two hours ago, and yet, you need to go over that next ridge and see what's there because … something always is. This philosophy of persistence and critical thought has served me well, and it is undoubtedly the single most important thing that I learned in graduate school and now try to pass on to my students.

Just last week, Alan and I were back in Owens Valley field checking some isotopic data. It was late and we were out of food and water. Walking over the Lone Pine fan, we came to a smooth dirt road, but with few words we turned and walked toward camp, across the jumbled blocks of the Alabama Hills. Within 200 meters, we stumbled on a long-abandoned channel of Lone Pine Creek, cut into the granite of the hills—a channel that, in six years of field work, neither of us had ever stumbled upon. The channel walls sparkled in the late afternoon sun, and staring back at us from the channel bottom was a perfectly symmetrical, meter-wide pothole—unchanged since the stream was captured and the water left 25,000 years ago. We marveled at the torrent of water that must have rushed through the now-dusty stream bed and of course took a sample of the water-polished rock. If we had taken the easy way home, down the road.…

There are so many others who have enabled me to become a scientist—fellow students at UW, particularly Doug Clark, with whom I shared an office, a long friendship, and ski trips on Mt. Rainier; my wife, Christine Massey, who has worked with me at almost every field site from the Arctic to Australia; colleagues such as Tom Davis, who took me to Baffin Island and nominated me for this award, and Milan Pavich, who has encouraged me to push cosmogenic isotopes just as far as they could go. Judy Hannah, as the UVM chair who hired me, showed me by example how to be a faculty member and was there my first year whenever I needed an ear. For years, Brian Atwater has been a critical editor of my writing and an example of field rigor. David Elmore, John Southon, Bob Finkel, and Marc Caffee taught me how to run an accelerator and take good data. Without them, the aroma of Marc's 2 a.m. cigars, and the support I have had from the University of Vermont, the National Science Foundation, the Army Research Office, the U.S. Geological Survey, and the Lintilhac Foundation, I'd have lots more sleep and lots fewer data.

So now I'm on the other side; I am the mentor. My students ask me questions I can't answer. They push me and I push them farther than either of us thought we could go. For me and many of our students, the geology department at Vermont and the field in which we work are a home. This is something special about geology; not something to which many other disciplines can lay claim. On a recent UVM regional geology trip to Washington, I made sure that all 35 of us climbed every mountain and looked at every rock; the students made sure I wasn't the first to the top and that little I said went unquestioned. Maybe, by learning how to think and how to challenge whatever they are taught, our students will grow to be the individuals and researchers who will give us all a better understanding of how earth systems function. Because of this, I see no way to separate teaching, mentoring, and research.

Many days, I remember something Alan told me when I left UW. He said, "You've done your job right when your students know more than you do and you are comfortable with that." So, I thank you for this award, and I take it as a challenge to train my students to be better and more skeptical scientists than I am. Pushing our science farther and wider and challenging existing dogma are the only ways in which we can hope to solve the vexing environmental and resource problems that face us as a global society.

Thank you again for this honor.

DISTINGUISHED SERVICE AWARD

presented to

ROYANN GARDNER, DAVID FOUNTAIN, LOUIS C. PAKISER, JR., ANTHONY RESO

Citation by ELDRIDGE M. MOORES

The GSA Distinguished Service Award was established by Council in 1988 to recognize individuals for their exceptional service to the Society. Tonight, on behalf of the Society, it is my honor to recognize four individuals who through their efforts and dedication have made a difference.

Royann Gardner is a perfectionist, and GSA benefited greatly from her dedicated work as head of the administrative department. Her question was always "Who else needs to know?"—and then to make sure that the information got to that person. She even helped to jump-start my editorship of *Geology,* by typing about a thousand letters to prospective authors. Her organizational skills, attention to detail, and thoroughly professional approach to her work earned her the respect, admiration, and affection of the many GSA officers, councilors, committee members, and editors who came and went during her tenure. She is very deserving of this Distinguished Service Award.

David Fountain has given immeasurably of his expertise, time, and concern during six years as co-editor of *Geology.* He has shepherded many hundreds of papers through the receipt, review, revision, and acceptance process (and rejected those determined to be unsuitable—perhaps the hardest part of the job). Seeing the need for a tailored tracking system for manuscripts and the people—authors, reviewers, and editors—associated with them, he developed such a system, now very close to being networked among the editors and headquarters. Ranging more widely, he initiated meetings of journal editors to share their concerns and address such issues as duplicate publication. These gatherings, held at GSA annual meetings, have led to increased communication among journal editors. This award does indeed recognize the distinguished service of David Fountain.

During Lou Pakiser's 40-plus year professional career, he has served the GSA and earth science community as a scientist and a public citizen. He has been active in a variety of committees with the Society, both formally and informally. In the mid 1970s Lou urged the creation of an ad hoc education committee to discuss the importance of bringing more women and minorities into the geosciences. This ad hoc committee has since become a standing committee and remains committed to recruiting and retaining women and minorities. Lou's efforts were before the Workforce 2000 report came out indicating that minorities and women would represent a larger component of the future workforce and long before it was politically correct to diversify that workforce. Lou's energy is limitless, and he has been active on behalf of women and minorities not only in his community, but in several professional organizations as well: the American Geologic Institute, the University of New Orleans, the U.S. Geological Survey Graduate Intern and Minority Participation in the Earth Sciences programs, and the American Indian Society for Earth Sciences, to name a few. It is my privilege and pleasure to present this award to Lou Pakiser.

Left to right: Anthony Reso, David Fountain, Eldridge Moores, Royann Gardner, Louis Pakiser.

Anthony Reso gave 12 years of exemplary service to the GSA Investments Committee, much of that time as chair. During his service, the investment portfolio produced $21.5 million to support GSA programs like DNAG, GSA Research Grants, and SAGE, and to protect the endowment from inflationary devaluation. In the past several years Tony's mutual fund expertise guided a successful foray into that investment category. Moreover, he served three years each on the Audit and Budget committees as well. It is literally true to say that GSA is much richer in terms of programs and assets because of Tony Reso's service. It is my privilege and pleasure to present to him the GSA Distinguished Service Award.

Response by ROYANN GARDNER

It has been a most gratifying experience to serve the Society in an administrative capacity and to observe the energetic enthusiasm, optimism, and fervor for the earth sciences that characterizes the GSA membership, its leadership, and the many volunteers who contribute their talents. It has also been my privilege to be affiliated with the professional staff at GSA headquarters. There, a team of dedicated men and women collectively, and tirelessly, direct their expertise to further the goals and purposes of the Society, and continually look for ways to respond to the challenges and changes affecting the membership and the geosciences. I am deeply grateful to the Society, and to the GSA staff, for the opportunities that led to this service award. This is truly a tribute to the members of the GSA staff.

Response by DAVID M. FOUNTAIN

I've learned a lot in the job as editor for *Geology.* Perhaps the most important thing I've learned is that publication of journals such as *Geology* and the *Bulletin* depend on the commitment and dedication of many volunteers. The high-visibility volunteers are the editors, but there are many other, hidden volunteers whose work is critical in getting these journals to press, an example being the home institutions that allow reduced work loads for editors. Our Editorial Board members, Associate Editors, and reviewers contribute their valuable time to provide us reviews we depend on to evaluate papers.

There is another type of volunteer important to publishing the Society's journals. These volunteers are people who spend extra time and effort well beyond their regular duties. One example is our outgoing president, Eldridge Moores, who, in his capacity as Society councilor, officer, and editor, has always given editors support, encouragement, and advice. He has been the editors' guiding light. Another individual in this category is Faith Rogers, who, in her years as managing editor for *Geology,* spent countless evenings and weekends preparing papers for publication.

Thank you for this award.

Response by LOUIS C. PAKISER

Three institutions have had special meaning for me during my professional career: first, the Colorado School of Mines, my alma mater, which taught me the basic skills of my profession; second, the U.S. Geological Survey, an organization I truly love, which provided me many professional opportunities and the opportunity to work for causes I believe in; and third, the Geological Society of America, which provided me with many opportunities to serve my profession and to bring talented young people of all backgrounds into the geological sciences. I am, therefore, especially pleased to accept the Distinguished Service Award from the GSA.

Among the many talented and dedicated people I worked with in recruiting minorities and women into our profession were Bill Bromery, who became the first black president of the GSA, Clyde Wahrhaftig, Mack Gipson, Lou Fernandez, Marilyn Suiter, and my wonderful secretary and friend, Louise Hobbs. Clyde, Mack, and Louise are deceased and sadly missed.

Although the number of minorities recruited into the geological sciences may not be large, they are increasing and they include the future leaders of our profession. I can mention only a few exceptional young scientists: Martha Garcia and her husband Earl Brooks, Wes Ward, Carlos Mendoza, David Lopez, and Rufus Catchings.

As we enter the 21st century, I am confident that our profession will become more creative and more colorful than it has ever been before.

I am grateful to the GSA for this special honor. Thank you.

Response by ANTHONY RESO

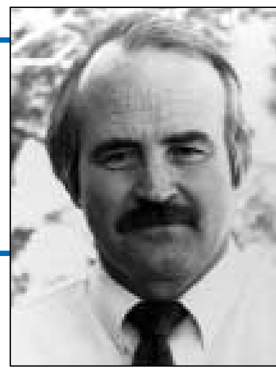
Thank you, President Moores, for your generous citation. I am very grateful and honored to receive this award. George Burns said, "You ain't nobody until somebody loves you." Well, my geological colleagues: I love you too.

Thank you.

RIP RAPP ARCHAEOLOGICAL GEOLOGY AWARD

presented to

LARRY D. AGENBROAD



Citation by JIM I. MEAD

I am very pleased to be able to help acknowledge the achievements of Larry Agenbroad. I have known Larry for what seems to be a thousand years, as a mentor, a colleague, and best of all, a compadre. Larry has a charisma about him that effervesces friendliness about education and an excitement about research on mammoths, geology, and archaeology. As a senior in anthropology and geology, I felt that I really knew the direction that I wanted to go, and I was headed in that direction, but when I met Larry at the excavation of the Lehner Mammoth Kill Site, southeastern Arizona, in 1974, it was he who really provided the catalyst for my future. I am where I am today thanks to Larry. I know that this is a similar scenario for many previous students of his.

Larry has given many gifts to the profession (take a look at his CV), but probably the one that has affected the most people, students and professionals alike, is his ability to get people excited about doing research. He has an innate ability to create new projects—projects with a different twist in design than what most of us can and do produce.

In the panhandle of Nebraska, Larry was shown a bunch of "sheep" bones eroding from a dozer cut near a spring. Upon examination of the deposit, his internal fossil-archaeology ticker went off—he knew that the site had more potential. Methodical and detailed excavations, typical of his techniques, proved that the locality was in fact a bison kill site (now known as the Hudson-Meng Bison Kill Site) with hundreds of animals. Larry not only recorded the use of bison by Paleoindians of the Alberta point tradition, but also trained scores of students (including me) to look for details and to think from a multidisciplinary framework—archaeology and geology.

Although some might consider Larry a loner, he is actually an ideal co-PI. For years we have worked side-by-side (him tall, me short) on the Colorado Plateau. He would always examine the locality from the holistic view, placing it within the area-wide framework, while I would be overly immersed in the detail. He never would push into someone else's "territory"; he always had his area and you yours, but he always wanted to know what you were finding so that he could learn.

He never really seemed to care about being in the limelight, but his charisma and expertise often forced him right to the front line. He has been in so many TV news blurbs, educational snapshots, interviews, and documentaries that I have no space here to go into them all. Once while filming with the BBC, Larry and I were doing a shot of walking up a canyon, side by side, casually talking about the dried dung remains of mammoth that we were going to examine in a nearby alcove. As we approached the hillslope entrance to the shelter, he insisted that I go first, right into the cave and the camera's view. I was thoroughly honored by his gesture. Later on I thanked him but insisted that he should have gone first, as he was the prime person for the film. Then he informed me, with a laugh, that if he had gone first, the sound recorder would have heard two voices and the camera would have seen only him, because I, being short, would have been hidden. We were truly a "Mutt and Jeff" team.

One of the best, if not the greatest, of his achievements is the Mammoth Site of Hot Springs, South Dakota. Not only did he assess a "strange and new find" in small-town USA, but he found the deposit to be unique and convinced the local people that they could capitalize on the find. Larry knew that the bones of tens of mammoths would be found in the filled sinkhole on the edge of that economically depressed town. He knew that to recover all of them and adequately curate and archive the remains would be a mammoth project in more ways than one! Using his innate ability, Larry convinced the town to form a private corporation to create a working museum. Today the site, under a beautiful and expanding building complex, curates and displays bones of more than 50 mammoths and educates over 100,000 interested tourists and students a year about the Ice Age.

Now what is he up to? Larry has begun the slow and methodical process of evaluating the numerous deposits of mammoth being recovered on the Channel Islands off southern California. He is trying to determine when and what these mammoths were doing on an island. Were they all pygmy mammoths or were there occasional strays swimming across the channel? Larry loves the intrigue of finding out the answers to a truly "mammoth problem."

I think that the boat ride reminds him of his navy days during the Korean War.

I could go on and on and on—I have not mentioned his works in hydrogeology, engineering geology, and Quaternary geology. The best way to witness his success is to go to the Mammoth Site, just 6 hours north of Denver (the Hudson-Meng site is nearby). He, with the help of others in his entourage, have assembled a truly world-class research-education-tourist monument. It is a monument to geology and paleontology, to education via the private sector, to the Ice Age, and to what a determined professional who cares about his profession and about students of all ages can do.

Response by LARRY D. AGENBROAD

I am honored, and humbled, by the receipt of the Rip Rapp Archaeological Geology Award for 1996, especially because I am aware of other worthy colleagues in this field of research. I express my appreciation to the award panel and the Society for this recognition. In part, this honor is shared with many persons who have influenced me, supported me, and collaborated with me, as well as numerous students. My wife, Wanda, and my sons, Brett and Finn, spent many field sessions with me, and put up with my absences as well.

As a Korean War veteran, I got a late start at higher education. It seemed that each time I earned a degree, there was no employment opportunity in whatever field I had just completed. As a result, I worked in underground mining; as a geophysicist for oil exploration in the Southwest; as a geophysicist-hydrologist with the Nevada Bureau of Mines in AEC-sponsored underground atomic device detonations; and as a hydrogeologist in the High Plains and the Colorado Plateau. Throughout this period, I continued working on advanced degrees, and in my final years at the University, I was a graduate teaching assistant in both the geology department and the anthropology department. It was then that I decided to go into teaching and research, a combination I have enjoyed since.

Applications of geology to archaeological investigations include Murray Springs Mammoth Kill Site and the Lehner Ranch Mammoth Kill Site in southeastern Arizona; The Lone Hill Desert Culture Site in the central San Pedro Valley, Arizona; investigations of the alluvial geology and it's relation to the archaeology of Grand Gulch, Utah; archaeological investigations of White Mesa, Glen Canyon National Recreation Area, Canyonlands National Park, Arches National Monument, Cedar Breaks National Monument, and Natural Bridges National Monument, in Utah; the Five Fingers, and 'Y' buffalo jumps of southwestern Idaho; the Hudson-Meng Paleoindian Bison Kill of northwestern Nebraska; the Sanson Buffalo Jump of the southern Black Hills, South Dakota; plus numerous Utah Department of Highways mitigation projects. It was during these investigations that two major changes in my research efforts began: (1) the at first subconscious, and later, conscious, tranfer of my focus from the hunter to the hunted—the Pleistocene megafauna, mammoths and bison, in particular—that early peoples had subsisted on; and (2) the realization that a geochronologic framework was necessary to tie the archaeological, paleontological, and geological environmental phenomena to a temporal setting within a region of study.

Archaeological geology is, of neccesity, a hybrid of at least two disciplines. I have always been an advocate of interdisciplinary work; my bachelor's degree is in geological engineering, a hybridization of geology and civil engineering. As I have already indicated, my teaching experience, as a graduate student, and later as a professor, encompassed more than one discipline. At Northern Arizona University, I initiated a graduate program in Quaternary studies, integrating anthropology, biology, geography, and geology.

Single discipline research is somewhat analogous (in my opinion) to the dark room experience of developing black and white film—especially at the hypo stage, where the image is faintly taking shape, yet the picture is still unclear, and certainly not sharp in all the details. To use that example applied to archaeological geology, most archaeological field techniques rely on geologic principles such as stratification, guide fossils (artifacts), sedimentary and hydrologic processes, source materials, and geochronology. More fundamentally, even the artifacts recovered, including ceramics, are in large part geologic in origin. Similarly, engineers construct their projects on, or in the crust of the earth, and their success (or failure) can largely be connected to the understanding (or lack of understanding) of geologic principles. What puzzles and alarms me is that most archaeological, and nearly all civil engineering programs fail to include geology in their programs of study. I feel this is a major error in our system of higher education.

Integration of geologic knowledge, principles, and processes with archaeology, paleontology, and engineering research has provided some of the most rewarding experiences of my career. Seeing the same data sets with different eyes and training has often enhanced the final outcome. It prevents the myopia of single-discipline studies.

Some of my geological colleagues have referred to Quaternary geology, especially archaeological geology, as "dirt geology". They want to hear their rock hammer ring when it strikes the outcrop, although many sedimentologists studying older deposits may get the characteristic thud of a hammer on soft sediments. My response to such banter is usually in the form of three questions: (1) Do you believe in the validity of Hutton's principle of uniformitarianism—i.e., the present is the key to the past? Usually the response can be paraphrased as "of course." My second question (2) is: What do you know about geologic processes in the Quaternary period? Specifically the Pleistocene and the Holocene epochs? A typical response is "very little." My third question (3) is, Then how can you be such an expert on the Permian (or Pennsyvanian, or whatever) if you don't understand the rates and processes preserved in the most recent geologic deposits—the Quaternary deposits?

I have beleaguered the Southwest archaeological community, 90% of whom deal only with ceramic cultures (ca. 2000 yr B.P.), with questions like, "Why don't you get into the REAL excitement of Southwest archaeology—the archaic and Paleoindian periods?" I am here to convince you that there are at least 9000 years of prehistory *prior to* their period of study. Using the Colorado Plateau as an example, I can provide ample paleontological evidence of the abundance of late Pleistocene megafauna (mammoth, bison, horses, camels, sloths, etc.); even an abundance of Paleoindian (Clovis, Folsom, and Plano) artifacts; plus rock art (petroglyphs and some pictographs), yet almost no one is exerting any research effort in this exciting and potentially rewarding area of prehistory.

Quaternary paleontology has made additional contributions to archaeological geology. Paleontological research of mammoths and contemporary Pleistocene megafauna and their possible association with early humans has led to reevaluation of spiral-fractured mammoth bones as *proof* of human presence in North America. The deposits at the Mammoth Site of Hot Springs, South Dakota, continue to yield spiral-fractured bones from a geohydrologic natural trap that predates human presence in the area (in my opinion). The discovery of Pleistocene megafaunal dung in hyperarid localities on the Colorado Plateau promises chronologically controlled paleoenvironmental-paleoclimatic indicators for late Pleistocene human habitats and provides models to demonstrate the ensuing degradation of those environments.

Most recently, I have been working from the "far side" (apologies to Gary Larson), chronologically speaking, looking at the distribution, evolution, and temporal history of the mammoths of the California Channel Islands and their possible association with the increasing temporal depth of human occupation or presence on those islands. Given the evidence from several archaeological colleagues, it appears we have a temporal gap of slightly more than 1000 years between the youngest (yet dated) pygmy mammoth remains and the oldest (yet dated) human presence on the islands. Perhaps Phil Orr (1941–1968) was partially correct: the earliest human islanders met the last of the pygmy mammoths. In that regard, I am often asked, "Won't it be exciting when you find a pygmy mammoth bone with a projectile point in it?" Taking a slightly less anthropocentric view, my reply is, "I'm looking for a human ribcage with a mammoth tusk in it!"

Academically, students sometimes are of the opinion that "everything has already been done or researched, so what can I contribute?" Off hand, I can think of at least 140 alluvial/fluvial valleys in the Great Basin which beg investigation; probably an equal number of canyons on the Colorado Plateau; uplands and high plains stretching throughout western North

America; and countless caves, alcoves, and rock shelters that await the investigations of trained researchers. Add to those potentials all the salvage and mitigation activity produced by the expansion of industry, housing, and transportation systems, and it seems archaeological geology will be an active, vital area of research for a long time in the future.

GILBERT H. CADY AWARD

presented to

FRANK E. KOTTLOWSKI

Citation by GRETCHEN HOFFMAN

Frank Kottlowski is best known for his years (1974–1991) as director of the New Mexico Bureau of Mines and state geologist, but the study of coal has been a part of his professional pursuits for over 40 years. Frank's work in coal began with a cooperative project between the Indiana Geological Survey and the U.S. Geological Survey, mapping the coal deposits in the Dugger quadrangle. Frank's dissertation at Indiana University, entitled "The Geology and Coal Deposits of the Coal City and Switz City Quadrangles, Southwest Indiana" continued his work on Indiana coals. This study, guided by Eugene Callaghan, then at the Indiana Geological Survey, included detailed geologic mapping and coal resource evaluation. These three quadrangles were later published by the U.S. Geological Survey in the Coal Investigations map series.

After receiving his Ph.D. in 1951, Frank accepted a job as economic geologist at the New Mexico Bureau of Mines and Mineral Resources, working for Dr. Callaghan, who had become director of the bureau. Frank probably thought he would never work in coal again, given the dismal state of the New Mexico coal industry in the 1950s. However, by the late 1960s the state's coal industry was improving with the advent of large-scale surface mining, and Frank was one of the few professional geologists in New Mexico whose background was in coal. Frank, along with Ed Beaumont, saw the need for New Mexico coal studies, particularly in the San Juan Basin. Several major coal investigations were organized and directed by Frank, first as acting director and then director of the New Mexico Bureau of Mines. These studies, often in cooperation with the U.S. Geological Survey, included coal mapping and coal resource and quality evaluations. A primary reference came from the first study "Strippable Low-Sulfur Coal Resources of the San Juan Basin in New Mexico and Colorado." This is one of the 40+ coal publications by Frank and co-authors that is indicative of the contribution he has made to the field of coal geology.

Frank has actively promoted coal development in New Mexico by serving on many committees, including the Four Corners Regional Commission Advisory Committee on Minerals and Fuels, as a mining representative on the New Mexico State Land Commission Advisory Council, and as chair of the New Mexico Coal Surface Mining Commission. As an adjunct professor at New Mexico Tech, he supervised many coal-related theses and dissertations. For his active role in many professional organizations, Frank has received Distinguished Service Awards from the GSA Coal Division, the AAPG at large, and the AAPG Energy and Minerals Division. Frank is a GSA Fellow, and an honorary member of AAPG and the New Mexico Geological Society.

Frank has certainly made significant contributions to coal geology in New Mexico, through his research and as an administrator. He has encouraged many others in their work in this field, both as a mentor and as a friend. His many contributions to the mineral's industry and to professional organizations reflect a dedication Frank has for all aspects of our profession. No one is more deserving of the Coal Division's Cady Award than Frank E. Kottlowski.

Response by FRANK E. KOTTLOWSKI

Thank you, Gretchen, for your kind citation. I am most grateful to the Coal Geology Division of the Geological Society of America for this utmost recognition that a coal geologist can receive, the Gilbert H. Cady Award. The award panel, chair John Calder, Gretchen Hoffman, Steve Greb, Robert Gastaldo, Jim Staub, and Brenda Pierce, had many worthy candidates; I am honored to be their choice.

Although I was not fortunate enough to be closely associated with Dr. Cady, to me he was a legend comparable to the stratigrapher William Smith of British geology fame. However, I have enjoyed association with Dr. Cady's coworkers and professional offspring, many of whom have received the Cady Award: Jim Schopf, Jack Simon, Aureal Cross, Bill Spackman, our recently departed dear friend Bob Kosanke, and Hal Gluskoter.

Particularly applicable to me is the thought that we stand on the shoulders of our mentors, are uplifted linking arms with our coworkers, and are sustained by our spouse and family.

Mentors? Many. At Butler University, Indianapolis, I had three years of business administration as an accounting major. During a 39 month interlude for WWII, serving as aerial navigator and photographic interpreter in Eighth Air Force, I enjoyed a few weekend passes looking at Great Britain's geology with a geologist buddy. Then in my seventh accounting semester, Charles Deiss, chairman of Indiana University's geology department (geology was an elective course), convinced me that knocking on rocks in the sunshine was more intriguing than sitting at a desk calculating taxes. Eugene (Pat) Callaghan, economic geology professor at IU, along with Paul Dean Procter, my dissertation chairman, guided my graduate research. Charlie Wier, outstanding coal geologist, head of Indiana Geological Survey's Coal Section, oversaw my coal projects, beginning a lifelong friendship. Joe Guennel, IGS paleobotanist, provided technical and morale support, as well as acquaintanceship with Bob Kosanke. Under a cooperative program of IGS with USGS, I reported on the coal geology of three 7-½ minute quadrangles, all published as USGS Coal Investigation reports. One of the USGS reviewers was Edward Beaumont.

Pat Callaghan became director of the New Mexico Bureau of Mines and Mineral Resources in 1949. He hired me as an economic geologist in 1951; he had broad shoulders on which to lean.

The early 1950s were dull years for coal mining and coal geology in New Mexico, because of the dieselization of the previously coal-fired transcontinental railroads, which utilize the southern, winter-warm routes in New Mexico. As Gretchen noted, the coal industry picked up in the late 1960s owing to the opening of large-scale strip mines to feed mine-mouth generating plants. Our low-sulfur Cretaceous coals became more important in the 1970s with EPA restrictions on sulfur. We were at the right place during the right time to have cooperative projects with USGS, EPA, and the New Mexico Research and Development Institute. These encompassed geologic mapping and coal resources and quality evaluations for northwest and west-central New Mexico. I was mainly the organizer. The detailed work was done mostly by Ed Beaumont, New Mexico's Mr. Coal, with his coworker John Shomaker, and our NMBM&MR staff members Dave Tabet, now with the Utah Geological Survey, Gretchen, who is now our senior coal geologist, Orin Anderson, senior field geologist, Steve Hook, now with Texaco, Frank Campbell (1947–1988), Art Cohen, then with Los Alamos

National Laboratory, and many others. We benefitted from the cooperation of USGS geologists Ed Landis, Bill Cobban, Jim Fassett, Chuck Pillmore, and many others. Recent support of our coal projects has come from our director, Charles Chapin.

In the early 1970s, New Mexico passed a coal surface-mining reclamation act, which was blended with the federal law and regulations in 1978. Almost from the beginning, I represented coal geology on the New Mexico Coal Surface-Mining Commission. It was crucial to have the realities of geology (in a semiarid state) interspersed with considerations of engineering, hydrology, and revegetation. The results have been significant, thanks also to efforts of Don Wolberg and Aureal Cross in paleontological resources conflicts. Service on the New Mexico commission led to service on coal reclamation issue committees of the National Academy of Sciences, including chairing several, and close working friendships with Don Haney, Charles Mankin, Bill Fisher, John Rold, and many others.

Some of the most pleasant and informative times have been with the Coal Geology division of GSA in technical sessions and field conferences. I chaired the division 27 years ago—what a difference today, especially the technical papers. The field trips were—and are—legendary. Where could one better experience coal geology than in Indiana, Kentucky, Illinois, West Virginia, Utah, Colorado, Wyoming, Oklahoma, Texas, Washington, Pennsylvania, and of course, New Mexico (led by Ed Beaumont and John Shomaker). Trips also included the Everglades (twice) and the Okefenokee Swamp. Most enjoyable was the 1968 trip to the Sabinas coal basin in northeast Mexico, led by our Mexican amigos and USGS's Chuck Pillmore and Bion Kent. The Mexico City 1968 GSA meeting featured a Coal Geology Division symposium in English and Spanish, which led to GSA Special Paper 179, *Coal Resources of the Americas,* published after a ten-year struggle with Spanish and Portuguese articles, ramrodded with Aureal Cross and Art Meyerhoff.

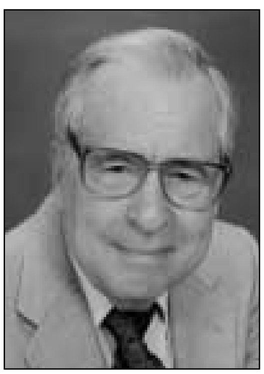
Working on division committees with the geologists already mentioned, as well as loquacious Sam Friedman, Russ Dutcher, Peter Hacquebard, John Crelling, Bob Finkelman, Gary Glass, Hermann Pfefferkorn, Jeremy Platt, Gilbert Smith, and Larry Woodfork, and those of you of the younger generation too numerous to be named individually, has been a highlight of my professional and personal experiences. Hopefully, by the caliber of my friends I should be judged.

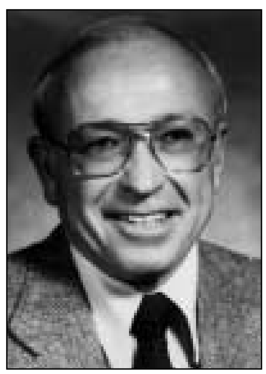
I thank my mentors at Indiana University, Indiana Geological Survey, and New Mexico Bureau of Mines and Mineral Resources, and my hard-working, honest, caring Hoosier mother and father. Nothing could have been done without the love, support, and understanding of my wife of 51 years, Florence, and my family: daughters Karen Harvey, Janet Wallace, and Dianna Schoderbek, husbands Albert Harvey (solid-state physicist for Tiokol) and David Schoderbek (geophysicist-geologist for Burlington Resources, Farmington, New Mexico—coal gas exploration!), grandchildren Adam (with wife Angie) and Benjamin Harvey, Zachariah Wallace, and Donald and Florence Schoderbek, and great-grandson Rick Harvey. As I gratefully accept this overwhelming Gilbert H. Cady Award, I do so in appreciation of my many coworkers, especially Ed Beaumont and Gretchen Hoffman, who should be co-recipients. Muchas gracias, thank you.

E. B. BURWELL, JR., AWARD
presented to

GERARD SHUIRMAN and JAMES E. SLOSSON

Citation by SCOTT F. BURNS


Shuirman


Slosson

It gives me great pleasure to announce the winners of the 1996 E. B. Burwell, Jr., Award, given each year by the Engineering Geology Division of GSA to the publication that best advances the knowledge concerning the principles and practice of engineering geology. The selection of the award committee is *Forensic Engineering: Environmental Case Histories for Civil Engineers and Geologists,* Academic Press, 1992. The authors are Gerard Shuirman and James E. Slosson.

The authors have filled a void in the literature with an excellent book on forensic engineering geology. This topic has been covered many times in short course notes, but their book is one of the first that discusses the topic with detail and then uses case histories to illustrate how to do it. The authors define forensic engineering as "of or suitable for public debate." Geologists and civil engineers need to contribute scientific-based data and conclusions to help in this "public debate" by making scientific investigations of accidents, engineering failures, and disasters in order to discover their causes. Forensic engineering geology really deals with determining *why* something happened.

The authors mention that forensic engineering geology is a growth industry. Maybe the growth comes from the overabundance of lawyers, the scarce-land syndrome, the decline in the immunity of public agencies, and/or the failure to strengthen outdated codes and enforce them. Getting involved in forensics is not for everyone. The authors state that the geologist–civil engineer must be able to explain complex items simply, to have patience to educate the client's lawyer on the nuances of the case, and to remain cool while under attack by opposing attorneys. The book emphasizes the steps necessary to complete a forensic investigation, the important court procedures, the needs of the expert witness, the relationship of the client to the attorney, and the challenges of the whole process.

The case histories include the natural and geologic hazards of floods, landslides, subsidence, erosion, and sediment deposition. Two of my favorites are the Malibu Big Rock Mesa slide and the Thistle slide in Utah. Each case-history summary includes sections on the investigation and analysis, the case preparation, the litigation phases where the investigator presents the data to prove causation, and the postmortem. The last step is so important. The authors discuss how the failure could have been prevented and what was learned for future planning, design, and public policy. Throughout the case histories the authors stress the importance of integrity and honesty and the responsibility to the court.

Gerry Shuirman was born in 1922 in Minnesota but grew up in Michigan. He received his B.S. degree in civil engineering in 1944 from the University of Michigan. He then became a member of the Navy civil engineering corps, the Seabees, and served for two years in the South Pacific. After the war he returned to Michigan to complete his MBA. He then moved to California, where he practiced civil engineering for ten years for the highway department and different consulting firms. In 1957 he became the president and founder of G. Shuirman and Associates, a firm in Los Angeles that specialized in site development, planning, and design, especially of earthworks storm drains, flood control structures, sewers, and water systems. In 1966 he co-founded and served as president of a similar consulting firm in Newport Beach known as Shuirman-Simpson. In 1972 G. Shuirman & Associates became Shuirman-Rogoway Associates. His companies had many clients, including architects, real estate appraisers, commercial and industrial firms, land developers, public agencies, health care organizations, education institutions, and military organizations. He became an independent consultant in 1978 and has been doing forensics ever since. In 1991 he retired and spent a great deal of time writing this book. He is a Fellow and Life Member of ASCE and has seven publications. He and his wife Shirley have been married for over 48 years.

James Slosson has been a mentor to many of us in the engineering geology field. He was born and raised in Van Nuys, California. He joined the U.S. Army in 1943 and served as a second lieutenant in World War II. After the war, he entered the University of Southern California and received three degrees in geology: B.A. in 1949, M.S. in 1950, and Ph.D. in 1958. While he was at USC he participated on the track team as an undergraduate, and while he was in graduate school he was an assistant coach of the team. From 1950 to 1973 he was a professor of geology at Los Angeles Valley Community College, and from 1950 to 1965 he was chair of the department. During his tenure at LA Valley College he began his career as a consultant. By 1973 he had worked on over 3000 projects. In 1973 he left Los Angeles to become state geologist and chief of the Division of Mines and Geology for the State of California in Sacramento. The state had hired him with the intent of getting more engineering geology into the division.

He returned to Los Angeles in 1975 to form Slosson and Associates, a company that he still heads today. His work mainly involves forensic geology, hazard mitigation and prevention, ground-failure abatement, ground-water studies, earthquake seismic hazard mitigation, and second-party reviews. He has been on many commissions over the years, including the California Seismic Safety Commission, the Board of Registration for Geology and Geophysics for California, FEMA's landslide hazard mitigation committee, and the National Research Council Committee on Ground Failure Hazards. He is registered as a geologist in 12 states in addition to California, where he is an RG, a CEG, a registered geophysicist, and an environmental assessor. He is a member of more than 15 organizations, including AEG, ASCE, NAGT, Sigma Xi, and GSA (Fellow since 1967). He has had more than 100 articles and papers published, mainly on natural hazards. He was the editor of volume 9 of the GSA's Reviews in Engineering Geology and will be a co-editor of the newest volume in that series. He has received many prestigious awards, among them the Richard Jahns Distinguished Lectureship in 1989 from the GSA, life membership from ASCE in 1991, the Distinguished Practice Award from the GSA in 1992, and honorary membership in AEG in 1995. Jim has been married to Nancy for over 49 years. At the age of 73, he is still working and having an impact in our field.

The Burwell Committee is proud to present the Burwell Award to these two extraordinary gentlemen who have devoted their lives to engineering geology and civil engineering. They have written a book that has had great impact on our professions and will continue to have an impact in the future.

Response by GERARD SHUIRMAN

I am pleased and flattered that the Geological Society of America has honored me as a co-recipient of the prestigious E. B. Burwell, Jr., Award. I am particularly proud of the fact that this award from GSA is to a civil engineer with little academic background in either geology or geotechnical engineering. What knowledge and understanding I may have acquired in geology has been through a fellow by the name of Jim Slosson.

First, it seems appropriate for me to relate how we came to collaborate on this book (the first for either of us), and to tell you about some of the people who made it possible.

Dr. Slosson and I can trace our personal friendship and professional association back almost 35 years. At that time, our firms worked together on projects involving large-scale grading, storm drainage, and flood control. My company did the civil engineering, planning, and design, and Jim's organization provided the engineering geology exploration, mapping, and consultation. Early on in the relationship, I began to fully appreciate the importance of his geological input to the success of these projects.

It became apparent to me that for every thousand dollars spent at the outset of a project for good geology, tens of thousands or hundreds of thousands, even millions of dollars might be saved in design costs, construction costs, change orders, and maintenance costs; not to mention possible injury or loss of life in the event of failures. But the biggest potential savings accruing from good geological input is the reduction or elimination of litigation or the threat of litigation. For example, Jim and I worked on a forensic assignment where an easily avoidable land settlement problem in a high-density hillside residential development resulted in tens of millions of dollars in successful lawsuits and out-of-court settlements.

In the mid-1970s, Jim and I were introduced to forensic geology and civil engineering by a feisty little Los Angeles County attorney named Max Truex. While an assistant track coach at USC, Jim had helped coach Max to the status of one of the world's premier distance runners. After becoming an attorney, Max carried his same competitive zeal into the courtroom. Among other things, we learned from Max the importance of objective investigation and honest and forthright expert witness testimony. Unfortunately for us all, Max became the victim of Parkinson's syndrome and succumbed only after his usual valiant fight. It is safe to say that Max Truex not only sparked our interest in forensics but showed us that one can be a competitive witness without resorting to advocacy.

The idea for the book came from my wife, Shirl, who had spent several years as a literary agent. She suggested we submit a letter of inquiry and a proposed outline to six or seven publishers who were most likely to be interested. The response was not exactly overwhelming. All but one publisher, Academic Press, politely turned us down. Erwin V. Cohen, then a Senior Vice President at Academic Press, was extremely interested in the concept and offered us a contract. Above all, he emphasized that we should make a strong appeal to the ethical aspects of the forensic process.

The manuscript took years to write because the cases we wanted to include dragged on forever in the courts. Meanwhile, Academic Press was very patient, and the vice president and editor, Charles G. Arthur, with whom we worked, was extremely helpful. With any undertaking of this kind there seem to be critical points where decisions must be made. One such turning point occurred when Mr. Arthur read our completed manuscript. To put it bluntly, he was bored with the first six chapters—which could be characterized as being "how-to" material—but keenly interested in the ensuing case histories. He strongly urged us to rewrite by melding most of the how-to material into the case histories. It was a hard job, but it apparently worked.

The reaction to the book was mixed, especially among our peers. On the one hand, the book received some great reviews from geologists, civil engineers, and attorneys we had never met, as well as some silent, if not chilly, responses from those with whom we have actually worked.

We've given some thought to this widely varied reaction and have concluded:

1. To those that know us we may be considered hypocrites in the central matter of advocacy. Certainly, we both have a competitive nature, and there may have been times, when in the heat of unmerciful badgering, when we appeared to cross that thin line between objectivity and advocacy. Speaking for Jim, too, it was certainly never our intent.

2. Many of our peers apparently feel we have been much too critical of our professions. We realize that only a relatively small percentage are involved in unethical or dishonest conduct, or blatant advocacy, in the courtroom. Unfortunately, these few are well known to attorneys in their particular locale, are very much in demand, and are handsomely paid. The spectacle gives us all a black eye.

3. I suspect that some of our peers feel there is nothing wrong in being an advocate. After all, one is only being a team player. Besides, some attorneys can be pretty intimidating to their own witness. I recall a well-

known and very successful attorney actually boasting that he would not hire an expert who wouldn't testify exactly as instructed. Geologists may be more vulnerable than engineers to such pressure and intimidations simply because geology is an art as well as a science. There seems much more latitude for diversity of honest, as well as dishonest, opinions among geologists than among engineers, whose profession is more precise and number oriented.

4. Many of our peers agree with the essence of what we have written—they just do not want it published. They apparently feel there are enough problems in making a living in their professions without introducing all the negative aspects of the fast-growing forensic field. Although the book was not intended as a whistle-blower (no actual names are included), some may perceive it that way. And we all know how popular whistle-blowers are in science, whether in government, academia, or industry.

As I have mentioned, one of the most satisfying aspects of my foray into forensic engineering has been my close association with Jim Slosson on so many assignments. To illustrate the closeness of this association, I recall a particularly nasty deposition in which I was being berated by the opposing attorney for constantly referring to Dr. Slosson as the source for certain information. Suddenly, he asked me in a sarcastic tone if I was related to Dr. Slosson. My first impulse was to say we were Siamese twins separated at birth. My second choice was to tell him that we were related by a common bond of lawyer phobia. Since there was a "rent-a-judge" present to maintain decorum, I chickened out and merely answered, "No."

Finally, I would like to touch on the close relationship between our professions. Geology and civil engineering have always been closely allied. In the 1800s and the early part of the 1900s, many of the prominent civil engineers were also geologists—and vice versa. It is basic that all civil engineering projects are supported by or located in Earth's crust. How can a professional relationship be any closer than that?

As technology mushroomed, greater and greater specialization occurred in both professions until today there are few possessing this dual capability. This is unfortunate, because in the 20th century there seems to me to have been a scarcity of civil engineers—particularly in policy-making positions—who fully appreciated the vital contributions that could have been, or still can be, made by engineering geologists. A striking example of this is in public works, especially in road and highway planning, design, and construction. For years, most road and highway departments (run by civil engineers) adopted a strange, illogical policy toward road-cut slopes. Few had staff or consulting engineering geologists and, even if they had, often paid them little heed until a problem arose during construction. The prevailing philosophy seemed to be: (1) The land planners, engineers, and appraisers, with occasional help from politicians, can determine the preliminary alignment and grade. Not much help needed from geologists here. Not much indeed! (2) We have a healthy maintenance budget, so if a slope fails we merely cut it back at a flatter angle and clean it up. (3) Cut slope features, recognized as essential in building and grading codes, such as intermediate terraces, drainage collection and downdrain facilities, subdrains, erosion control, etc., are not cost effective, especially when additional right-of-way is relatively inexpensive.

The fallacies of this approach are all too obvious. First, the cost of doing it right in the first place is far less than the original construction, plus the remedial work and the possible cost of requiring additional right-of-way. More important is the potential property damage and injury or loss of life, not to mention the lawsuits that would inevitably follow.

Engineering geologists should not have to wait to be called in until after the slope failure. They should be consulted in the early phases of route selections as well as in design and construction supervision. Land required for right-of-way slope acquisition could be done much more accurately with early geological input. It is mind-boggling to drive along not only remote county roads but even interstate highways and see all the potential physical hazards and litigation related to cut slopes. It's enough to assure the legal profession a steady stream of income and the public a steady stream of taxes.

Jim and I have been involved as experts in a never-ending series of lawsuits in connection with a 1983 Malibu landslide. The lawyer for the first plaintiff was able to convince a jury that the slide was triggered by a cut slope failure on a county road. In fact, the cut slope was too steep—hard to argue that point since it failed. But subsurface exploration performed after the first trial yielded evidence of a deep-seated series of slip surfaces and that the road failure was not the proximate cause of the slide—in fact, not a cause at all. Too late. Thus, 13 years later there is still no end in sight to the litigation. Moral of the story: If the cut slope had been proper, the slide would still have occurred when it did and with the same results, but county taxpayers would not be picking up the tab for something for which the county was not responsible.

I'm convinced that engineering geology is under-appreciated not only by civil engineers but by the public in general. Until recently, I envisioned forensic geology as only what Jim Slosson does. That was until I read a fascinating article in *New Yorker* magazine by the preeminent geology writer John McPhee. McPhee relates in his unique prose the role of forensic geology in solving major crimes. Being of World War II vintage, I was particularly intrigued by the account of how a small, elite team of geologists working for the War Department in Washington was able to pinpoint the location of Japanese facilities where balloons, laden with bombs, were being assembled and launched toward the United States mainland. It was a clever scheme, with the purpose of doing random damage, such as starting forest fires, but mainly to cause panic. Many of these balloons did reach our western states and did cause some deaths and injuries—a fact closely concealed by the War Department with the cooperation of the media. The balloons carried sand ballast, which became the focus of the geologic analysis. First, the geologists determined that all the sand was from the same source. Then, they painstakingly studied Japanese geologic maps until they were able to eliminate all potential launching sites except one. General Doolittle's bombers then proceeded to wipe out the fabrication and launching facilities. The tactic was apparently never attempted again.

McPhee relates other fascinating stories of how geologists, working for the FBI, had been instrumental in solving major crimes. It is amazing, at least to me, that earth and rock embedded in tire treads can be analyzed and then traced to its most probable source thousands of miles away. I wasn't even aware that the FBI employed geologists.

All this merely emphasizes how impressed I am with the wide scope of your profession and its great value to our society.

In closing, I thank you again for honoring Jim and me and our book. We can only hope that the book causes a few young geologists, engineers, and students to think about the importance of honesty and integrity in practicing their professions. If it does, the book will have been a worthwhile endeavor.

Response by JAMES E. SLOSSON

I am extremely honored to receive the Burwell Award and especially pleased to share the Award with Gerry Shuirman for the book *Forensic Engineering.* I also want to thank those within GSA who are responsible for the selection. The register of previous recipients of the Burwell Award reads as an honor roll of very talented professionals whose careers I have followed, respected, and often referred to in my days in the practice of geology—names such as George Kiersch, Dave Varnes, and Robert Leggett, among a lengthy list familiar to all of us in our geologic endeavors. There are so many facets within the field of geology that it is actually possible to identify a mentor for almost any assignment you might accept from this list of honorable colleagues. I found that in my days as state geologist for California, my daily routine included what I referred to as "changing gears" an untold number of times a day to adapt to the questions within our field. It was always encouraging to realize that my resources were never-ending within the eminence represented in this group.

I would further like to acknowledge my graduate school professors who forced us to be resourceful and to be able to jump and run for each class assignment. Gerry and I found forensic engineering and geology to be similar in the need to be quick and resourceful.

It must not go unsaid that not only do I share the award but also a fond and long-standing friendship with Gerry Shuirman—

that's an enviable combination! Our professional lives have intertwined over the past 30 years, and our respect for each other has culminated in this book as an effort to illustrate to others that the two disciplines are, indeed, compatible as well as necessary components of successful teamwork toward a satisfactory work product. Whether the case is won or lost, the gratification is in the final presentation of what you believe is the best case possible, with a scientifically accurate explanation for your client, because you believe in it and the principles on which it is founded. We wanted the attorney(s) we were teamed with on each case to be better prepared and more knowledgeable in science and engineering than the opposition and to know the true causes and effects. Justice is not always guaranteed, but if you and your team have joined together in assembling every detail and molded it into a fine-tuned submission to judge and jury, you have succeeded. Data should never be cooked or falsified just to please a client and attorney. Above all, scientific integrity must be the primary goal.

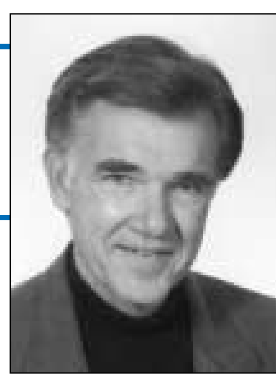
We came to realize early on that by drawing on our own case histories, we could point the direction that a new and increasingly important field of expertise might develop into an appreciation for higher standards for all professionals to follow—be they engineers, geologists, architects, attorneys, litigants, jurists, or even journalists. As Jon Kusler, a multitalented attorney, stated in his forward to our book, "The role of the expert witness is not an easy one for the uninitiated." He points out that one entering this role has the responsibility of dealing with complexities of proof and confrontation and challenges constantly posed by attorneys and opposing experts. These, at times, can be very caustic. We have drawn on our cases to bring an awareness of the ethical and professional aspects of the total forensic process and the analytical retrospect of specific failures and disasters, delving into the whys and hows of the events, discussing the plausible mitigation that could have been pursued, and the lessons that should have been gleaned from each. Our postmortem sections for each case history attempt to not only explain the causes and effects, but also discuss how the failures or problems could have been avoided or mitigated. We should be able to depict questions needed to bring public education and awareness of the process from each of these cases. We strived to encourage judges to become better informed relative to all aspects of a case and its evidence, to keep legislators up-to-date to develop or provide adequate legislation, and to see to it that the general public is better informed so that they can pressure elected officials and administrators as well as the judiciary to take timely and pertinent action to reduce or even eliminate or prevent the recurrence of damage related to engineered facilities. As we stated, our original intent was to provide a guide for engineers and geologists who are or may become similarly involved in forensic work. As we compiled our histories, we felt we could appeal to a more diverse collection of readers, to include attorneys, land planners, insurers, and anyone else who might be involved in areas of concern. We further advanced the suggestion that it be used as reference material for upper-division and graduate-level students in civil engineering and geology—a useful suggestion, from the response that we have had from such professors as Scott Burns at Portland State University. It is more than gratifying to think one can have some influence on the students of today and the professionals of the future.

An interesting approach developing at Arizona State University is a joint effort by the College of Law and the Department of Geology to expand on the principles of both fields and address the issues that come to the forefront relative to the legal aspects of geology, to explore the interface between science (particularly geoscience) and the legal system. I will be watching closely to see the results of this teaching experiment. I hope that it will be a model for other universities as a tool to improve the litigation process as it relates to our sciences.

An additional aspect of our book that Gerry has touched upon is one that some of our colleagues have taken issue with us for, but one we feel very strongly about: professional performance. I am most pleased to see that GSA is coming to the forefront about this, as indicated by the GSA Presidential Conference on "Ethics in the Geosciences" scheduled to be convened in July of 1997. I can only hope that by addressing performance, others might be prodded into thinking about the link between the tremendous increases in litigation and the decreases in quality in the work product from beginning to completion of projects. Damage reduction can be accomplished if only the potential consequences of a "bad job" are addressed early on in the development and construction phases. There would be no need for the current beaten path to the courts.

It goes without saying that our work could not have been finalized without the participation and counsel of members of the engineering and geological professions. Engineers who lent their expertise included Douglas L. Hamilton, Robert C. MacArthur, Richard L. Meehan, and Delmar D. Yoakum. Geological advisors included Vincent S. Cronin, Alexander R. Ball, Paul L. McClay, and Thom Slosson—all of whom had vital parts to play in the development of these cases. The legal field was graciously represented by the attorneys on several of the cases such as Steven R. Borer, David B. Casselman, Arnold K. Graham, John F. Krattli, John C. McCarthy, James C. Powers, and Michael F. Richman. Throughout the book are illustrations, charts, and maps compiled by Gay Havens, whose ability to comprehend our needs and those of the readers is unmatched—she has now fulfilled her dream of living in the outdoor splendor of the mountains of Lake Tahoe after patiently tolerating our demands for 25 years. As Gerry pointed out, we both owe acknowledgements to his wife, Shirley, and my wife of half a century, Nancy, for their tolerance in helping us find the right format and words to translate our technical vocabularies into the everyday words of any potential reader, and also living each and every one of these cases with us from start to finish.

GEORGE P. WOOLARD AWARD
presented to
NIKOLAS I. CHRISTENSEN



Citation by WALTER D. MOONEY

The George P. Woollard Award of the Geophysical Division of the GSA recognizes outstanding geophysical contributions to the understanding of geology. For a geophysicist whose first love is geology, such a recognition is particularly gratifying. Nik Christensen is certainly such a person.

Nik began his career at the University of Wisconsin, where he completed both his undergraduate and graduate degrees. His B.S. was in geophysics, and his Ph.D. was in metamorphic petrology, with his field area in Connecticut. George Woollard, who was at Wisconsin at the time, urged Nik to combine his knowledge of physics and geology by going to work at Harvard in the laboratory of Francis Birch, who had recently published several benchmark papers on the constitution of Earth's interior, and on the elastic properties of igneous rocks.

It is perhaps no surprise that Nik's first papers from his work at Harvard were on the elastic properties of metamorphic rocks. His field work had certainly convinced him that metamorphic rocks were abundant in Earth's crust—far more so than was implied by the simple model consisting of a granitic upper crust and basaltic lower crust.

For reasons known only to Nik, in the early 1960s he measured both the compressional and shear-wave velocities of these metamorphic rocks, despite the fact that the shear-wave structure of the crust was essentially unknown from seismic refraction field measurements, and only poorly known from surface-wave studies. It would take crustal seismologists more than 20 years to catch up with Nik's laboratory measurements. (In fact, I'm not sure that we have even today completely caught up!)

While measuring shear-wave velocities, Nik discovered the phenomenon of shear-wave splitting, and published this observation in the *Journal of Geophysical Research* in 1966—over a quarter of a century ago. Once again, he was well ahead of his time, and today shear-wave anisotropy in the crust and upper mantle is one of the primer research topics in geophysics because it provides a measure of structure, composition, and deformation of the lithosphere.

In the late 1960s, Nik joined the faculty of the University of Washington, by way of the University of Southern California. These were heady days for marine geophysics as the plate-tectonics revolution swept the globe. By measuring the elastic properties of ophiolites, Nik and graduate student Matt Salisbury were able to demonstrate that these bodies provided a match to oceanic crust and upper mantle. This and other studies by Nik demonstrated that serpentinite is not abundant in the oceanic crust, and that mafic igneous rocks and their metamorphic equivalents are the dominant rock types.

Despite his activity in marine geophysics, Nik remained loyal to his upbringing in the heartland of the continental interior and continued his studies of the continental crust and upper mantle. In 1975, together with graduate student David Fountain, Nik promoted the concept that the lower crust consists of mafic granulites, a conclusion that has survived more than 20 years of scrutiny.

Nik moved to the Big Ten league when he joined the faculty at Purdue in 1983. In the years that followed, he pursued a variety of exciting topics in both field and lab studies. Among these are the origin of crustal reflections (with graduate student Dan Szymanski), the island-arc model of continental growth as exemplified by the Kohistan arc in Pakistan (with Jay Miller), and further studies of seismic anisotropy, attenuation, and pore pressure.

It was in the middle 1980s that I began to collaborate with Nik on the USGS Trans-Alaska Crustal Transect. During numerous field seasons in Alaska I benefited from numerous lectures on petrology at the outcrop, and had the privilege of carrying 20-kilogram rock samples down steep slopes with Alaskan haul-road 18-wheelers whizzing by at the base. It was exhilarating and I'm glad that I survived to tell the tale. By building on our cooperation in Alaska, I have had a marvelous time working with Nik on the more general problem of the structure and composition of continental crust.

Doing laboratory work requires the ability to work with your hands as well as your mind. Outside the lab Nik has applied this ability to the restoration of classic cars from the late 1950s. As he has explained to me, most people form a special bond with objects of desire from the high school and college years, and in his case this includes his wife of 35 years, Karen, and his 1957 Chevy Bel-Air convertible. Well, you either know about classic cars, or you don't, so I won't try to explain this magnificent obsession.

This short citation presents the listener with a brief overview of Nik's contributions, and a rare opportunity. I refer to the fact that Nik has often been making measurements in his lab that are fully appreciated only 20 years later (shear-wave splitting, for example). The opportunity is obvious: talk to him after his acceptance speech and ask him what he's working on. There's your chance to get in on the ground floor on a topic that will be center stage in the year 2016.

Nik, on behalf of the Geophysics Division, and your numerous friends and colleagues from around the world, please accept the 1996 George P. Woollard Award for your outstanding scientific contributions.

Response by NIKOLAS I. CHRISTENSEN

Thank you, Walter, for the splendid citation. I am sincerely grateful to the Selection Committee, the Geophysics Division, and the Geological Society of America for honoring me with this award. The names on the list of previous Woollard awardees are most impressive, and I am deeply honored to join them.

It is a particular pleasure to receive an award that recognizes George Woollard, who had a major influence on my professional career. This career was opened to me by George in 1955 when I entered the University of Wisconsin as a freshman and he was assigned as my undergraduate advisor. In the following year I enrolled in Geology 159, a geophysics course taught by George. I clearly recall the unique sense of enthusiasm for understanding the earth, which George passed on to his students. I learned from George about the importance of the interdisciplinary nature of geophysics. He was one of the first professors to teach me an appreciation for the use of quantitative approaches in solving geologic problems.

As an undergraduate student at Wisconsin, I was fortunate to take additional geophysics courses, which were taught at the time by two young faculty members, John Steinhart and Bob Meyer. Upon entering graduate school, I elected to continue at the University of Wisconsin and pursue a Ph.D. in metamorphic petrology, and at the same time maintain close ties with my interest in geophysics by minoring in physics. During my last semester as a graduate student, George called me into his office and suggested that my interests in petrology and geophysics could nicely lead to a research career in rock physics. When I expressed interest, I remember George immediately lifting his phone and calling Francis Birch to arrange for me to travel to Cambridge to interview for a postdoctoral position at Harvard.

I have fond memories of discussing research with George at meetings and of visiting him at the Hawaii Institute of Geophysics. During his career, he never lost a bit of his enthusiasm for science or his knack of passing on this enthusiasm to colleagues and students.

I have been very fortunate to be at the right place at the right time. I joined Francis Birch's group at Harvard in 1963 to study seismic anisotropy of lower crustal metamorphic rocks and mantle peridotites. Little did I realize then how important anisotropy would become in future seismological research. The late 60s and 70s were exciting times because of the many major discoveries in plate tectonics. During this marvelous period in the earth sciences, my main interests turned toward oceanic crustal and upper mantle studies. We learned much about the oceanic crust by studying rocks from dredge hauls, the Deep Sea Drilling Program, and ophiolite complexes. Thanks to NSF and ONR funding, I was able to launch field programs to study ophiolites in Cyprus, Oman, Newfoundland, and New Zealand, and to participate in major drilling programs in Iceland and Cyprus. Our finding that ophiolite peridotite anisotropies match marine refraction anisotropy observations in both magnitude and direction convinced me that oceanic crust and upper mantle is indeed exposed on Earth's surface.

Our laboratory studies have also focused on many continental problems, including the origins of fault-zone and deep crustal reflections, lower crustal composition, the origin of crustal low-velocity zones, crustal anisotropy, and the influence of pore pressure on seismic velocities. These studies have been stimulated by tremendous advances by the seismology communities over the past two decades and have also been accompanied by field work in such geologic paradises as Alaska, British Columbia, and New Zealand. To quote Bob Hope, "I almost have been to as many places as my luggage."

I believe the key to successful experimental work is directing the measurements to meaningful geological and geophysical problems. In this regard there is certainly a great deal of important experimental rock geophysics to be done in the future. We are still largely in the preliminary stages of understanding Earth's lithosphere.

Few scientists reach the point of receiving awards because of their own unaided research efforts, and I owe a great deal to a large number of colleagues and former teachers, including George Woollard, Francis Birch, Bob Gates, Con Emmons, Peter Misch, Randy Gresens, Brian Lewis, Herb Wang, Bill Hinze, and Walter Mooney. Success in any endeavor is largely a matter of associating with very good people.

This award recognizes my wife, son, and daughter. Special thanks also go to my parents for their love, encouragement, and support.

I have been preoccupied for all of my career with teaching and have been fortunate to have been associated with an outstanding group of graduate students, to date numbering almost 30. Working with them has been the most rewarding aspect of my career. Much of my published research has been the result of joint work with students, and they also deserve credit for this award. I hope that I have passed on to them some of the enthusiasm for geophysical research that George Woollard bestowed upon me.

I thank you most sincerely for this honor.

HISTORY OF GEOLOGY AWARD
presented to

GORDON L. HERRIES DAVIES

Citation by URSULA B. MARVIN

I feel that I first “met” Gordon Davies one evening in the early 1970s when I came upon a book called *The Earth in Decay* in one of the 27 bookstores scattered about Harvard Square. I picked it up, leafed through it, and found I could scarcely put it down. Page after page captured my interest. Familiar figures from the distant past sprang into view and were placed squarely within the context of their times. The book radiated authority of the sort one can depend on in one’s own writing and teaching, but above all I realized I could hear a person talking—spinning the history of 300 years of British geomorphology, from 1578 to 1878, in his own, personal voice. It was the voice of a fair-minded, affable, thoroughly knowledgeable observer.

Needless to say, I bought the book and read it into the late hours of that very night. Since then, I have referred to it again and again, either to review Gordon’s views on the evolution of geological ideas or to search out background materials for the light they might throw on the works of contemporary figures in other fields. I finally met Gordon in person in 1975 at the Charles Lyell Centennial Symposium held by the International Commission on the History of Geology (INHIGEO) in England and Scotland. Once I had identified Gordon by his name tag, I introduced myself and told him how much I had enjoyed his book. With his natural cordiality, we soon became good friends and had long, enjoyable talks during the rest of the meeting.

Two years later, when my husband and I decided it was time to visit Ireland on our way to England, Gordon conducted us on a grand tour of Trinity College in Dublin, with its great library where a page is always open for viewing of the matchless *Book of Kells.* He then sat us down in his office to look at topographic maps. Gordon outlined a route for us, roughly counterclockwise around the republic, that would enable us to take in the historic, prehistoric, and geomorphologic wonders of Ireland that we especially wished to see. We could not have had better guidance—short of persuading Gordon to come along with us, which we failed to do.

On that visit I learned that, despite his positions as a Fellow of Trinity College and as the full member of INHIGEO from Ireland, Gordon is not Irish. He was born in England, near Manchester, to a mother trained as a musician and a father who presided over the family’s household-furnishings business while maintaining interests in geology, the history of the Middle Ages, and a hobby of building models of 18th-century men-o’-war. In such a home, Gordon developed abiding interests in geology and the historical approach to things. He also began to feel a yearning toward the sea, which intensified during boyhood visits with his grandmother, Edith Herries, whom he describes as a true Victorian lady with a keen intellect and a fascination with ships and the sea.

When Gordon was 13 years old, his father brought home a copy of Arthur Holmes’s *Principles of Physical Geology,* and he and Gordon read it avidly. This seemingly casual event sparked Gordon’s lifelong interest in geomorphology. He keeps that well-worn book on his desk to this day. Nevertheless, at 14 years of age, Gordon resolved to follow a seafaring career, an ambition he nourished for three years before yielding it up—not, he remarks, without regrets that still linger. For our part we can only rejoice that he made this decision, else he might have been forever lost from the company of historians of geology.

When the time came for him to enter a university, Gordon chose the Honors School of Geography at Manchester, thinking that he would learn more about geomorphology in a Department of Geography than he would in a Department of Geology. He found the courses to be disappointing, but he remained at Manchester until he earned his B.A. and M.A. degrees in geography. While there, he opted to take a postgraduate seminar that met at 9 o’clock on Monday mornings. This was his first formal encounter with the history and philosophy of science, and he found it fascinating. Others were not so enthusiastic; after the first six weeks of assembling at that unpopular hour, Gordon was the only survivor of the nine students who had begun the course.

In 1954, Gordon crossed the Irish Sea to accept the post of assistant lecturer in geography at Trinity College in the University of Dublin. He declares that his scholarly career really started at the moment he arrived in Dublin. With complete freedom to pursue whatever research problems took his fancy, and with full access to that magnificent library, Gordon adopted Trinity College as his true alma mater. After three years, he acquired a second M.A. degree, from Trinity, and an appointment as lecturer in geography.

By 1959, Gordon felt it was time to begin a book on the history of geomorphology. He thought he could do it on the side—-while carrying on a full program of work on the geomorphology of southeastern Ireland. But things did not work out that way. Nine years passed between the time he sketched an outline for his book and the publication of *The Earth in Decay.* Meanwhile, he published his first papers on history of earth science, served three years as president of the Geographical Society of Ireland, earned his Ph.D. degree from the University of Dublin with a dissertation on the history of British geomorphology from 1578 to 1797, and was elected a Fellow of Trinity College.

In 1964, Gordon became a TV and radio personality, presenting a series of commentaries on geological subjects. With one year off, he continued his appearances until 1973, becoming a popular source of scientific information on the U.S. Apollo missions to the Moon.

In 1967–1968, Gordon spent his sabbatical year as a visiting professor in the University of Oregon at Eugene, where he gave his first full course on the history of earth sciences. There, he encountered the stupendous geomorphology of the great American West and fully understood for the first time why the central focus of geomorphology shifted from Europe to America after that region was opened, toward the end of the 19th century. Gordon also discovered, to his astonishment, that students and faculty at Eugene thought nothing of driving 100 miles to the university at Portland for afternoon tea—a distance almost equal to the width of Ireland. No one ever drives from Dublin to Galway for tea.

On his return home, Gordon began ten years of service as editor of *Irish Geography* and completed *The Earth in Decay.* The book proved to be the definitive volume on the history of British geomorphology and its role in the development of geomorphological ideas throughout Europe. It sold out very quickly, and today booksellers report long waiting lists for copies, which, when found, bring high prices. I feel very fortunate to have bought mine early. For the past 20 years, Gordon has been collecting material for a second edition (or, more likely, a new version), but he has none in press at the moment.

During the 1970s, Gordon was appointed an associate professor of geography at Trinity College, elected to INHIGEO as the full member from Ireland, and as a member of the Royal Irish Academy. He began twenty years of service on the editorial board of *Annals of Science,* coauthored *Ireland,* a volume in the series The Geomorphology of the British Isles, and coconvened a symposium commemorating the life and work of Richard Griffith, whom many call "the father of Irish geology." The symposium resulted in a volume of essays, *Richard Griffith 1784–1878.*

In 1977, Gordon added Herries, his mother's maiden name, to his own in an effort to avoid confusion with Gordon Davies, a newly appointed professor of modern history at Trinity College. Perhaps this simplified things at Trinity, but it caused near havoc among librarians, bibliographers, and friends. Most of us, at some time or other, have suffered a bad moment wondering whether Gordon L. Davies and Gordon L. Herries Davies are the same man.

In the 1980s, Gordon published *Sheets of Many Colors: The Mapping of Ireland's Rocks, 1750–1890,* a fascinating account of 18th and 19th-century approaches to geologic mapping. He also founded and chaired the Irish National Committee for the History and Philosophy of Science, chaired a joint committee of the Royal Dublin Society and the Royal Irish Academy on Historic Scientific Instruments, and accepted a position as general editor of a proposed multivolume *Dictionary of Irish Biography.* Gordon got the project started but resigned a few years later, in part because he could not prevail upon the Royal Irish Society to publish the dictionary as a CD-ROM.

In 1988, Gordon took early retirement to devote himself wholeheartedly to writing on the history of earth science. In search of a tranquil ambiance, he moved with Dr. Jean Archer, his companion of 18 years, to a property in the Tipperary countryside that includes their house, built in 1703, the ruins of an Anglo-Norman castle (ca. 1190), a Great Hall (ca. 1300) and an Elizabethan house (ca. 1500).

Although he can and sometimes does use a typewriter, and fully appreciates CD-ROM, Gordon still writes his books and papers with a fountain pen—a technique which surely demands a greater focusing of attention on composition than is attained by any of us who blithely write and delete and cut and paste on our word processors.

Gordon's most recent book, *North from the Hook: 150 Years of the Geological Survey of Ireland,* appeared last year in recognition of the Ireland Survey's sesquicentennial year. A friend of mine at the University of Galway wrote, "Beautifully produced, excellent illustrations, but above all written in Gordon's mellow, warm and inimitable style that leads the reader on seeking more. This is an international classic."

Many of us on both sides of the Atlantic share a great appreciation for Gordon's distinguished career. Earlier this year, the Geological Society of London presented him with its Sue Tyler Friedman Medal for his work on the history of geology.

Mr. Chairman, I am honored to present Gordon L. Herries Davies for the History of Geology Award of the Geological Society of America.

Response by GORDON L. HERRIES DAVIES

The History Division has done me a great honor. You have placed me in the distinguished company of those notable figures who have been the previous recipients of this award. I can only be profoundly moved and deeply grateful. To my friend Ursula Marvin, I must express a very special debt of appreciation. I was delighted at the news that she was to be responsible for my citation, and I have just listened to her eloquent words with pleasure, if also with some modest embarrassment.

In August 1975, I attended the memorable Sir Charles Lyell Centenary Symposium held, in part, in Edinburgh. There, one morning, I became the focus for a little incident which, ever since, has been influential with me. During the course of a visit to the Upper Library, in Robert Adam's Old College, I was approached by four American members of the party. "We are all familiar with your recently published *Earth In Decay,"* observed their spokesman, "but having now met you, we wish to report that in reality we find you to be entirely different from the author we had shaped in our imagination." I was startled!

Ever since, I have striven to ensure that in my writing I did reveal what I hoped was the real me. In particular, I have sought to indicate that alongside my interest in the history of the earth sciences, I have an abiding passion for books, for the Victorians, for places as the scene of historical events, and for ships and the sea. That little incident in Edinburgh more than 20 years ago becomes now my excuse for a few moments of introspection.

In my teaching and my writing, I have so often confidently explained why this or that geologist thought as he did. I have explained how James Hutton's deism and the denudation dilemma led him to his Theory of the Earth. I have accounted for Charles Lyell's devotion to the marine erosion theory of topography. I have pretended to understand the pivotal significance of Richard Griffith's remarkable geologic map of Ireland in its author's nonagenarian life. I have traced what I supposed to be the formative influences bearing upon J. B. Jukes's seminal paper of 1862 on the rivers of southern Ireland. But to unravel the influences that have shaped one's own thought seems to be a far more daunting task.

At the Awards Ceremony on Monday evening I sat feeling as must an orphan when other children speak of their parents. I heard distinguished geologists express gratitude to their former teachers for scientific inspiration, and to their one-time supervisors for academic guidance. When I entered into the history of the earth sciences I was unaccompanied. I possessed no guardian angel. Jukes ever referred to Adam Sedgwick, his Cambridge professor, as "my father in geology." No such paternal figure lurks in my own intellectual story.

I had published my earliest historical paper before I discovered that Victor Eyles, Joan Eyles, and John Challinor had for long been at work within my newly discovered historical garden. They made me most welcome, as, on this side of the Atlantic, did George White and Albert Carozzi when I visited them in Urbana, Illinois, during the fall of 1968. But there was no escaping the fact that our garden was then but thinly populated. In those days we never dreamed that this noble Society would come to possess a History of Geology Division, that the world's senior geological society would add to its numismatic treasures a medal awarded for contributions to the history of our science, or that there would be founded an international society and journal expressly devoted to studies in the development of the earth sciences.

Turning from negative facts to positive influences, I come to an impress which has shaped every facet of my life—the impress of Trinity College, the University of Dublin. As Ursula has explained, I had the good fortune to be appointed to the faculty of the college in 1954, and in three ways the college subsequently molded my intellectual career.

First, within Trinity College I am surrounded by distinguished ghostly figures from the past. That famed chronologer, James Ussher, was one of the first students admitted to the college when it opened its doors for the first time in 1593. Across the square from my own department lie the chambers where lived William Smith, "the father of English geology," when he was in Dublin in 1835 to enjoy that year's meeting of the British Association and to receive from the university the sole academic honor ever conferred upon him. His nephew, John Phillips, was our first professor of geology, and in our Museum Building are the rooms where, before the Geological Society of Dublin, Jukes first outlined his views on the southern Irish rivers, and where John Joly reflected upon the age of the earth and conducted his experiments with radioactive minerals.

Second, I have had at my disposal the magnificent library that since 1801 has enjoyed the privilege of receiving a copy of every volume published within the British Isles. Our copy of Nathanael Carpenter's *Geography Delineated Forth in Two Bookes* is a presentation volume from the author to Ussher. Our copy of the 1912 translation of Georgius Agricola's *De Re Metallica* is signed by U.S. President Herbert Clark Hoover. It has been a thrill to find myself repeatedly handling such works.

Finally, the college has allowed me the freedom to follow the gleam of my research interest wheresoever it might lead. A geomorphologist and geographer has been left free to devote himself to explorations in the history, philosophy, and sociology of science. Within my university we have a tradition of such intellectual liberty. It is a liberty for which I have always been profoundly grateful.

There is upon me one other very positive influence to which I must allude—the influence of the American West. The West is my second home. It is a portion of Earth's surface with which I enjoy a very special relationship. To come to the American West to receive this award is a doubly satisfying experience. To find myself, as I did upon my arrival in Denver, again looking out over the Great Plains toward the snow-capped Rockies was sufficient to bring to my eyes the tears of a joyful and emotional reunion.

I first came to the West in 1967 when I accepted the offer of a visiting professorship in the University of Oregon at Eugene. At that time, I do confess, I was woefully ignorant of the West. For example, it was not until my crossing to New York en route for Eugene that, in the library of the liner *United States,* I made my first and sadly delayed acquaintance with Meriwether Lewis and William Clark. That ignorance I speedily sought to dispel. I visited as many of the glories of the West as I was able. From the Scablands of Washington to Organ Pipe Cactus National Mounument in Arizona, and from the Black Hills in the east to that "Incomparable Valley" in the west, I relished all those magnificent landscapes. The West, for any earth scientist, is at once both a superb laboratory and a breathtaking museum. Further than that, it offers a wealth of scenes associated with some of the great American fathers in our science.

It was during the 1860s that geological writings emanating from the American West began to command attention within the British Isles. At that time there was a deep interest in geomorphology among British and Irish geologists. A debate was raging over the nature of the processes responsible for the shaping of Earth's topography. Three of the most active participants in the debate were three senior members of the staff of the Geological Survey of Ireland: Joseph Beete Jukes in Ireland, Andrew Crombie Ramsay in England, and Archibald Geikie in Scotland. Jukes died in a Dublin lunatic asylum in 1869 and Ramsay was in 1872 translated to administrative duties when he succeeded Sir Roderick Murchison as the Survey's director-general. That left Archibald Geikie to stand alone in the vestments of the high priest of British geomorphology.

In 1879 Geikie came to see the West for himself. He toured Colorado, Idaho, Utah, and Wyoming. He spent time with Clarence Edward Dutton. He met up with John Wesley Powell at Salt Lake City. He was vastly impressed by all he saw. He was excited—but he was saddened. He realized that the protracted debate over the nature of the processes responsible for shaping our continents would never have occurred had the West been discovered earlier. In the West—amidst landscapes uncomplicated by glaciation, vegetation, and human interference—there were instantly to be learned lessons which in Europe it had taken decades, if not centuries, to achieve.

Perceptive man that he was, Geikie recognized that the future of geomorphology must lie with American geologists. Ambitious man that he was, Geikie had no wish to play second fiddle under an American baton. The man who in 1865 had devoted a whole volume—a delightful volume—to an explanation of the landscapes of his native Scotland now turned his back upon geomorphology. The entire community of British geology, in ovine fashion, followed Geikie's lead. When geomorphology revived within the British Isles following World War I, that revival took place among geographers rather than among geologists. As Ursula has explained, my own origins were in a department of geography rather than in one of geology. Thus was my own career shaped by Geikie's experience of the American West at a time when Rutherford Birchard Hayes was the nineteenth President of the USA.

Archibald Geikie died eight years before my own nativity, but, in a way, I do regard myself as his posthumous intellectual son. It was his eloquent writings that in large measure inspired my own interest in the history of our science. It was while reading his account of Murchison's 1860 tour of the Scottish Highlands that, exactly 100 years later, the idea of writing a history of geomorphology first gripped my imagination.

Earlier this month I was in Edinburgh, the city of Geikie's birth, and for a few minutes I stood reverently outside Ramsay Lodge, the house just below the Castle Esplanade which from 1871 until 1878 was Geikie's home. There, with Auld Reekie expansed before me, I reflected upon Geikie planning his excursion to the American West and upon the manner in which that excursion and the American West itself had both had their bearing upon my own career.

That evening I addressed the Edinburgh Geological Society—a society with which Geikie was closely associated—and, following upon some kind remarks made by the president of the society, I made to the society a promise. I pledged that when, shortly, I appeared before the Geological Society of America in Denver to receive this honor, I would appear wearing the necktie that the Edinburgh society issued in 1984 to mark its sesquicentennial. That promise I have kept, and it only remains for me again to express to this division and to the Geological Society of America my heartfelt thanks for the distinction just conferred upon me. The island whence I come is small, and there are few of us living there. It is profoundly satisfying to find that my humble contributions to the history of our great science have not passed unnoticed by one of the most eminent scientific societies within this great land of yours.

O. E. MEINZER AWARD
presented to
JOHN L. WILSON

Citation by STEVEN GORELICK

There are few tasks I can approach with greater enthusiasm than presenting to John L. Wilson the 1996 O. E. Meinzer Award. On behalf of the Hydrogeology Division, I congratulate John, his lovely wife, Betty, and their brilliant daughters, Laurie and Megan.

I have had the good fortune to know John for almost 20 years and believe that he richly deserves this recognition. However, when he asked me to deliver this citation, I felt somewhat uncomfortable because in all honesty, I didn't know what a citation was. I discovered that it has two relevant definitions: first, a friendly introduction of one being honored with an award; second, a record of impending punishment associated with a violation of the law. With this clarification in hand, I regained comfort, for I adopted the second definition. Therefore, before getting into the substance of John's contributions, which the GSA has recognized with this Meinzer Award, I will take the opportunity to answer the question, "Who is John Wilson?"

On the professional side, John is a first-class researcher, outspoken scholar, and dedicated, enthusiastic educator. On the personal side, he is charming, generous, and a procrastinator. At meetings like this, as well as with his students, and on project review panels, he enjoys asking challenging questions and frequently provides pithy critiques of just about anybody's work (whether they wanted it or not).

John has been a professor since 1973, first at MIT and then New Mexico Tech, and until recently was director of the Hydrology Program at New Mexico Tech. John is best characterized by his former students. One such former student said, "You have to approach John like you would approach a stray dog. If you exude fear, you'll get bitten. If, on the other hand, you distract his attention with something of interest, he'll wag his tail and initiate play." Another student stated, "When I left Tech, my respect for John was wholly intact, and my admiration for his knowledge and patience unshakable. On the day I left Tech, he said something that made me stop dead in my tracks. John said, "See you in court some day."

On a serious note, John is a broadly based hydrogeologist who has provided insights into many, many problems. He was elected a Fellow of AGU, served as the 1992 Darcy Lecturer, and contributes actively in various professional organizations and on scientific panels. From the time I was a graduate student I always tracked down John at professional society meetings to discuss research problems and approaches. For years, I have seen him provide a wealth of great ideas and feedback to many hydrogeologists, not just his own students. John has a wonderful talent for putting people on track by making productive and thoughtful suggestions for their future research. I consider him to be among the most knowledgeable, engaging, and generous gentlemen scientists I have ever encountered. But, I did say that John is a procrastinator, didn't I? Well, in addition to last-minute lecture preparation, John doesn't always get around to publishing as much as he should, given the quantity of his ideas and numerous projects he has worked on. Along these lines, a number of years ago I was searching for a way to broach this matter with him and said, "John, you know how much I admire your work and generosity with ideas. Well, I never told you this, but did you realize that you have the highest ideas-to-publications ratio of anyone I know?" He gave me a funny look, not knowing exactly how I meant that. In his honor, I now propose the "Wilson Index" of ideas-to-publications as a new measure of creativity relative to procrastination, for which John Wilson scores a value of 100, or LWI (that's Log Wilson Index) value of 2.

Fortunately, for the hydrogeological community, John Wilson has taken the time to put into writing some very important contributions, four of which were recognized by his receipt of this year's Meinzer Award. The Meinzer Award is given to the author of a published paper or body of papers of distinction advancing the science of hydrogeology. John has been a pioneer in the area of visualization and study of pore-scale physical processes. His flow visualization work has provided insight into the migration of nonaqueous fluids and particles through porous media. Although one fine paper cited for this award was "Induced Infiltration in Aquifers with Ambient Flow," by John Wilson (Water Resources Research, v. 29, no. 10, 1993), three of the four papers cited by the Meinzer Award Committee cover his work in the area of flow visualization. The first is, "Visualization of Residual Organic Liquid Trapped in Aquifers," by S. H. Conrad, J. L. Wilson, W. R. Mason, and W. Peplinski (Water Resources Research, v. 29, no. 2, 1992).

In this work, etched-glass micromodels were used to inspect the dynamics of multiphase fluid displacement processes, with particular emphasis on residual organic liquid blobs trapped by capillary forces. In addition to introducing innovative visualization techniques and providing insight into the morphology of organic phases at the pore scale, Wilson helped make the expression "blob" a respected and commonly used term in the lexicon of contaminant hydrogeology.

The remaining papers are: "Micromodel Studies of Three-Fluid Porous Media Systems: Pore-scale Processes Relating to Capillary Pressure-Saturation Relationships," by W. E. Soll, M. A. Celia, and J. L Wilson (Water Resources Research, v. 29, no. 2, 1993) and "Visualization of the Role of the Gas-Water Interface on the Fate and Transport of Colloids in Porous Media," by J. Wan, and J. L. Wilson (Water Resources Research, v. 30, no. 1, 1994).

In these works, digital image analysis of micromodel flow behavior made it possible to study nonaqueous fluid migration as thin films. Furthermore, this research showed that a static gas-liquid interface serves as a surface onto which particulates, including colloids and bacteria, irreversibly sorb and are retarded. Unfortunately, and of great relevance to the community of alcohol-consuming hydrogeologists, Wilson and his co-authors neglected to state whether their conclusions apply to the gas-liquid interface in beer, ale, or stout.

To conclude this citation, I would like to make one more point. Beyond the papers cited specifically for this award, John Wilson has made many other significant contributions in the areas of flow and transport modeling as well as uncertainty analysis. Several of these works have served as steppingstones for research by many others and are frequently cited. It should be clear that our recognition on this day for his accomplishments is long overdue.

Please join me in congratulating John L. Wilson, recipient of the 1996 O. E. Meinzer Award.

Response by JOHN L. WILSON

Steve, thank you for those comments, and thanks to the Selection Committee—particularly Les Smith, to the Hydrogeology Division, and to the Geological Society of America. It is, of course, a pleasure and an honor to accept the O. E. Meinzer Award. It is an additional distinction, one that most of you would probably forgo, to give Steve the opportunity to apply my name to a new scientific term or index. There were warning signs. A couple of years ago it was Steve's turn to receive the Meinzer Award. Irwin Remson was the citationist. In his acceptance speech Steve recognized Irwin by describing a volume unit of measure known as the Remson. Defined by Ken Belitz of Dartmouth, it is "the quantity of water sufficient to kill one acre of broccoli."

I was originally trained as a fluid mechanician, and as a student in that field it was a dream to have my name attached to a dimensionless number. As you may know, the Froude number refers to the ratio of gravity forces to viscous forces in a fluid, while the Reynolds number refers to the ratio of inertial forces to viscous forces. We now have the Wilson number or index, the ratio of ideas to publications. I had hoped for something more consequential, but at least I am not responsible for killing vegetables.

The Meinzer Award is named after O. E. Meinzer, one of the fathers of modern hydrology. He and his peers built the foundation for much of the current work in hydrogeology, a fact we tend to overlook in our teaching, leaving our students largely ignorant of the past. This award honors him and, by extension, his peers, and reminds us of the importance of the history of our science. If you haven't read a historical paper recently, do it.

The citation for the Meinzer Award mentions four papers. Three of these papers, the ones on flow visualization, were co-authored with graduate students Steve Conrad, Wendy Soll, and Jiamin Wan, and constitute a portion of their theses. I will tell you something about each of them, but first a little story about the first paper.

In the years prior to my arrival at New Mexico Tech, my attention had been focused on the mathematical modeling of ground-water hydrology, the subject of the first paper. Halloween evening is just two days away; the idea for that paper was worked out on another Halloween evening. My wife, Betty, and daughters, Megan and Laurie, were out trick-or-treating, and I was left to confront the random groups of goblins and witches coming to the door. Between assaults on our candy supply, I developed a mathematical theory to describe how a well captures water from a nearby stream. I wrote up this theory, submitted it, and forgot about it. A few months later I received the reviewed manuscript. The reviewers suggested that the paper needed work, and it promptly went into the file cabinet. When I took it out, redid the theory (much better this time), and resubmitted it, Megan was in high school. I believe this behavior is consistent with my Wilson Index of 100.

Like many other mathematical modelers, in this and other studies I was attempting to improve hydrologic models by introducing additional mechanisms and processes. At this point let me quote from Vit Klemes (1988): "The problem was that most of these mechanisms were not well understood; nor were their interactions.… Thus the resulting models were concoctions of few facts and many artificial constructions, in which the individual processes are represented by postulated rather than by established mechanisms and interactions, and by assumptions arrived at by simplistic reasoning rather than by serious hydrologic research. In effect they are, for the most part, just complex assemblages of black, or at best, dark gray boxes." Vit was referring to models of surface runoff, but the comments apply to hydrologic models in general.

At Tech I became an experimentalist, returning to my fluid mechanics roots, where advances are made by the synthesis of experiment and theory. Steve Conrad and I started working together on multiphase flow issues of hydrologic importance and, with the encouragement of Norman Morrow, decided to examine these issues at the pore scale using micromodel flow visualization techniques. I became not only an experimentalist, but a microscopist. It was an exciting period, with lots of fresh ideas, and a great deal of fun for me. We were conducting what Sir Peter Medawar has called Baconian science. Look where no one has looked before and you may learn something new and important. Deeper understanding will follow with more traditional hypothesis tests.

Recently Dr. Conrad described to me the "Rule of Three" used by my students at the time. (I wonder whether this rule is just further evidence for my Wilson Index of 100.) Conrad explains that when I visited the lab I would frequently mention some new idea I wanted us to examine. Under his leadership the group ignored me. If the idea was good enough to warrant a second mention, some time later, that too was ignored. It was only when I mentioned the idea a third time that the group believed the idea was important enough to take seriously, and got to work on it. It must have been a useful filter, this rule of three, for the group produced plenty of good work.

Wendy Soll was a Ph.D. student at MIT who became familiar with this work and decided to make a two-week visit. Two weeks became two years, and Wendy still calls New Mexico home. Together with Mike Celia she had built a mathematical percolation network model of three-phase flow. It was among the first models to attempt to explain the interactive behavior of water, a gas, and a nonaqueous phase liquid in a porous media. In my lab we constructed micromodels mimicking her mathematics (did I get that backwards—a physical experiment mimicking an abstract model?) and discovered the importance of film flow in determining three-phase flow behavior. Wendy thought she would build a few micromodels and take them back to MIT. It was much harder than that, and she stayed. Or maybe it was the green chile.

Jiamin Wan was a geochemist looking for a change. When she joined my group, we both realized that the physics of multiphase flow was not her thing. About that time I had decided to start looking at colloid behavior experimentally, and Jiamin's chemistry background was perfect. We spent six months coming up to speed, and realized that to make an important contribution we would have to do something completely different. I remembered that mobile clay minerals had influenced some of the earlier multiphase flow experiments conducted by Steve Conrad and, later, Robert Mace. Jiamin and I decided to examine colloid behavior in the presence of two fluid phases, a surprisingly neglected topic. Most of her work was with a simple gas-water system, but it led to the identification of two forces acting on particles, including bacteria, at these interfaces. Capillary forces make it difficult to remove particles from the fluid-fluid interface; once attached they don't want to let go. But we also found a new, attractive structural force of particles to the gas-water interface, recently measured by atomic force microscopy. The result is that colloid behavior in the vadose zone and other multiphase flow situations is much different from what our mathematical models had previously assumed. It influences the assessment of nuclear waste repositories and the mobility of disease-carrying bacteria and viruses, and may even play a role in pedogenic processes. We would have learned none of this without Jiamin's very careful experimentation, for which I will be forever grateful.

There are many other students, colleagues (especially at MIT and New Mexico Tech), teachers, and family that I could and should thank. I cannot thank them all, so I have chosen a few representatives. I am especially proud of my former students. Among them is Lloyd Townley, with whom I learned a great deal about modeling and numerical methods. Among my teachers is Lynn Gelhar, who mentored me for years, and is responsible for bringing me into this field. He taught me many things, the most important of which is the value of persistent, critical thought. Among my valued colleagues is Fred Phillips, who has patiently listened to my confused thoughts, and through his criticism has helped me organize them. Most prominent is my family, especially my wife, Betty, who suffers the most from the effects of my Wilson Index, and my daughters, Megan and Laurie. I thank Betty for her support and good humor. She is universally acknowledged by former students as the glue that holds together not only our personal family, but also my academic family.

Let me finish by returning to the concept of scientific indices. I would like to introduce the Gorelick index, named after Steve. As you may know Steve is a gourmet. I remember ten days in Switzerland with him—wonderful, rich food, followed daily by mild indigestion. Imagine attending a conference with Steve. The Gorelick Index is the ratio of the number of gourmet meals to the number of conference days times 100, and it measures the culinary tastes of a scientific traveler. Steve scores a value of 100.

G. K. GILBERT AWARD
presented to
ROBERT P. SHARP

Citation by HUGH KIEFFER

Grove Karl Gilbert was an eminent field geologist with foresight into the field we now call planetary geology. This is also an apt description of Robert P. Sharp, the recipient we honor tonight. He shares with Gilbert a keen perception of nature and being a model and inspiration to many who follow. Bob Sharp was a young Californian at a time when Gilbert was concluding his long study of the American West. Bob gained an appreciation of nature roaming the Sierras as a youth and received a bachelor's degree in geology at Caltech. He then streaked through graduate school at Harvard, being, I am told, the only entering student who both had made maps and was well trained in chemistry and physics. Or perhaps I should say he flowed through graduate school, for, in 1937, he was invited to join a geology boat expedition through the Grand Canyon for study of the Archean rocks of the Inner Gorge. After the eminent senior geologists had divided the rocks amongst themselves for study, Bob decided to study what wasn't there, and produced the first, and perhaps most significant, paper of the expedition; a description of the major erosion surfaces. This eye for the important issues became a characteristic of his career.

Bob has had a long and productive relation with glaciers. When at his first academic post at the University of Illinois, he was invited to join an expedition into the Saint Elias Range along the Yukon-Alaska border. Bob has described the logistical challenge of the trip into the center of the Malaspina Glacier in terms that make it sound only slightly less severe than doing geology on Mars. During the war he served in the Army–Air Force Intelligence Unit on survival techniques. While he was stationed in the Aleutians, some visiting general said, "I don't believe all this stuff you guys write. Let's see how you do," and set Bob off alone on an uninhabited island with a minimal survival kit. Well, Bob survived just fine and made a geologic map of the island and published the results.

After the war, he taught for a few years at the University of Minnesota, and then joined the Division of Geology at Caltech, rekindling an association that has prospered ever since. Bob became chairman of the division five years later, a position in which he made impressive contributions to planetary geology.

Bob had begun his lifelong romance with the Pleistocene in graduate school. He became a geomorphologist, especially a glacial geomorphologist. Long a proponent of doing field work with minimal complications, he developed a rather precise technology of banging on the rocks in moraines with a hammer and listening to their sound to determine how long they had been subjected to weathering, thus dating the glaciation. He termed this method "isotone geochronology." He became enamored with this technique and convinced the Caltech administration to displace the established field of vertebrate paleontology with this new field of isotone geochronology. But, through a typographic error, the position announcement went out as isotope geochronology, and before Bob could correct this, the geochemists had arrived in abundance: Claire Patterson, Sam Epstein, Gerry Wasserburg, and the rest of the crowd. Never admitting to his mistake, Bob nurtured this group to world eminence, and planetary science has benefitted greatly ever since.

In the dawn of spacecraft exploration of the planets, Bob was asked to be the geologist for the Mariner 3 and 4 television experiment teams. Over the next 20 years, he was an author on more than 20 papers on the description and interpretation of the surface of Mars and the processes that have formed it. His trilogy in the *Journal of Geophysical Research* describing the Martian surface through analyses of Mariner 9 images is a benchmark of perception and foresight.

Bob has made major contributions as a leader and educator. He had a vision that the future of Earth's sciences needed to include planetary science, and he initiated the program in planetary geology at Caltech. He assembled and supported the talented faculty whose students, grandstudents, and great-grandstudents populate the discipline today.

The honorific recognitions of the magnitude and abundance of Bob's contribution are numerous. Bob was identified in 1950 as one of the ten outstanding college teachers in America. He is a Fellow of the GSA, of the American Geophysical Union, of the International Glaciological Society, and of the American Academy of Arts and Sciences. He received his first award from the GSA, the Kirk Bryan Award, in 1964, and the Penrose Medal in 1977. He is being honored by the Quaternary Geology and Geomorphology Division during this GSA meeting. He has been elected to the National Academy of Sciences. He has received both a distinguished Eagle Scout Award and the National Medal of Science. His vita does not mention that there are both a mountain and a glacier named for him in Antarctica, and an asteroid—appropriately, a Mars-crossing asteroid. Caltech has an endowed professorship in his name, of which he was the first occupant.

His field guides to the geology of southern California and to glaciers are wonderfully instructive, and I highly recommend them to you. In the latter, there is brief reference to a story of how Barclay Kamb defined a lengthy and unpronounceable Germanic term for the foliated ice in glaciers below the juncture of two ice falls, a term that ended with a sound something like a sneeze. Bob promptly called this the "Gesundheitstrasse," a term that has stuck ever since.

Bob is an inspiring teacher. His lectures get to the heart of the issue, and his style of presentation is very effective in getting ideas across to undergraduates and lay audiences. His introductory courses in geology were enormously popular (and contributed to my move from physics). His field trips are perennially oversubscribed, and faculty frequently want to go along; several faculty will now proudly state that they have been on as many as possible of the "Ring Cycle" of trips around southern California, Nevada, and Utah. Bob began the Pahoehoe week-long field trips, emphasizing volcanology, for graduating and graduate students, and he designed these to be instructive for, and attractive to, planetary geologists. These annual trips are now supported by a Swiss foundation. Bob continues to run these field trips, as well as very popular expeditions for alumni.

Bob's field trips are meticulously prepared and run. He will "dry run" trips, even if he has done them several times before. His field trips are run like atomic clockwork. If you are one minute late, you see the vans pulling out of the parking lot. I was late for one, and I had to drive 150 miles to catch up. I share this dubious distinction with people who later became the director of the Jet Propulsion Laboratory and the head of the National Academy of Sciences.

Bob sees Earth as a planet; the methods and interpretive methodologies developed by study of Earth are fundamental to planetary geology. What we see must be explained by a physically rational sequence of processes. Bob draws a rigorous distinction between description and interpretation, and he admonishes about the inappropriate use of genetic terminology.

Bob's teaching that keen observation of nature is the backbone of geology has been an inspiration to generations of students. Interactions with Bob continue to be educational, no matter how long one has been out of school. I cannot recall a conversation with him that was not provocative and entertaining in some way. Bob is an avid fly fisherman, and I include in my education his famous dictum, "If you want to catch a fish, you must think like a fish." This symbolizes his philosophy: If you wish to understand nature, you must not try to outguess her but try to understand her ways. Bob could properly be called "the Socrates of geology." I think this is an appellation that Gilbert would have vigorously endorsed, and he would surely approve of the recognition of Robert P. Sharp with the G. K. Gilbert Award.

Response by ROBERT P. SHARP

Thank you, Hugh, I scarcely recognize the fellow just described, but I do know that he pulls his field boots on one at a time, just like the rest of us. It is easier to be a respondent than a citationist. In the latter role you are constrained in what you can say about the awardee, but as a respondent you can say anything you please.

I have long regarded G. K. Gilbert as the greatest of all American geologists. It is good that the Planetary Geology Division honors his name; he richly deserves it. Gilbert entered planetary geology by a side door. During the Wheeler surveys in 1871 to 1874, he became well acquainted with explosion craters of the San Francisco volcanic field in north-central Arizona. In 1891 he visited and was fascinated by nearby Coon Butte (Meteor Crater), which is not surprising, since he had long been interested in astronomy and the possible influence of astrophysical phenomena on earthly features and environments.

Prevailing opinion in the late 1800s held that Coon Butte was a phreatomagmatic explosion crater. From Gilbert's detailed topographic mapping of the butte, study of lunar craters via the Naval Astronomical Observatory in Washington, raindrop imprints, and experiments with throwing clay pellets into a dish of clay, as well as other experiments, he concluded that the morphology of impact craters, rather than volcanic craters, matched the topography of Coon Butte. His primitive but extensive magnetic measurements, which failed to reveal any anomaly related to his impacting "star," unless it was buried 50 miles down, caused him to equivocate in his famed 1895 presidential address to the Geological Society of Washington. Subsequent recognition that the "star" was fragmented on impact and that the face of our moon was primarily the product of meteoroidal impacts, not volcanism, brought Gilbert the recognition he richly deserved. It was a seminal accomplishment. Nobel Laureate Harold Urey, upon arriving independently at the same conclusion years later, was thunderstruck when he learned that Gilbert had scooped him. He subsequently became a great admirer of Gilbert's work.

I do not normally think of myself as a planetary geologist. At heart and in practice I am an old-line field geologist. I got into the planetary geology game by a back door, but, as you see, with an impeccable precedent.

In the early 1960s, Bob Leighton, a Caltech physics professor, was commissioned by NASA to design and build a television camera, with the aid of NASA's Jet Propulsion Laboratory (JPL) in Pasadena. The camera was to fly on Mariner spacecrafts to Mars. Leighton realized a geologist would be useful in interpreting the photos, so he drafted Bruce Murray of the Caltech Geology Division to help. Recognizing that morphology would be involved, Murray persuaded me to join the project.

Mariners 3, 4, 6, 7, and 9 were all to go to Mars with cameras aboard—3, 4, 6, and 7 as flybys and 9 as an orbiter. Owing to shroud trouble, Mariner 3 never got out of Earth orbit, but Mariner 4 flew past Mars on July 14, 1965, and returned 16 useful pictures. The procedure was a bit like leaning out the window of a Greyhound bus and snapping a few shots of the passing scene.

Things were a little primitive in those days. Big radio antennae at Goldstone were not yet available to receive the digital data from Mariner 4, and it took eight hours to play back just one photo. Most of those first received looked like white postage stamps, but as the dark side of the planet was approached, shadows strengthened and things got better. Computer specialists at JPL did a marvelous job of making the photos legible, and in due time, it became obvious that the surface of Mars, with its many craters, was more lunar than earthly. Clyde Tombaugh, an astronomer from New Mexico, had speculated as far back as 1950 that the martian surface should be cratered. It must be a great feeling to have your speculations so dramatically confirmed.

Mariners 6 and 7 followed in 1969 and provided more photos of different parts of Mars, but again only in limited number and of modest resolution. Mariner 9, which orbited Mars in 1971–1972, revealed the varied character of the martian surface. By that time, interplanetary communication had improved so that photos were accessed in real time. This introduced national television and radio into the procedure. The Space Flight Operation Facility (SPOF) at JPL became a beehive of public interest, media presentations, and space-program promotion.

Some amusing and some awkward experiences resulted. I recall coming out of the SPOF building one evening after an open session to which favored local citizens had been invited. Mars was clearly visible low in the southern sky. A matronly lady, a visiting guest, was standing on the top step of the building, right arm raised, forefinger extended and moving in circles as she gazed at Mars. It was probably the first time she had realized that planets other than Earth rotated on their axes. It was an amusing and rewarding sight. Chalk one up for education.

In 1969, Mariner 7 was scheduled to arrive at Mars five days after Mariner 6. Mariner 6 had done its job, and the results were being digested when, mysteriously, contact with Mariner 7 was lost, putting everyone into a state of high tension. A large number of us were assembled in a JPL auditorium to iron out differences of opinions on the Mariner 6 photos. Bud Schurmeier, project director, was in the midst of a summarizing statement when out of an intercom that should have been turned off came a booming voice, "WELL HELLO, SWEETHEART, WHERE HAVE YOU BEEN?" This was not an operator greeting his long-absent girlfriend, but a joyful announcement that contact with Mariner 7 had been restored.

During the Mariner 9 orbiting mission, proceedings were regularly on national radio and television. These programs were spearheaded by Al Hibbs of the JPL staff, who did an admirable job at this sort of public relations. Frequently, he had one or two of the Mariner 9 team aboard to answer his questions or offer comments on incoming photos. One day Bob Leighton, our principal investigator, and I were on deck, each with a monitor to view the incoming photos. On came one showing a horrible mess of jumbled landforms, in retrospect probably chaotic terrain. Leighton studied it briefly and then turned to me, "Dr. Sharp, what does that look like to you?" I hadn't the foggiest idea what the mess was, so I replied, "Well, Bob, to be truthful, that looks like the insides of the radiator on my old car when I take the cap off and peer in." Many of you will recall how gunked up radiators got in the older days when filled mostly with plain water. Hibbs enjoyed my comment, but Leighton, a serious fellow, was less amused.

One night I was working in the inner sanctum at JPL during the Mariner 9 operation, when a technician monitoring incoming photos shouted with great excitement, "Hey, I've got a lake." A lake on Mars would indeed be top news, so I scurried over to view the photo. It showed a crater with a floor covered by gigantic sand dunes. Fortunately, a geologist saw it before the "lake" story got out to the public. Waves on that lake would have been hundreds of feet high and some Mariner 9 faces very red.

The media hype associated with the real-time operation of Mariner 9 was awkward, on occasion. Reporters wanted to know what was significant in a photo the moment it arrived. Your response was necessarily highly qualified. One day I came out of the JPL inner sanctum, from which the press was barred. A reporter I knew slightly grabbed me, shoved a microphone in my face and said, "Now, Dr. Sharp, what does all this mean to a guy drinking beer at a bar in Compton [a Los Angeles suburb]?" I babbled about how exploration of any kind, geographical or intellectual, was one of the more noble endeavors of the human race, and in the long run it brought benefits to all of us in unexpected ways.

I subsequently got involved, with colleague Mike Malin, in interpreting features shown on the splendid ground-level panoramas produced by the Viking landers in 1975. Upon studying those photos intently you develop an illusion you are actually sitting inside the lander peering out a porthole at the martian landscape. The view is exciting, but you ache to reach out and lift up just one of those rocks within arm's reach of the lander. It's an experience in frustration.

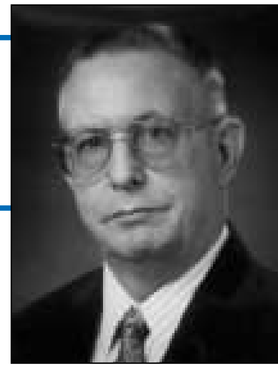
Much remote sensing is involved in planetary exploration, and speculations are abundant. People with open, imaginative, freewheeling minds are better remote sensors than those who demand hard, cold facts before reaching any conclusions. Carl Sagan, a member of the Mariner 9 team, had such a mind. The press liked him because he could produce a seemingly reasonable idea on the spur of the moment.

G. K. Gilbert was first and foremost a field geologist. Had I been a contemporary, I would have been honored just to carry his geological hammer in the field. I proudly accept this award as a token of recognition for my fellow field geologists the world over. I like to think it sends a message saying that in this modem world of computer modeling and sophisticated laboratory analyses, the elements of reality introduced by good field work are needed more than ever. It pleases me to imagine that GKG is sitting up there monitoring this occasion and its salute to good old-fashioned field work with a great big smile on his face. He was a field geologist to the core, one of our greatest.

KIRK BRYAN AWARD

presented to

ROGER T. SAUCIER



Citation by LAWSON M. SMITH

The Kirk Bryan Award of the Geological Society of America for 1996 is presented to Roger T. Saucier for his treatise *Geomorphology and Quaternary Geologic History of the Lower Mississippi Valley.* As with previous awards of this most significant recognition of geomorphologists and Quaternary geologists, I believe that Kirk Bryan would be proud of the research and the scientist that this year's honor recognizes. With the 1996 Kirk Bryan Award, we celebrate a major contribution to the understanding of a critical part of the Quaternary history of North America and a masterful synthesis of the life's work of a gifted and dedicated scientist. Like the classic document that it revises, Roger's monograph will be read and used by a wide range of scientists and engineers as the definitive reference on the Lower Mississippi River Valley and large alluvial rivers throughout the world.

Published in December 1994 by the Mississippi River Commission (MRC) of the U.S. Army Corps of Engineers, *Geomorphology and Quaternary Geologic History of the Lower Mississippi Valley* formally represents the revision of the monumental work of Harold Norman Fisk. Fisk's *Geological Investigation of the Alluvial Valley of the Lower Mississippi River,* was also published in December by the MRC—in 1944. Fisk's work pioneered the application of Quaternary geology and geomorphology to river engineering and the infancy of engineering geology while introducing many engineers to the importance of river valley evolution over geologic time scales. Roger's work over 36 years has demonstrated the criticality of integrating Quaternary geology and geomorphology to civil engineering and other sciences while critically appraising key Fiskian concepts in light of new information.

In the spring of 1992, senior engineers of the MRC decided that the time had come to begin the huge task of revising the almost sacrosanct epistle of H. N. Fisk. It was clear that Roger Saucier stood head, shoulders, and waist above all others working in the Lower Mississippi Valley in terms of qualifications to prepare the new document. Roger accepted the challenge to complete the synthesis in just two years (almost singlehanded) while continuing half-time as special assistant to the director of the Environmental Laboratory working on a myriad of projects far removed from the subject of this award. The resulting 364-page report and impressive folio of 28 color plates are testimony to Roger's ability to gather and analyze a broad spectrum of information to unravel a complex story and to his well-known tenacity to produce a first-rate product in an extremely timely manner.

The report begins with a succinct background of the history of geologic investigation in the Lower Mississippi Valley and discussion of the sources of data used in the investigation, emphasizing the wealth of relevant information developed over the past 50 years. True to Roger's practice of providing a careful and thoughtful introductory explanation, he outlines the purpose and style of the manuscript as a foundation for multidisciplinary application. A comprehensive but succinct introduction of the major geographic and physiographic settings of the Lower Mississippi River Valley (LMRV) follows, setting the stage for a detailed treatment of geologic processes and controls. Roger insightfully outlines the relevant histories of North American glaciation, climate, sea level, tectonics and diapirism, and subsidence in terms of their influence on the geomorphic development of the LMRV. The value of Roger's broad experience in large engineering and resource management projects is everywhere evident in this and the following section on the regional geologic framework, describing in detail the fundamental elements and interactions of the LMRV system while laying the groundwork for using this information in multidisciplinary studies.

Landscapes, landforms, and formational geomorphic processes of the LMRV are next presented in a manner that clearly defines a rationale for categorizing and describing the many features of a large alluvial valley and progradational deltaic plain. Roger uses aerial photographs and diagrams to lead the reader through the many depositional environments and landforms of the LMRV, including fluvial, lacustrine, eolian, deltaic, deltaic-marine, and "unusual" environments such as pimple mounds and sand blows. Of considerable value and interest to sedimentologists, stratigraphers, and geotechnical engineers is the formidable discussion of the lithology, soils, and geotechnical properties of the depositional environments of the LMRV. Roger summarizes the results of many, including his own, subsurface investigations in the LMRV, defining the state of knowledge of the stratigraphy.

Perhaps the most interesting and provocative section of the report describes the Quaternary stratigraphy and chronology of the LMRV, arguably the Fisk topic most in need of revision. Roger's comprehensive synthesis of information gleaned from his lifetime of careful study of LMRV chronology and the results of others provides a framework for integration of Quaternary interpretations of the valley with the Quaternary history of both the midcontinent and the Gulf of Mexico. The criticality of understanding the complex Quaternary response of the Lower Mississippi River to upstream glacial advance and retreat and sea-level fluctuation in the Gulf of Mexico is a central theme of this discussion, and Roger carefully weaves the connections.

Of particular importance to the timely topic of earthquake preparedness in the LMRV is the discussion of tectonics and neotectonism in the valley. The many geomorphic features of the valley which owe their origin to neotectonism are described, with implications to the profound natural hazards which they indicate. Roger Saucier closes the technical part of the report with a discussion of "special engineering considerations," the constant challenges of groundwater resources management, riverbank caving, landsliding, and river engineering in the LMRV. Roger saves the most intriguing part of the report for last—his presentation of worthy research questions for the many young scientists he has stimulated by his research.

The ribbon that ties this remarkable package together is the impressive folio of color plates (Volume Two). Contained in Volume Two are 14 maps, at a scale of 1:250,000, of the Quaternary deposits of the LMRV, a hypsometric map of the suballuvial surface, 1:250,000 structure-contour maps of the suballuvial surface, and a sequence of 13 paleogeographic reconstructions of key periods in the development of the valley, from approximately 2.5 million years to about 1000 years ago. Just as I was introduced to fluvial sedimentology and geomorphology 25 years ago by Fisk's impressive maps and diagrams, Roger's maps and illustrations will represent invaluable tools for teaching the complex evolution of alluvial systems to future earth scientists.

I have had the pleasure and immeasurable benefit of Roger Saucier's tutelage, collaboration, and friendship for 17 years at the Waterways Experiment Station (WES). His illustrious and respected career in the Environmental and Geotechnical Laboratories has set the standard for dedication and professional integrity for others to emulate. When Roger retired from WES after 32 years of federal service, his absence substantiated what many of his coworkers believed, that his presence measurably raised the quality and integrity of WES.

"Retirement" is not relevant to Roger Saucier. With his new-found freedom from entanglements in a wide range of environmental issues, Roger has immersed himself even deeper into the questions of the Quaternary history of the Lower Mississippi River Valley. As a meticulous and thorough researcher, he is in great demand as a consultant and now has time to devote to people who value his insight and productivity. At a time when many respected scientists wrap up their careers for the comfort of an easy chair and grandchildren, Roger is busier than ever. The document that we honor today is the culmination of the first 35 years of his career. I fully expect that the GSA will again have the opportunity to celebrate a monumental contribution of Roger Saucier.

Response by ROGER T. SAUCIER

Receiving the Kirk Bryan Award is truly an exceptional honor. I am deeply humbled to join the ranks of such prestigious award winners! I especially thank Lawson Smith not just for his many kind remarks, but for providing liaison and management of the project that led to the manuscript, giving me a lot of counsel and moral support, and nominating me for this award. I also thank Whitney Autin and Stan Schumm for their nominations and support, the members of the panel, and the division officers. I fully realize that winning an award of this type is to a large extent a matter of the quality of the competition, and where in GSA could it be any higher than in the Quaternary Geology and Geomorphology Division? I thank the management of the U.S. Army Corps of Engineers Mississippi River Commission for recognizing the need for an updated geological synthesis and finding scarce overhead dollars to support the effort for two years, and to pay for the considerable publication costs. Finally, I extend my appreciation to the Waterways Experiment Station management for allowing me to rearrange my work schedule so I could devote half my time to the effort over a two-year period. Needless to say, I was also blessed by having access to extraordinary resources in editing, design, data management, and graphic arts. Whitney Autin gladly accepted the role of principal technical reviewer and took his task *very* seriously. I think only the title page of the draft survived without serious comment.

When I first announced—now about four years ago—that I would be delaying my retirement to develop a 50-year update of Harold Fisk's 1944 classic on the Lower Mississippi Valley, two types of reactions were prevalent. Some said that this would be the chance of a lifetime. In hindsight, I heartily agree. Others said this would be a terrific way to end my career. I now believe those in the latter category were some of my more competitive colleagues who were only hoping this would be true. As Lawson said, however, I have found out that there *is* a life beyond the federal bureaucracy—indeed, a lucrative and *most enjoyable* life. While others relax or fish or hunt, I am thrilled to be able to devote 40 to 50 hours per week to field work, interpreting boring logs, studying aerial photos, writing reports, and presenting papers. But you'd better believe I still have time for the grandkids!

Lawson has covered in detail *what* is contained in my monograph and its significance, but let me express my view of what *I* believe is its most important message. In large measure, I accepted the challenge to write it to fulfill a moral obligation and to practice some self-discipline. I will get back to these points in a few minutes.

When I was a junior in high school, I became fascinated with archaeology and was finding and recording shell middens in south Louisiana. Soon I began wondering why they were located where they were, so I devised my own hand auger to explore subsurface stratigraphy, starting in my own back yard. About this time, I found out about the wonderful world of aerial photography and soon became a frequent visitor to the Corps of Engineers offices in New Orleans to beg and borrow whatever I could. Fortunately, there were some who were sympathetic to that pestering kid who came on a bicycle and who kept wanting to browse in their files. Of course I was not aware of it for years, but this was the beginning of my appreciation of the absolute dependency and symbiotic relationships among the disciplines of geomorphology, archaeology, and engineering in Quaternary studies in an alluvial and deltaic setting.

For the next two decades, I was extremely fortunate to be able to steer my career in that direction. I entered Louisiana State University, where I worked and studied under the renowned geomorphologist Richard Russell, cultural geographers Fred Kniffen and Bill McIntire, and archaeologist Bill Haag. They guided me through a tough but eminently rewarding curriculum in geography, anthropology, geology, botany, and agronomy. Even before I graduated, thanks to my friendship with geologist Charles Kolb, I set my sights on the Waterways Experiment Station as a place where I could pursue my career and my prime focus—*applied, interdisciplinary research* rather than basic research or teaching. I succeeded in landing a job in the Geology Branch.

Research in a mission-oriented government laboratory has its limitations. You work on what you are assigned to, and you can't apply for NSF or similar grants. Discretionary research funds are scarce, and generally you can't maintain a geographic focus or even a topical one. However, I soon found that the Corps of Engineers was highly receptive to innovative applied geomorphology and Quaternary studies, and I was able to propose, justify, and obtain funding for extensive basic mapping and investigations in the Mississippi Valley. Along the way, I developed an ever-deepening conviction of the necessity for interdisciplinary studies and methodologies. For example, the geotechnical properties of deposits cannot be understood without a knowledge of geosols and weathering processes. The distribution and character of depositional environments cannot be predicted without an understanding of Quaternary history and chronology. Buried horizons cannot be identified and traced without an appreciation of their geotechnical properties. Archaeological site distribution cannot be understood without a knowledge of fluvial processes. Holocene meander-belt chronological models cannot be developed without a knowledge of prehistoric settlement patterns. And I could go on and on!

After about 15 years in this world, something of a digression occurred. In hopes of advancing in the federal service, I opted to become a program manager—a *manager* rather than a scientist. I spent another 15+ years in this career. Although my attention was diverted away from the Mississippi Valley, I did have an opportunity to direct some exciting multidisciplinary research in the environmental sciences. In hindsight, however, I realize now how frightfully close I came to becoming a true bureaucrat. What kept me sane was an ability to say yes to an ever-increasing amount of interdisciplinary consulting throughout the valley area.

Now let me explain what I meant when I said I feel I had an obligation to prepare the synthesis. As many of you know, I have been an outspoken, harsh critic of Fisk's 1944 geological summary. In fact, I am known in some circles as "the Fisk basher." I readily admit that I have gone to considerable lengths to demonstrate that his chronology is basically incorrect and some of his concepts are fundamentally wrong. But I have really been most outspoken not about him or what he wrote, but about how his work has been received and used. It is no overstatement to say that his 1944 report was a panacea to archaeologists struggling to devise cultural chronologies and has been held in reverence ever since. It first proved difficult and later impossible for me to stand aside and see outdated concepts and information being accepted and used over and over again without question. After all, this was the bible! It was even more frustrating to see sound archaeological evidence repeatedly being dismissed because it was inconsistent with what had become an obsolete geological model. Certainly, archaeologists could not be blamed. They were struggling to keep abreast of rapidly expanding knowledge in their own discipline. They could not monitor developments in other fields, especially when those developments were not widely published and readily accessible.

Early in my life, I was taught that criticism should be constructive, and ideally it should be done only when you can offer a better alternative. I realized that there was no acceptable alternative to Fisk's 1944 monograph, so I felt that I had an obligation to try to provide one. But what I needed next was self-discipline and a mandate. All my life, I have been the type of person constantly wanting to move on to new projects and new problems. I even surprised myself recently when I reviewed my résumé and found that I have conducted geomorphological studies of no less than 89 topics, areas, or sites in the Mississippi Valley area. Without question, it was time for me to pause to look back, to summarize and synthesize, and to make a holistic assessment of not just *these* project results, but a vastly expanded literature representing major advances in knowledge offered by hundreds of individuals. Fortunately, I was given the mandate by the Corps of Engineers and the resources to carry it out. New projects would just have to wait—and they did!

In addition to providing a wealth of data, much of it unpublished, on multiple aspects of the Quaternary of the Mississippi Valley, my monograph is a statement of my philosophy. It demonstrates how geomorphic processes, landscape evolution, landform development, and paleoenvironmental changes in a dynamic setting can *only* be understood through the most broadly interdisciplinary approach possible. At the same time, it also demonstrates how a similar approach is essential to an understanding of human adaptation to a dynamic environment, both in prehistoric times and today.

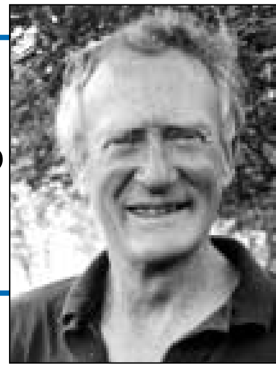
Eleven years ago, within a few blocks of where we are today, I was presented with the Roald Fryxell Award for Interdisciplinary Research by the Society for American Archaeology. You know, I'm getting to really like Denver! Until today, that award was the highest honor of my career. But the Kirk Bryan Award is much sweeter, because it comes from my colleagues and peers in my own professional field. Justifiably, this is a much more critical and demanding audience.

To me, just being a Quaternary scientist is a reward in itself. This is icing on the cake. I thank the GSA and all of you for this exceptional honor.

STRUCTURAL GEOLOGY AND TECTONICS DIVISION CAREER CONTRIBUTION AWARD

presented to

WIN MEANS



Citation by DECLAN G. DE PAOR

I think it is appropriate, in a peculiar way, that I have been asked to deliver this citation honoring Professor Winthrop D. Means with the 1996 Career Contribution Award. I am not a former student of Win's nor a co-PI on any of his research projects, nor a colleague from his days at Harvard, Cambridge, or Berkeley. We met at a conference in Rennes in 1982, I subsequently visited his lab at SUNY Albany, we wrote a paper together, and we stayed in touch, remaining good friends whilst vigorously contesting the relative merits of various off-axis Mohr circle conventions. And yet it feels as if Win was an undergraduate teacher and graduate advisor and external examiner and research collaborator of mine. I think I represent a good number of the structure and tectonics community when I say this; I'm sure a lot of you feel like continuing-education students of Win Means.

When I first became interested in structural geology during the 1970s, my lecturer recommended John Ramsay's book *Folding and Fracturing of Rocks,* suggesting that I read the text and skip over the equations, as he himself had done. However, as the 1980s approached and the content of journals such as *Tectonophysics* became increasingly quantitative, it soon became apparent that skipping the equations was not a viable option in the long term. When I needed to improve my understanding of the fundamentals of continuum mechanics theory and their ramifications for structural studies, it was to Means's book *Stress and Strain* that I turned. I can honestly say that reading it was a turning point for me. It made continuum mechanics interesting and relevant, and it illustrated the benefits of simplification over complexification. Again, I feel confident that I'm not the only one here today who might still be "skipping the equations" but for Win's tutelage.

What sets Win's teaching methods aside from the rest, I think, is that every concept is carefully developed and none is made to appear more complicated than it need be. Too many quantitative geologists attempt to impress their audience with a snow job that would make the average Albany winter storm seem pale by comparison. Some may succeed in impressing their bedazzled listeners, but mostly they merely cause their audience to dwindle. Those few structural geologists who actually enjoy working through pages of calculus or linear algebra know full well that there is as much junk published under the guise of quantitative science as there is in purely descriptive literature. Win's contributions stand in stark contrast to the majority; he has managed to attract students to his field through quantitative presentations on difficult topics without ever resorting to obfuscation. In Win's case, the snow is reserved for weekend recreation.

The application of continuum mechanics theory to structural geology is just one of Win's interests. Indeed, a journal editor (who shall remain nameless) offered me some advice on the preparation of this presentation. She said that she hoped I would not just talk about Win's Mohr circle work but would also emphasize his contribution to reviewing and editing. Actually, I needed no prompting—like most of you, I have noticed the frequency with which Win's help is acknowledged in the literature. It is unfortunate that the citation index lists only the publications referred to in a paper. If there were an index listing those whose critical reviews and helpful comments were acknowledged, you can be sure that Win's name would top the list in our field. Most of us groan at the sight of another manila envelope in our mailbox. Win, on the other hand, regards reviewing as a privilege—a great opportunity to study research results long before they appear in print and, in the case of research proposals, to influence the direction in which our science is headed.

Although he has published a lot of theoretical material and influenced theoretically minded students such as Richard Thiessen and Andy Bobyarchick, as well as visiting research associates such as Peter Cobbold, Subir Ghosh, and myself, Win would probably describe himself as an experimentalist, principally, and in this area his contributions have been quite remarkable. I defy anyone to name a competitor for the title of "Most Original Designer of Experiments." He and Janos Urai independently invented, and together developed, the study of rock analog materials in real time under the microscope, and his students, notably Mark Jessell, Youngdo Park, and Jin-Han Ree, along with postdoctoral fellow Janos Urai, have made this field flourish. It can hardly be mere chance that some of the brightest young researchers in the next generation of structural geologists have served their apprenticeship in the basement laboratory at Albany. Because they are spread so widely around the world, Win, your former students cannot all be here today to help you celebrate. However, Janos Urai (now on the faculty at Aachen, Germany) asked me to convey his warmest regards, and Mark Jessell (at Monash, Australia) said to congratulate you "for producing a generation of experimentalists with an organic chemical dependency."

The impact of these experiments has been enhanced by the widespread availability of the Means and Urai deformation rigs. Experimentalists tend to be empire builders, constantly seeking more laboratory space in which to house bigger and better megabuck machines. Most would like you to believe that they alone can perform their intricate experiments successfully. In contrast, Win has gone to great pains to design portable, inexpensive experimental equipment. Before laptop computers came into vogue, he was distributing cheap, palmtop deformation rigs to colleagues worldwide. Win's altruism is worthy of mention. I recall that when I interested him in commercial distribution of a compact disc containing images from his analog deformation experiments, Win insisted that the majority of the profits go to the GSA Foundation.

Most of you would probably not associate Win with field geology, yet he has that aspect of the discipline covered also. He carried out notable field studies whilst on the faculty of the University of Otago, New Zealand, trained field-oriented students such as Bruce Nisbet, Bill Gregg, Bill Bosworth, and Mark Swanson—students who went on to both fame and fortune—and is known for his memorable oral contributions to the many field trips in which he has participated. I well recall a trip on which several geologists, including Win and me, were engaged in a lively discussion on the best approach to the measurement of strain in the "conglomerate" at our feet. Win announced that, in his view, the rock was not a conglomerate at all, but rather that it contained fragments of bedding strongly transposed on a transecting cleavage. We all looked again and saw that he was right. Win once gave a GSA talk at a session where most speakers were trying to race through 45 slides, as usual. He showed only three and the third was the same as the first.

Win's combination of theoretical, experimental, and observational skills made him an ideal textbook author, and his famous *Outline of Structural Geology,* coauthored with Bruce Hobbs and Paul Williams, had a remarkably long run on the geological best-seller list. You might think that this much would be enough to keep any mere mortal fully occupied. However, during my time at Albany, I was struck by the calm, organized manner in which Win combined his research and teaching activities with the responsibilities of chairing his department and serving on innumerable panels and committees, while still leaving time for relaxed discussion and exercise. Win would be in the middle of a discourse on some obscure point of continuum mechanics theory when his watch would chime and he would head across campus for a game of racketball, returning an hour later to take up where he had left off.

It is not normal, on occasions such as this, to list a person's shortcomings in addition to his or her achievements. However, I must mention one of Win's failings: he has no real understanding of the value of his own work nor any appreciation of the importance of his community service contributions in our science. He may even try to tell you that he has not been terribly productive or that his interests have been esoteric. Pay no attention to him! Whether you judge his work, as a previous dean of mine might have, in citations per square foot of lab space per overhead dollar per fortnight, or by any other scale, Win's a winner.

Response by WIN MEANS

Thank you Declan, not only for the loan of the jacket, but for the nice citation.

I accept this award with the greatest pleasure. And I hope it will encourage the efforts of others like me, who do offbeat research, who publish rather little, and who think of publication as a kind of teaching—teaching in the global classroom (to put it grandiosely), where each of us is teacher and student, by turns.

Having pocketed the prize, let me now confess my lifelong weakness: my personal and scientific maturity has always lagged my chronological age by about 15 years. This means I entered Berkeley for graduate study at an effective age of 8. Berkeley wasn't doing much hand-holding then, so I emerged at age 12 only slightly improved, and not much influenced by any of the faculty there. Greg Davis wrote in our newsletter that he thought I might eventually "amount to something." I certainly didn't amount to much at Berkeley. But I did acquire some enforced independence of mind, and I served an apprenticeship in field work, under my own expert supervision. I mapped a small area in central Nevada, and succeeded in identifying a low-angle normal fault as a thrust fault. For this the Ph.D. was awarded in 1960. Perhaps the faculty thought: not bad for an unsupervised 12 year old. At least he didn't map the fault as a glacier.

Following this success, I left the country, and over the next decade and a half, met the people who really helped me most: five geologists, an atmospheric electrician, and a machinist. Let me tell you about each one.

Doug Coombs, at the University of Otago in New Zealand, showed me that writing is hard work. I had never been close to anyone writing a paper before. At age 13, I was astonished to notice Doug in his office, night after night, when I was going home, bent to the evidently hugely prolonged task of writing a paper, maybe only a section of a paper. Until then, I suppose I thought you finished some research, scribbled a few words down, and the rest of the paper would arrive by stork the next morning, in a blanket hung from his bill.

Mervyn Paterson, at the Australian National University, was my first shining example of a scientist using plain words and first principles. I must have been surrounded by such people before, but they just hadn't registered. Mervyn also demonstrated to me how an eminent experimentalist could run a big piston right through a small, expensive furnace, and demolish it. At age 16, I thought: If that's all it takes to do experiments, then why shouldn't I do some?

My horizons really leapt outward when Paul Williams came to Albany in 1970, and Bruce Hobbs joined us for a year in 1971. At age 23, I hadn't even dreamed of writing a book, but these two came bouncing in through the snow one morning and announced we were going to do a successor to Sherbon Hills's little text. I probably threw up sensible objections, but their confidence prevailed, and the book appeared in 1976. I remember how proud we were.

Besides entraining me in book writing, Paul opened my eyes at outcrops and through the microscope, and Bruce got me started on tensors. I salute these two friends and mentors, wherever they are. I remember in particular an inspiring moment with Bruce. He was lecturing Paul and Bruce Nisbet and me on deformation theory, and he started his lecture one day by telling us that everything he had explained the previous day was wrong. I learned from Bruce, as I had from Mervyn, the comforting lesson that people of great accomplishment can foul up, and also recover gracefully.

My other main geological mentor and friend has been Brian Bayly, at Rensselaer Polytechnic Institute just across the Hudson River. Brian picked up where Mervyn Paterson left off, and showed me again, repeatedly, what clear language and clear thinking are like. It is reductionist to the point where it becomes beautifully general. Brian has helped me greatly over the years, restraining my worst impulses and cultivating others. I have followed in his footsteps as much as anyone's.

Finally, I need to mention Bernard Vonnegut and Alton Hajeck. Soon after I arrived in Albany, at age 17, I was most impressed to see Vonnegut, the famous cloud physicist, using a conspicuously rough-hewn apparatus, made of wood and hardware cloth, to learn about thundercloud electrification. I always thought he was using a teakettle too, but he tells me now that the teakettle was for lunch, not science. What Bernie did for me was to encourage a bent I already had, to do experiments with simple but novel apparatus. For this I needed all kinds of small, metal rigs and jigs, and here's where Al Hajeck came in. For many years, Al produced a steady stream of beautifully made devices, including our two first rigs for squeezing crystalline materials in thin section. If I can eventually match Al's superb skill at work and his decency as a human being, I'll be content. You smile? You think it's impossible? Remember, I'm only 48. There's plenty of time yet, for improvement.

I haven't left much space for my students. Let me just say that I have enjoyed working with them, one and all, even though it has been hard sledding at times. I think of myself as being a teacher *mainly,* engrossed in the business of finding "the easy way up" for learners, and aware that their fresh eyes may help us see. Too bad for the students, of course, to have had such a late-bloomer as guide. But I suppose the academy has known greater evils than this.

My thanks again, to our division board and committee members, to my former Ph.D. student Jin-Han Ree (who came all the way from Korea for this event), and to you all.

Stealth Attack on Science in the 104th Congress

Tamara Nameroff,
1996–1997 GSA Congressional Science Fellow

Environmental science came under intense scrutiny in the last Congress. A series of hearings held by the House of Representatives Energy and Environment Subcommittee of the Committee on Science entitled "Scientific Integrity and the Public Trust" focused on alleged abuses of science in regard to stratospheric ozone depletion, global climate change, and health risks of dioxin exposure. The testimony and questioning at these hearings were analyzed by Rep. George E. Brown, Jr. (D—CA), the Ranking Minority Member on the Committee and long-time friend of science. In a recent report, "Environmental Science Under Siege: Fringe Science and the 104th Congress," he expressed his alarm at what he saw as an attack on the scientific method. Representative Brown's analysis suggested that these hearings outlined a new definition of "good science" for decision-makers. If this is accepted on Capitol Hill, potentially far-reaching and serious implications exist for the use of science in the public policy-making process.

Panelists who testified at these hearings were high-profile scientists who were highly skeptical of mainstream, peer-reviewed scientific literature. Most of these scientists work for political think tanks, rather than university or government laboratories. And unlike many scientists, who eschew involvement with the public, the panelists frequently publish their opinions, based on their interpretations of scientific data, in newspapers and political journals. Their message at the hearings was that science was distorted to promote an environmentalist agenda. Panelists alleged that scientists were in collusion with environmental regulators. As part of a sinister plot to perpetuate bureaucracies that fund scientific research, scientists would "exaggerate their certainty and consensus on environmental problems." Bureaucrats "could use these statements, with help from their environmental activist allies, to push through ever more stringent regulations and ever greater funding for the researchers." In effect, "scientists sold their integrity to the bureaucrats in exchange for steady funding."

The good news is that, according to Brown, no credible evidence was presented at these hearings that environmental scientists distorted the results of their research for their own political gain. But the hearings revealed a more distressing underlying theme: a deep distrust of the scientific enterprise and an absence of understanding about what science can and cannot do.

Most scientists likely would agree that peer review and the scientific method ensure the quality and integrity of science. In contrast, the hearings criticized these cornerstones of science and suggested that scientific "truth" was more likely to be found at the fringes of science rather than at the center. Representative Brown's report suggested that the skeptics who testified and the representatives who were sympathetic to their views appeared to believe that the skeptics' conclusions were correct simply because they were not popular in the scientific mainstream. One representative used the example of Galileo as a case in defense of skeptic scientists: Galileo bucked conventional wisdom to show that Earth was not the center of the universe. However, modern skeptics seem to have forgotten that Galileo used the scientific process, and not local editorial boards, to demonstrate that he was right. Skepticism certainly has its place in science, but like the jurisprudence axiom, "innocent until proven guilty," the burden must be on the challenger to show that the prevailing view is wrong. And of course, this cannot be accomplished unless challengers use the peer-reviewed scientific process to examine alternative hypotheses.

According to Brown, these hearings revealed an assumption that Congress could somehow sift the "truth" from legitimate scientific disagreements. As politicians generally are not trained to judge the merits of complex scientific research, a congressional "science court" is clearly untenable. For example, one key area of debate in the Environmental Protection Agency (EPA) Dioxin Reassessment was the EPA's assumption that dioxin has a linear dose-response on human health. However, Subcommittee Chairman Dana Rohrabacher (R—CA) expressed his frustration in trying to understand testimony on this critical issue: "I don't know how many people on this panel understand it or this committee understand it, but I am sure that it's an important question, and we need to make sure that people are on the record even on issues that the committee doesn't understand."

Another disturbing development at these hearings was the emphasis on empirical science to the exclusion of theoretical science. Many representatives equated "sound science" with observational data. This emphasis demonstrates that fundamental confusion about the nature of science exists on Capitol Hill. The classic scientific method involves making observations, developing and testing hypotheses, and establishing and refining a model to explain the hypotheses. The definition "good science = data" truncates the scientific method after the first step and renders meaningless efforts to create a broad understanding not only of environmental problems, but of research in any field.

The "Congress-as-science-court" model presumes that the scientific method is flawed because science rarely delivers an unequivocal answer. The subcommittee interpreted the witnesses' testimony as evidence that, as a result of scientific uncertainty, science has no constructive role in policy-making unless scientists are unanimous in agreement that a problem exists. Such a view undermines the use of science to build consensus on both domestic and international policies. It is reasonable to assert that scientific uncertainty creates the risk that any given regulatory response will be less than optimum. Although science can help to bound the discussion, it was never meant to determine the right policy choice. Policies are made by reference to values, not science.

The assumption that scientists are incapable of providing objective information to Congress has disturbing implications. In addition to casting serious doubt on the principle of scientific method, this assumption undermines the value of science in public policy. Scientists must vigorously defend the basic integrity of their community and the validity of the scientific method. Politicians need to hear that the time-tested process of peer review remains the best means of ensuring quality and objectivity on scientific issues. To remain silent suggests that scientists accept the paradigm introduced in the 104th Congress, and are willing to let politicians summarily dismiss the contributions of science to the policy-making process. ■

Tamara Nameroff, 1996–1997 GSA Congressional Science Fellow, serves on the staff of Senator Joseph Lieberman (CT). The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 1434-HQ-96-GR-02768. The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government or GSA. You can contact the author at Tamara_Nameroff@lieberman.senate.gov or get an update on other activities on the GSA Web site (http://www.geosociety.org/iee/felnews.htm). Representative Brown's report is on the Internet at http://www.house.gov/science_democrats/envrpt96.htm.

Valerie G. Brown, *Director of Development, GSA Foundation*

FROM THE GROUND UP

At the time of his recent death, astronomer Carl Sagan may have been among the best-known scientists in the universe. That disgruntled some of his colleagues, who criticized him for having become an icon of popular culture. Sagan himself was disgruntled by "the glorification of stupidity." In a lecture entitled "Is There Intelligent Life on Earth?" he articulated the paradox of a public thirsting for accessible information about science (as demonstrated by the phenomenal success of his own presentations) and an "establishment" of politicians, educators, and media who do not satisfy that thirst.

FACT: More than half of American adults do not understand that Earth orbits the sun.

FACT: More than 75% of American adults do not understand basic science and technology.

All American adults today live in a world increasingly shaped by the very sciences and technologies they do not understand. Who, then, is making the decisions that define the world of science and technology we are living in?

Responsible citizens must know something about science in order to participate in the policy decisions that determine the content and quality of their lives. Does it not follow that responsible scientists must do all they can to ensure a knowledgeable citizenry? Sagan thought that people who could grasp stock-market principles and sports statistics could also grasp the themes and import of astronomy. His body of work proved him right.

QUESTION: If astronomy, why not geology?

What's happening in the heavens is no less relevant to our welfare and interests than what's happening on our planet. GSA member John McPhee has proved the point in writings vividly describing the connections between the life of Earth and life on Earth. GSA itself, with the Institute for Environmental Education (IEE), seeks to contribute to what is generally known and understood about these connections.

IEE is founded in GSA's century-old reputation for integrity, quality, and objectivity in promoting geoscientific research and teaching. Its programs linking this resource to policy-making communities facilitates integration of sound scientific information into discussion and resolutions of environmental issues.

IEE maintains a database of more than 250 GSA members who are specialists in environmental geoscience and who volunteer to provide expert advice when needed. The U.S. Forest Service, the National Park Service, and the Council of Energy Resource Tribes are among the organizations that have called on this capability.

In response to the Congressionally mandated merger of the U.S. Geological Survey and the National Biological Service, IEE sponsored two highly successful workshops that brought together earth and life scientists representing academia and the public and private sectors. Their considerations of interdisciplinary opportunities have already had an impact on USGS program development.

The Roy Shlemon Applied Geology Mentors program brings outstanding geoscientists to GSA section meetings for one-day workshops on professional and intellectual applications of environmental and engineering geoscience. Topics presented by the 1996 mentors included geotechnical aspects of debris flows and the challenges of dealing with federal regulations.

These programs illustrate the creative value of gifts given by the many members and friends of GSA whose support of IEE helps us foster the glorification of understanding. ■

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Digging Up the Past

Most memorable early geologic experience: Descending into an abandoned Mexican gold mine via a notched log, then crawling along a drift so narrow, I had to remove the Brunton compass from my belt.

—Arthur Socolow

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Hutton-Lyell Bicentenary—1997–1998

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For the History of Geology Division of GSA

This year marks the bicentenary of one of geology's more curious coincidences, the death of James Hutton and the birth of Charles Lyell in 1797 only five months apart. Although history is riddled with similar coincidences, this one deserves special attention because claims have been made for each of these luminaries having been "the founder of modern geology." Is there any validity to such declarations? Should we even care? Some people think that both men were important enough that a special Hutton-Lyell Bicentenary Conference will be held in London (July 30–August 3) and in Edinburgh (August 5–9). Some similar activities are planned for North America during 1997–1998.

JAMES HUTTON (1726–1797)

James Hutton was born in Edinburgh, Scotland, the son of a successful merchant, who bequeathed him an inheritance that included two farms. To learn the most advanced agricultural practices, he first went to southeastern England, where he observed erosion and deposition by rivers and the sea. After a decade of farming, he relocated to Edinburgh to join the liveliest minds of the Scottish Enlightenment in debating such topics as medicine, botany, agriculture, meteorology, and chemistry. Hutton's interest in geology began in England where the evidence of decay of the land seemed in conflict with the conventional view of Nature as the perfect creation of an Infinite Wisdom for the benefit of humankind. It was the resolution of this philosophical paradox that motivated his development of a theory of the earth that would provide cyclic renovation as well as decay.

As geology students learn, Hutton called upon heat within the earth to create new, fertile land by elevation of the sedimentary refuse from the decay of former lands. Upheaval was accomplished by the forcible intrusion of granitic magma from deep in the earth. He believed that heat also caused the consolidation of strata. One consequence predicted from his theory was that there should be evidence of past upheavals and erosion of ancient landscapes. In 1787–1788 he confirmed his prediction by discovering three widely separated exposures of the angular unconformity at the base of the Old Red Sandstone. Of most profound importance was his reasoning by analogy from modern processes to explain ancient phenomena. From his assumption of a uniformity of processes throughout history, Hutton inferred that the earth must be unfathomably old and that "no vestige of a beginning, no prospect of an end" can be discerned in the rock record.

Hutton's dynamic theory of Earth's crust opposed the conventional Neptunian wisdom of a static crust upon which all rock types, including granite and basalt, had been deposited from a universal ocean. Besides the sheer novelty of his theory, Hutton's postulate of heat as the cause of consolidation of sediments, a strange theory of matter, and the unfathomable magnitude of Earth history implied by "peering into the deep abyss of time" were major obstacles to its acceptance. The two-volume 1795 version of *Theory of the Earth* best known today was written largely in response to criticisms, but Hutton's death prevented its completion; it was not until 100 years later that a third volume containing most of his empirical evidence was discovered and published by the Geological Society of London in 1899. The incompleteness of the 1795 publication and its rambling rhetorical style clouded the theory, and it was to address these shortcomings that John Playfair published a concise and eloquent *Illustrations of the Huttonian Theory of the Earth* (1802); it was from Playfair that most people, including Charles Lyell, gained access to Hutton's ideas.

Several recent writers have argued that Hutton's importance has been overstated. It is said that his ideas had little impact beyond Edinburgh and that the theory was a too-speculative throwback to 17th century system builders. Stephen Gould also stressed the anomaly that the discoverer of deep time showed little interest in geologic history and fossils. The mythical image of Hutton as hero and Abraham Werner as villain created by fellow Scot Archibald Geikie, in his 1897 *Founders of Geology* needed to be challenged, but the discovery and publication of Hutton's *Lost Drawings* in 1978 and recently discovered Hutton correspondence suggest that he was more inductive than revisionists have alleged.

CHARLES LYELL (1797–1875)

Charles Lyell was also of Scottish ancestry, but he lived mostly in or near London. His interest in geology was spawned by Robert Bakewell's *Introduction to Geology* and lectures by William Buckland at Oxford. His career as geological author was launched in 1828 when he resolved to abandon an unrewarding law practice and make his first trip to the extinct volcanoes of the Auvergne district of central France and then to southern Italy. Soon thereafter, the first of 12 editions of his epic *Principles of Geology* appeared (1830–1833). Lyell's flair for clear writing and broad synthesis illustrated with countless examples from all over the world made his books both financially and intellectually successful. The profound influence of the *Principles* upon young Charles Darwin helps support the frequent claim that it is the single most important book ever published on geology.

At Oxford, Lyell was disenchanted by Buckland's flamboyant style and his appeal to deluge geology. He made it a lifelong mission to "save the science from Moses" by insisting that the only valid method for understanding the history of Earth was by invoking only "presently acting causes" to explain all geologic phenomena. But Lyell's version of this uniformitarian method, as it soon came to be known, was more extreme than either his contemporaries or any modern scientist would accept; it was certainly more extreme than Hutton's, from which it was inherited with minimal acknowledgment. Lyell insisted not only upon the uniformity of *kinds* of processes, but also of their *rates* and *intensities* throughout time. Because of his stubborn insistence upon this untenable steady-state view and the

Hutton-Lyell *continued on p. 42*

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continued from p. 39

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When was the last time you hired a new employee? Did you waste time and effort in your search for a qualified geoscientist? Let the GSA computerized search file make your job easier. Simply fill out a one-page order form available from GSA—and the GSA computer will take it from there. You will receive a printout that includes applicants' names, addresses, phone numbers, areas of specialty, type of employment desired, degrees held, years of professional experience, and current employment status. Résumés for each applicant are also sent with each printout at no additional charge. For 1997, the cost of a printout of one or two specialty codes is $150. (For example, in a recent job search for an analyst of inorganic matter, the employer requested the specialty codes of geochemistry and petrology.) Each additional specialty is $50. A printout of the applicant listing in all specialties is available for $350. If you have any questions about your personalized computer search, GSA Membership Services will assist you. The GSA Employment Service is available year round; however, GSA also conducts the Employment Interview Service each fall in conjunction with the Society's Annual Meeting (this year in Salt Lake City, Utah, October 20–23). You may rent interview space in half-day increments, and GSA staff will schedule all interviews with applicants for you. In addition, GSA offers a message service, complete listing of applicants, copies of résumés at no additional charge, and a posting of all job openings. For additional information or to obtain an order form to purchase a printout, contact T. Michael Moreland, Manager, Membership Services, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, or E-mail: member@geosociety.org.

GSA ANNUAL MEETINGS

1997 *See the April issue for themes and symposia.*

Salt Lake City, Utah
October 20–23
Salt Palace Convention Center
Little America Hotel

Abstracts due: ***July 9***

General Chair:
M. Lee Allison,
Utah Geological Survey

Technical Program Chairs:
John Bartley, Erich Petersen,
University of Utah
Proposal Deadline was January 2.

Field Trip Chairs:
Bart Kowallis,
Brigham Young University
Paul Link, *Idaho State University*

Both technical program and field trip deadlines have passed.

1998

Toronto, Ontario, Canada, October 26–29
Metro Toronto Convention Centre
Sheraton Toronto Centre Hotel and Towers

General Chair: ***Jeffrey J. Fawcett,*** *University of Toronto*

Technical Program Chairs:
Denis M. Shaw, *McMaster University*
Andrew Miall, *University of Toronto*

Due date for symposia and theme proposals:
January 2, 1998

Call for Field Trip Proposals:
We are interested in proposals for single-day and multi-day field trips beginning or ending in Toronto, and dealing with all aspects of the geosciences. Please contact the Field Trip Chairs listed below.

Pierre Robin
University of Toronto
Dept. of Geology
22 Russell Street
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(416) 978-3022
fax 416-978-3938

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FOR INFORMATION ON ANY GSA MEETING CALL THE GSA MEETINGS DEPARTMENT
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E-mail: **meetings@geosociety.org** ***or see GSA's World Wide Web page at*** **http://www.geosociety.org**

FUTURE MEETINGS

1999 — Denver, Colorado .... October 25–28
2000 — Reno, Nevada .... November 13–16
2001 — Boston, Massachusetts .... November 5–8
2002 — Denver, Colorado .... October 28–31

CALENDAR

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

1997 Meetings

May

May 13–15, **Basin and Range Province Seismic Hazard Summit,** Approaches and Techniques for Seismic Hazard Characterization in Extensional Regions, Reno, Nevada. Information: Western States Seismic Policy Council, 121 Second St., 4th Floor, San Francisco, CA 94105, (415) 974-6435, fax 415-974-1747, wsspc@wsspc.org, http://www.wsspc.org.

June

June 1–6, **Canadian Society of Petroleum Geologists–Society for Sedimentary Geology (SEPM) Joint Convention,** Calgary, Alberta. Information: Jim P. Letourneau, letournj@hpcl.com, http://www.cspg.org/cspgsepm97/.

July–August

July 30–August 3, **Bicentennial Conference: Charles Lyell,** London, UK. Information: Geological Society, Burlington House, Piccadilly, London W1V 0JU, UK, phone 44-171-434-9944, fax 44-171-439-8975, conf@geolsoc.cityscape.co.uk.

August

August 5–9, **Bicentennial Conference: James Hutton,** Edinburgh, UK. Information: Royal Society of Edinburgh, 22-24 George St., Edinburgh EH2 2PQ, UK, phone 44-131-225-6057, fax 44-131-225-6277.

September

September 1–5, **Association of European Geological Societies 10th Meeting,** Challenges to Chemical Geology '97, Carlsbad, Czech Republic. Information: Vojtech Janousek, Czech Geological Survey, Klarov 3, 118 21 Prague 1, Czech Republic, 420-2-581-6620, fax 420-2-581-8748, janousek@cgu.cz, http://www.cgu.cz/maegs.htm.

September 3–4, **Alexandria University Third Conference on Geochemistry,** Alexandria, Egypt. Information: A. M. El Bouseily, Alexandria University, Faculty of Science, Geology Dept., Alexandria, Egypt, phone 20-3-492-1595, fax 20-3-491-1794.

October

October 20–23, **Geological Society of America Annual Meeting,** Salt Lake City, Utah. Information: Meetings Department, GSA, P.O. Box 9140, Boulder, CO 80301, 1-800-472-1988, (303) 447-2020, ext. 133, meetings@ geosociety.org, http://www.geosociety.org.

1998 Meetings

February

February 12–17, **AAAS Annual Meeting and Science Innovation Exposition,** Philadelphia, Pennsylvania. Information: AMSIE'98, American Association for the Advancement of Science, 1200 New York Ave., NW, Washington, DC 20005, (202)326-6450. *(Symposium proposals due April 1, 1997.)*

March

March 8–15, **Case Histories in Geotechnical Engineering Fourth International Conference,** St. Louis, Missouri. Information: Shamsher Prakash, 308 Civil Engineering, University of Missouri, Rolla, MO 65409-0030, (573)341-4489, fax 573-341-4729, prakash@novell.civil.umr.edu, http://www.umr.edu/~conted/conf8926.html.

March–April

March 30–April 3, **Ninth International Symposium on Water-Rock Interaction,** Taupo, New Zealand. Information: B. W. Robinson, Wairakei Research Ctr., IGNS, Private Bag 2000, Taupo, New Zealand, phone 64-7-374-8211, fax 64-7-374-8199, wri-9@gns.cri.nz, http://www.ruamoko.gns.cri.nz/wri-9.html.

April

April 14–18, **Geoscience 98,** Keele, UK. Information: Conference Dept., Geological Society, Burlington House, Piccadilly, Londfon W1V 0JU, UK, phone 44-171-434-9944, fax 44-171-439-8975, conf@geolsoc.cityscape.co.uk.

May

May 27–30, **7th International Conference on Ground-Penetrating Radar,** Lawrence, Kansas. Information: Richard Plumb, Radar Systems and Remote Sensing Laboratory, University of Kansas, 2291 Irving Hill Rd., Lawrence, KS 66045-2969, (913)864-7735, fax 913-864-7789, gpr98@rsl.ukans.edu, http://www.rsl.ukans.edu/~gpr98.

June–July

June 28–July 5, **Gondwana 10, Event Stratigraphy of Gondwana,** Rondebosch, South Africa. Information: Organising Committee—Gondwana 10, Dept. of Geological Sciences, University of Cape Town, Rondebosch 7700, South Africa, phone 27-21-650-3171 or 2925, fax 27-21-650 3167 or 3783, gondwana@geology.uct.ac.za, http://www.uct.ac.za/depts/cigc.

August

August 10–14, **International Mineralogical Association 17th General Meeting,** Toronto, Ontario. Information: Eva Schandl, Dept. of Geology, University of Toronto, Earth Sciences Ctr., 22 Russell St., Toronto, Ontario M5S 3B1, Canada, (416)978-7084, fax 416-978-3938, ima98@quartz.geology.utoronto.ca, http://www.geology.utoronto.can/IMA98.

August 17–20, **5th International Symposium on the Jurassic System,** Vancouver, British Columbia. Information: Paul L. Smith, Earth and Ocean Sciences, University of British Columbia, 6339 Stores Rd., Vancouver, B.C. V6T 1Z4, Canada, (604) 822-6456, fax 604- 822-6088, E-mail: psmith@eos.ubc.ca, http://www.eos.ubc.ca/jurassic/announce.htm.

September

September 10–20, **IGCP Project 367 Final Meeting and INQUA Shorelines and Neotectonics Commissions,** Corinth and Samos, Greece. Information: Stathis Stiros, Inst. of Geology and Mineral Exploration, 70 Mesoghion St., Athens 11527, Greece, phone 30-1-771-5522, fax 30-1-775-2211, stiros@prometheus.hol.gr; Paolo Antonio Pirazzoli, CNRS, URA 141-Lab de Geographie Physique, 1 Pl. Aristide Briand, 92190 Meudon-Bellevue, France, phone 33-1-4507-5558, fax 33-1-4507-5830, pirazzol@cnrs-bellevue.fr.

September 21–23, **Symposium on Epicontinental Triassic,** Halle, Germany. Information: G. H. Bachmann, G. Beutler, or H. Haubold, Inst. of Geosciences and Geiseltal Museum, Martin Luther University, Domstr. 5, D-06099 Halle/Saale, Germany, phone 49-345-55-26070. fax 49-345-55-27178.

September 21–25, **International Association of Engineering Geology 8th Congress:** A Global View from the Pacific Rim, Vancouver, British Columbia, Canada. Information: Kim Meidal, Secretariat, 8th Congress IAEG, c/o BC Hydro, 6911 Southpoint Dr., Burnaby, B.C., V3N 4X8, Canada, (604)528-2421, fax (604)528-2558, kim.meidal@bchydro.bc.ca; http://www.bchydro.bc.ca/bchydro/IAEG/IAEG98.html

Send notices of meetings of general interest, in format above, to Editor, GSA Today, P.O. Box 9140, Boulder, CO 80301, E-mail: editing@geosociety.org.

Hutton-Lyell *continued from p. 40*

subtleties of Victorian social structure, Lyell's system was by no means universally popular. In large part, his rigid position was a strategy to discredit all suggestions of directionality or progress in Earth history, including organic evolution. Besides unflagging appeals to "present causes," Lyell is also remembered for his ingenious technique for subdividing the Tertiary and for efforts to quantify changes.

Unlike Hutton, Lyell visited North America. Between 1841 and 1853, he and his wife crossed the Atlantic four times. Except for their last visit, he lectured and traveled widely to study the geology and people of two dynamic young nations. During 25 months of travel spanning a dozen years, the Lyells saw more of North America than had most of its citizens. His bibliography profited with two travel journals, more than 30 scientific articles, and countless American geological examples for his books. The Lyells formed a very positive attachment to North America and its people. Although at first there was tension with our geological community, which was hypersensitive about priority for ideas in the face of such an acquisitive and prolific English author, in the end relationships remained cordial. It is certainly not true, as was alleged years ago, that Lyell liberated American geology from the dark ages of Wernerian Neptunism. In fact, he was deeply impressed by both the quality and quantity of American research.

OBSERVANCE OF THE BICENTENARY

From July 30 through August 1, 1997, Lyell will be celebrated at the London Geological Society. Discussions will include: Life

Hutton-Lyell *continued on p. 43*

March *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
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Hutton-Lyell *continued from p. 42*

and Times of Lyell, Stratigraphy and Paleoenvironments, Regional Geology, Surface Processes and Climate, Active Tectonics, and Man and the Environment. Two excursions will take participants to places in southern England that were important to Lyell. From August 5 through 9, Hutton will be celebrated at the Royal Society of Edinburgh. Topics there, in addition to Hutton's theory, will include: Fluxes of the Earth, Kindling Fires in Little Crucibles, Catastrophism and Uniformitarianism, and Hutton, Lyell and our Dynamic Earth. There will be excursions to localities relevant to both Hutton and Lyell. At both cities, talks of a historical nature will be coupled with talks presenting the present and future impacts of the legacies of Hutton and Lyell. The talks will be invited, but a limited number of poster presentations may be accommodated. Information and registration forms can be obtained as follows: London—fax 44-171-439-8975; Edinburgh—fax 44-131-225-6277.

What about North American observance of this bicentenary? The 200th anniversary of Hutton's death was recognized with a GSA forum in New Orleans in 1995. The GSA History of Geology Division has been encouraging GSA sections and other regional societies to hold sessions or conduct field trips related to Hutton and Lyell. It is still not too late to plan something! Finally, a symposium on the legacies of Hutton and Lyell is planned for the 1998 GSA Annual Meeting, in Toronto. G. V. Middleton of McMaster University, Hamilton, Ontario, and Keith Tinkler of Brock University, St. Catherines, Ontario, are co-chairs for that event. ■

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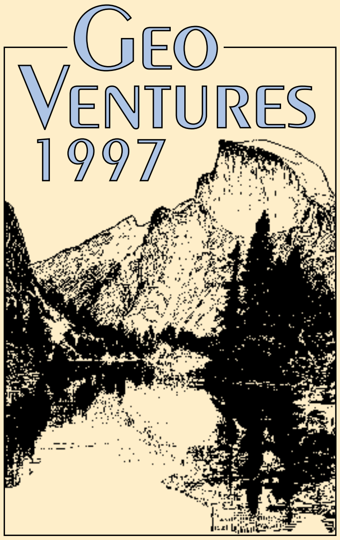
MARCH 1997



Full information appears in the December and January issues and on GSA's web page: http: //www.geosociety.org /meetings.

Field Trips with a Difference … for GSA Members and Friends

Space is going fast: the Yellowstone trip is sold out, Mount St. Helens has four spaces left, and the other three are filling quickly. Please get in touch with us soon if you are interested. Detailed information on itineraries, registration fees, and travel arrangements will be sent on request.

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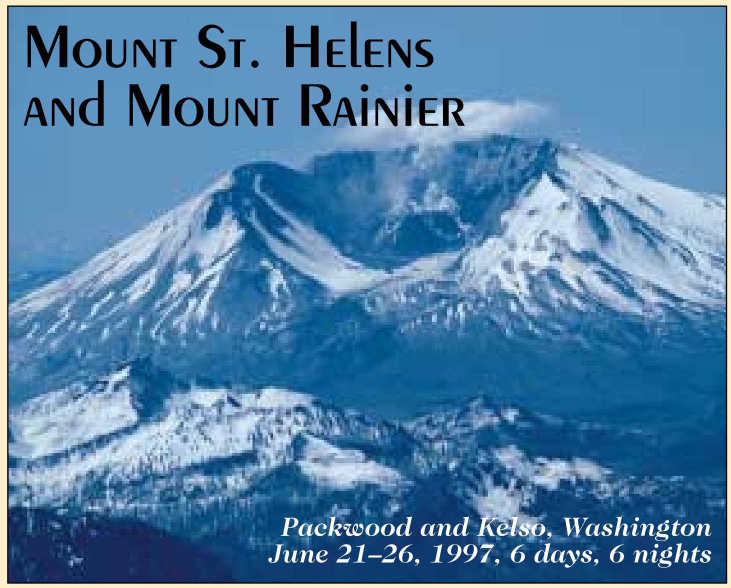
fax 303-447-0648, E-mail: ecollis@geosociety.org

GeoHostel

Richard B. Waitt, U.S. Geological Survey, Vancouver
Patrick Pringle, Washington Dept. of Natural Resources.

This GeoHostel will focus on field trips to Mount St. Helens, especially to explore processes and effects of the cataclysmic eruption of May 18, 1980. Among these are: decapitation of the former summit; world's largest historic landslide; a tsunami wave as high as 800 feet on Spirit Lake; the gigantic pyroclastic surge ("lateral blast") that in four minutes mowed down 235 square miles of mature forest; great muddy floods (lahars). Everyone should see this world-class natural extravaganza before it becomes obscured by trees. Two days will be devoted to the east and southeast sides of Mount St. Helens, two days to the south and west sides, including two stunning new visitors' facilities in the heart of the devastated area, and one day at spectacular Mount Rainier (northeast, east, and south flanks) in Mount Rainier National Park. With the remaining snow still visible on the higher mountain peaks, June will be stunning for photography.

Members: $650 *Nonmembers: $700*



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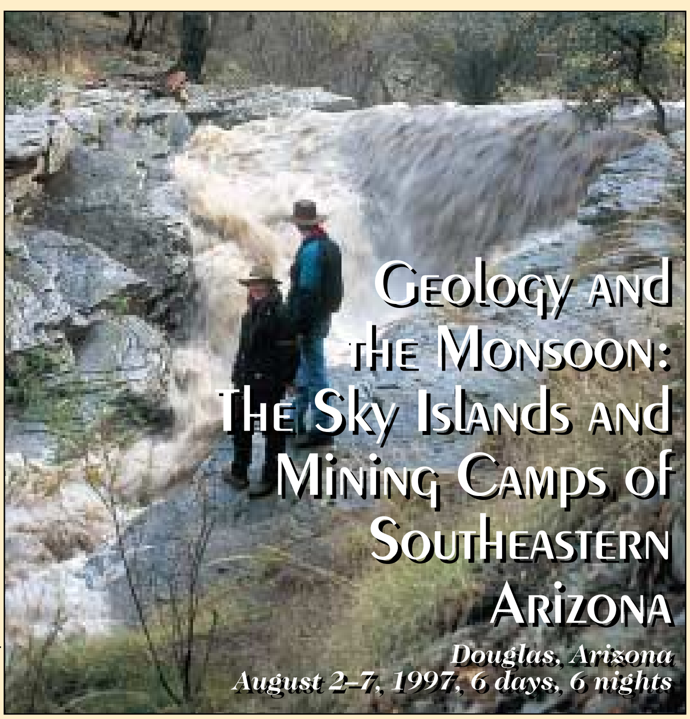

Photo by Tim Lawton

GeoHostel

Tim Lawton and Nancy McMillan,
New Mexico State University

Above the grasslands of southeastern Arizona, isolated ranges the "sky islands," rise to heights of 9000 feet. August is a perfect time to travel there. The geology and natural history of these mountains bear stronger affinities with the Sierra Madre of Mexico than with the Rocky Mountain cordillera, making the region unique in the United States. The monsoon of late July and August brings cooling—and sometimes drenching—afternoon rains and an array of Madrean wildflowers to the higher elevations. The geology of the Chiricahua, Mule, and Huachuca Mountains records Paleozoic marine deposition, Jurassic-Cretaceous crustal extension and basin formation, latest Cretaceous mountain building and basin inversion of the Laramide orogeny, and catastrophic volcanism in the Tertiary. This GeoHostel, which includes a program of ambitious hikes, will explore the geology and the natural and human history built on it by means of a series of field trips and half-day hikes to several ranges and mining centers. Located within 50 miles of the Mexican border, the area is a world-renowned mecca for birdwatchers.

Members: $540 *Nonmembers: $590*

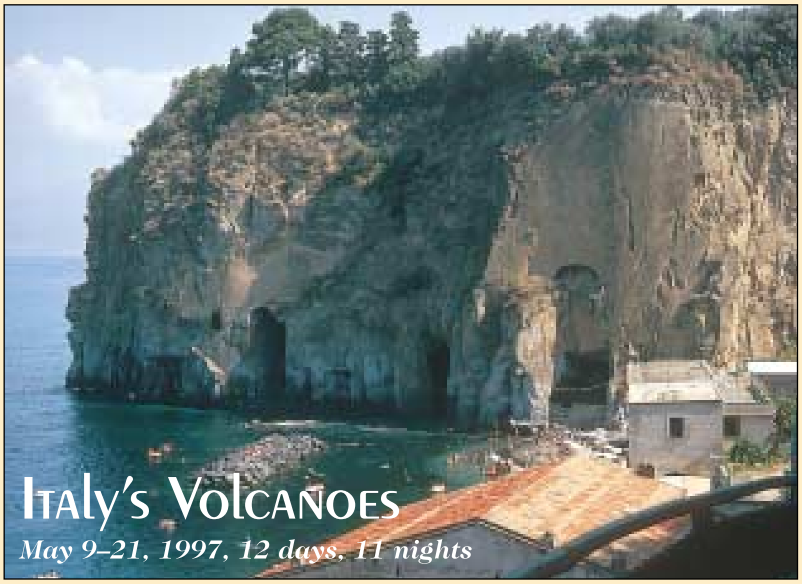

Photo by Haraldur Sigurdsson

Italy's Volcanoes

May 9–21, 1997, 12 days, 11 nights

GeoTrip

***Haraldur Sigurdsson**, Graduate School of Oceanography, University of Rhode Island*
***Mauro Rossi**, University of Pisa, Pisa, Italy*

This unique trip is almost filled, and the primary payment is due on February 28. If you are interested, call us today. On May 9 air travel to Rome begins and connects to Naples. The first day of the trip begins with exploration of Vesuvius volcano. The trip continues with visits to the archaeological sites of Pompeii and Herculaneum. Over several days, the trip goes by ferry to the volcanic islands of Stromboli, Lipari, and Vulcano, and then continues to Sicily for an ascent of Mount Etna. Homeward bound begins on May 21.

Members: $2345   *Nonmembers: $2475*

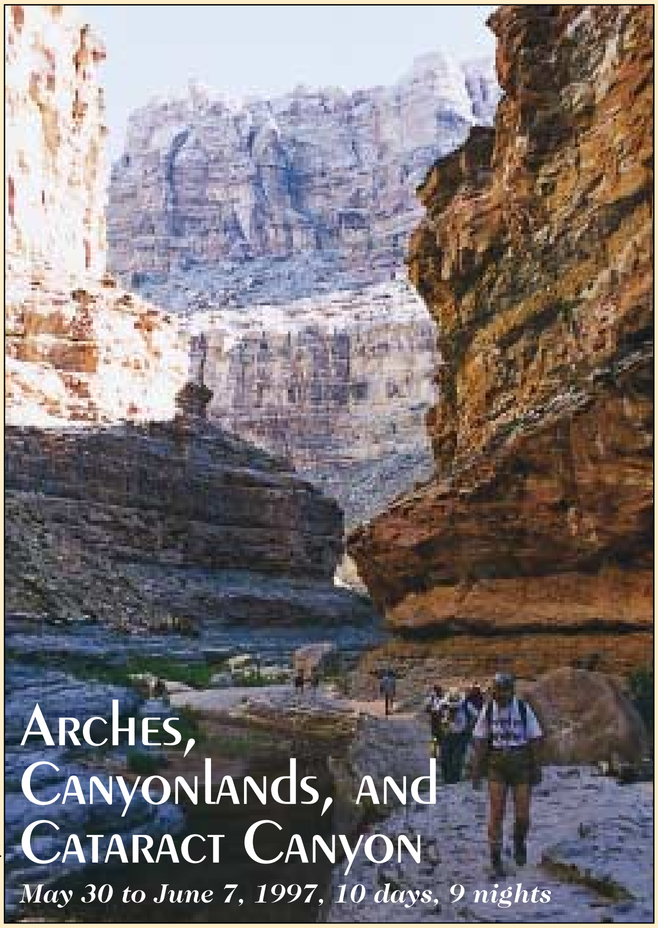

Photo by Ken Kolm

Arches, Canyonlands, and Cataract Canyon

May 30 to June 7, 1997, 10 days, 9 nights

GeoTrip

***Jack Campbell**, Fort Lewis College*

Including whitewater rafting and hiking, this trip is an exceptional geological experience for the physically active person. We will hike the rim area of the Canyonlands, including trips to the geologic formations and features of the LaSal Mountains and Arches National Park. On day 4, we will head out from the Upheaval Dome site and hike down to the river to meet the boats. Each day on the river, there will be hikes and geologic excursions from the campsite to a remarkable new area . On day 7, we'll go through Cataract Canyon, which is a major whitewater experience. On day 8, we'll hike out of the unforgettable Dark Canyon back to the rim for a return sunset overflight to Moab.

The fee covers ALL meals for the four days in and around Moab *(except for breakfast on the departure day);* comfortable van transportation; double-occupancy lodging in modern Moab Valley Inn; five days on the Green and Colorado rivers; complete duffle package of tents, sleeping bags, and pads; geological reading materials and guidebook; the companionship of an expert scientific leader; and finally, a spectacular evening overflight of Canyonlands.

Members: $1445   *Nonmembers: $1545*

GeoHostel

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The Geology of the Yellowstone-Beartooth Country, Montana and Wyoming

July 19–24, Red Lodge, Montana • 6 days, 6 nights • Robert Thomas and Sheila Roberts, Western Montana College

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Positions Open

GEOMORPHOLOGY POSITION

The Department of Geosciences at the University of Arizona invites applications for a tenure-track appointment in geomorphology. The position will be available by January 1998. Salary will be based upon qualifications. A Ph.D. or equivalent degree is required.

We seek applicants with strong backgrounds in the area of surficial processes and landscape evolution. Preferences will be given to candidates with a strong record of publication and demonstrated effectiveness in obtaining research funding. A strong commitment to excellence in undergraduate and graduate education is essential, and preference will be given to candidates with demonstrated teaching ability.

The selection process will begin May 15, 1997 and continue until the position is filled. Interested applicants should submit a curriculum vitae, a statement of research and teaching interests, and a list of at least three references with addresses, e-mail, phone, and fax numbers to:

Professor Joaquin Ruiz, Chairman
Department of Geosciences
The University of Arizona
Gould-Simpson Building, Room 208
P.O. Box 210077
Tucson, Arizona 85721-0077
Ph: (520) 621-4827

The University of Arizona is an EEO/AA/ADA compliance employer. Women and minorities are particularly encouraged to apply.

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**UNIVERSITY OF NEVADA, RENO
MACKAY SCHOOL OF MINES**

The Department of Geological Sciences, Mackay School of Mines, University of Nevada, Reno, invites applications for a position as Assistant Professor in Economic Geology (tenure-track).

Applicants should have knowledge and field experience in mineral deposits typical of the circumpacific region. We are particularly interested in applicants with expertise in modern analytical instrumentation. A Ph.D. in Geology is required. A record of published research and industry experience is desirable. The successful candidate will be expected to develop a sponsored research program.

UNR's program in Economic Geology is one of the strongest in the U.S., thanks to the following: 1) the Ralph J. Roberts Center for Research in Economic Geology (CREG), 2) the Department's strong tradition of field-based teaching and research, 3) activities of the Nevada Bureau of Mines and Geology in economic geology, and 4) a wide range of analytical facilities at Mackay School of Mines includes microprobe, SEM, XFR, XRD, ICP, fluid-inclusion, and computer map-making and visualization systems. CREG, part of the Department, is a partnership with the Nevada Mining Industry and the U.S. Geological Survey that offers unparalleled opportunities for education and research.

The successful candidate will be expected to complement the teaching and research efforts of other faculty in the Department and CREG, especially those involved in studies of mineral deposits and related geologic features, and to contribute to the operation of analytical and/or GIS/mapping systems within the School. Undergraduate/beginning graduate-level teaching responsibilities will include an introductory course in economic geology and a senior-beginning graduate course in advanced mineralogy.

A curriculum vitae, a statement of scientific and professional activities and teaching and research interests, and three or more letters of recommendation should be sent to: Prof. Tommy Thompson, Search Committee Chair, Department of Geological Sciences/172, University of Nevada, Reno, Reno, NV 89557. All application materials should be received by April 1, 1997. The University of Nevada is an equal-opportunity/affirmative-action employer. Women and minorities are especially encouraged to apply.

VALDOSTA STATE UNIVERSITY

The Department of Physics, Astronomy, and Geology invites applications for a position as Lab Coordinator and Instructor. M.S. in an appropriate physical science is required. We seek an individual with evidence of excellence in teaching and with expertise in Environmental Geography and either introductory astronomy, geology, or physics. Responsibilities are to instruct introductory physical geography labs, along with either astronomy, geology, or physics labs, to prepare and disassemble labs, to maintain and repair equipment, and to carry out other duties as assigned. We offer a B.S. with a major in Environmental Geography, recently approved by the Board of Regents of the University System of Georgia. Student response to the new major exceeds expectations. We also offer B.S. degrees in Physics and in Astronomy, and a minor in Geology, as well as a program in Engineering with transfer to Georgia Institute of Technology.

Valdosta State University is an Equal Opportunity/Affirmative Action Employer. Salary for the twelve-month, non-tenure-track contract is commensurate with qualifications. Starting date is July 1, 1997. Submit letter of application, curriculum vitae, and three letters of recommendation by March 31, 1997. Apply to Dr. Dennis Marks, Head, Department of Physics, Astronomy, and Geology, Valdosta State University, Valdosta, Georgia 31698-0055.

EASTERN KENTUCKY UNIVERSITY

Sedimentary Geologist. The Department of Geology invites applications for an entry-level, tenure-track position beginning August 15, 1997. The successful candidate must have academic training/experience in the broad field of sedimentary geology. Preference will be toward clastic sedimentology, stratigraphy, and applications to the Department's strong emphasis in applied geology. Candidates must have a strong commitment to teaching excellence at all levels and develop an active research program involving both undergraduate and graduate students. Ph.D. required. Eastern Kentucky University (www.eku.edu) is a large, comprehensive, regional university located in the Bluegrass region of Kentucky 25 miles south of Lexington. Candidates should submit a letter of application, curriculum vitae, statement of teaching philosophy, and arrange to have three letters of recommendation sent to: Dr. Gary L. Kuhnhenn, Char, Department of Geology, Eastern Kentucky University, Richmond, KY 40475-3129 by April 15, 1997. Address questions to glykuhnh@acs.eku.edu.

Eastern Kentucky University is an equal opportunity/affirmative action employer. Female and minority applications are strongly encouraged.

**VISITING ASSISTANT PROFESSOR OF GEOLOGY
VASSAR COLLEGE**

The Department of Geology and Geography at Vassar College is searching for a dynamic earth scientist to fill a one-year leave replacement position beginning August, 1997. This individual will preferably have completed the Ph.D. prior to coming to Vassar. The successful candidate will teach four courses (two per semester) including Physical Geology, Hydrology, Advanced Topics in Environmental Geology and one ocurse selected from Historical Geology, Earth Materials, or Environmental Earth Science, depending on the candidate's expertise. All classes have opportunities for field and GIS mapping components.

The Department of Geology and Geography at Vassar College is composed of three geologists and three geographers, and is located in a newly renovated building with automated XRD, sedimentology, rock preparation, and GIS laboratories. The Patricia Bullitt Collins Field station on the 500-acre Vassar farm also is an integral element in our geology and environmental sciences programs. Vassar College is a private, liberal arts institution of approximately 2,200 students located in the heart of the Hudson River valley.

Applications, including letter of interest, statement of teaching philosophy and research interests, and three letters of reference should be mailed by April 1, 1997 to Jeff Walker, Chair of Search Committee, Department of Geology and Geography, Vassar College, Poughkeepsie, NY, 12604-0255. Our e-mail address is jewalker@vassar.edu. Vassar College is an affirmative action, equal opportunity employer.

**ECONOMIC GEOLOGIST / PETROLOGIST
SOUTH DAKOTA SCHOOL
OF MINES AND TECHNOLOGY**

The Department of Geology and Geological Engineering is seeking to fill a 1-year, term contract position at the Assistant or Associate Professor level in economic geology/hard-rock petrology. Depending on the availability of funding, the position may continue for more than 1 year. The successful candidate will be required to teach undergraduate and graduate classes in economic geology, mineralogy, and petrology, and is expected to have an established research program or be able and willing to develop a funded research program in support of the M.S. and Ph.D. degree programs. Ph.D. is required, and it is preferable that the candidate has experience in mineral exploration and/or mine geology. Salary will be commensurate with qualifications and experience.

Send vitae, letter of application, and three letters of reference to: Dr. Colin J. Paterson, Chairman, Dept. of Geology and Geol. Eng., SDSM&T, 501 E. St. Joseph St., Rapid City, SD 55701. Applications will be reviewed beginning March 15, 1997, and will continue until a suitable candidate is hired. Address inquiries to paterson@silver.sdsmt.edu, phone (605) 394-2461, fax 605-394-6703. Information on the university and department, located in the beautiful Black Hills, is at the following Web address: http://www.sdsmt.edu/campus/mineral/geology/geolhp.htm SDSM&T is an AA/EEO/ADA employer and provider.

Consultants

LOOKING FOR A HOME FOR YOUR COLLECTION? Museum curator provides adivce or referrals to departments, companies, or individuals seeking to sell or donate collections of minerals, rocks, ores, fossils, geobooks, etc. Contact: A. Sicree, 122 Steidle, University Park, PA 16802, (814) 865-6427; sicree@geosc.psu.edu.

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

Opportunities for Students

Graduate Research Assistantship, University of Nevada, Las Vegas. The Geoscience Department invites applicants for M.S. research in the field of economic geology/geochemistry. The research project involves investigation of Carlin-type gold mineralization at an active gold mine in northern Nevada. Funding includes a two-year stipend and research funds; summer funding may be available. A letter of interest should be sent to Jean S. Cline, Department of Geoscience, 4505 Maryland Parkway, Box 454010, Las Vegas, Nevada 89154-4010, 702/895-1091, or e-mail jcline@nevada.edu.

JOI/USSAC Ocean Drilling Fellowships. JOI/U.S. Science Advisory Committee is seeking outstanding doctoral candidates who are enrolled at U.S. institutions to conduct research compatible with that of the Ocean Drilling Program. April 15, 1997 is the next fellowship application deadline for both shipboard and shorebased research proposals. Shipboard research is related to future ODP legs on which students wish to sail as scientists. Shorebased research may be directed towards broader themes or the objectives of a specific DSDP or ODP leg—past, present, or future.

Shipboard proposals submitted for the upcoming April 15 deadline should be based on the following ODP legs: Leg 176 Hole 735B, Leg 177 Southern Ocean Paleoceanography, Leg 178 Antarctic Peninsula, Leg 179 NERO/Hammer Drilling, Leg 180 Woodlark Basin, Leg 181 SW Pacific Gateways, and Leg 182 Great Australian Bight. Staffing for these legs will begin during the next few months. Fellowship candidates wishing to participate as shipboard scientists must also apply to the ODP Manager of Science Services in College Station, TX. A shipboard scientist application form and leg descriptions are included in the JOI/USSAC Ocean Drilling Fellowship application packet.

Both one-year and two-year fellowships are available. The award is $22,000 per year to be used for stipend, tuition, benefits, research costs, and incidental travel, if any. Applicants are encouraged to propose innovative and imaginative projects. For more information and to receive an application packet, contact: Andrea Johnson, JOI/USSAC Ocean Drilling Fellowship Program, Joint Oceanographic Institutions, Inc. 1755 Massachusetts Ave., NW, Suite 800, Washington, DC 20036-2102 (Telephone: 202-232-3900, ext. 213; Internet: ajohnson@brook.edu).

Graduate Assistantships/Coastal Processes, Texas Christian University. The Geology Department has assistantships available for M.S. research in most fields of geology. A new area of expertise includes coastal and estuarine dynamics, with emphasis on modeling nearshore profile and shoreline variability, andalyzing the impact of tidal inlets on adjacent beaches, and quantifying estuarine circulation and sediment transport patterns. Study areas include the Outer Banks of North Carolina, Kennebec River Estuary in Maine, and Long Island Sound. In addition to full laboratory and analytical facilities, the department houses the Center for Remote Sensing and has an extensive computer network. Financial aid includes two-year stipend, full tuition waiver, and research funds. Contact Michael Fenster, Department of Geology, TCU, Fort Worth, TX 76129. tel (817) 921-7506, m.fenster@tcu.edu, http://geowww.geo.tcu.edu/

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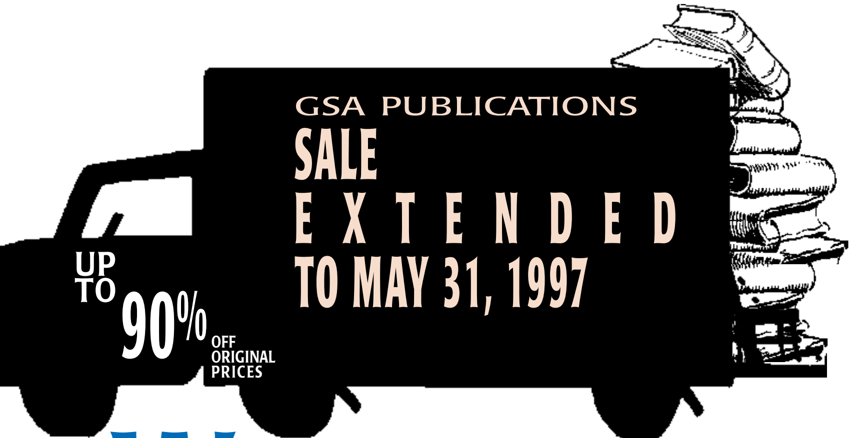
NORTHEASTERN SECTION, March 17–19, Sheraton Valley Forge Hotel, King of Prussia, Pennsylvania. Information: William A. Crawford, Department of Geology, Bryn Mawr College, Bryn Mawr, PA 19010-2899, (610) 526-5112, fax 610-526-5086, wcrawfor@brynmawr.edu. *Preregistration Deadline: February 14, 1997.*

SOUTH-CENTRAL and ROCKY MOUNTAIN SECTIONS, March 20–21, University of Texas, El Paso, Texas. Information: Elizabeth Y. Anthony, Department of Geological Sciences, University of Texas, El Paso, TX 79968-0555, (915) 747-5483, anthony@geo.utep.edu. *Preregistration Deadline: February 7, 1997.*

SOUTHEASTERN SECTION, March 27–28, Auburn University, Auburn, Alabama. Information: Mark G. Steltenpohl, Department of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4893, steltmg@mail.auburn.edu. *Preregistration Deadline: February 21, 1997.*

NORTH-CENTRAL SECTION, May 1–2, The Concourse Hotel, Madison, Wisconsin. Information: Thomas J. Evans, Wisconsin Geol. & Nat. History Survey, 3817 Mineral Point Rd., Madison, WI 53705, (608) 263-4125, tevans@facstaff.wisc.edu. *Preregistration Deadline: March 28, 1997.*

CORDILLERAN SECTION, May 21–23, Kona Surf Resort and Convention Center, Kailua-Kona, Hawaii. Information: Ralph Moberly, Department of Geology and Geophysics, University of Hawaii, 2525 Correa Road, Honolulu, HI 96822, (808) 956-8765, ralph@soest.hawaii.edu. *Preregistration Deadline: April 18, 1997.*



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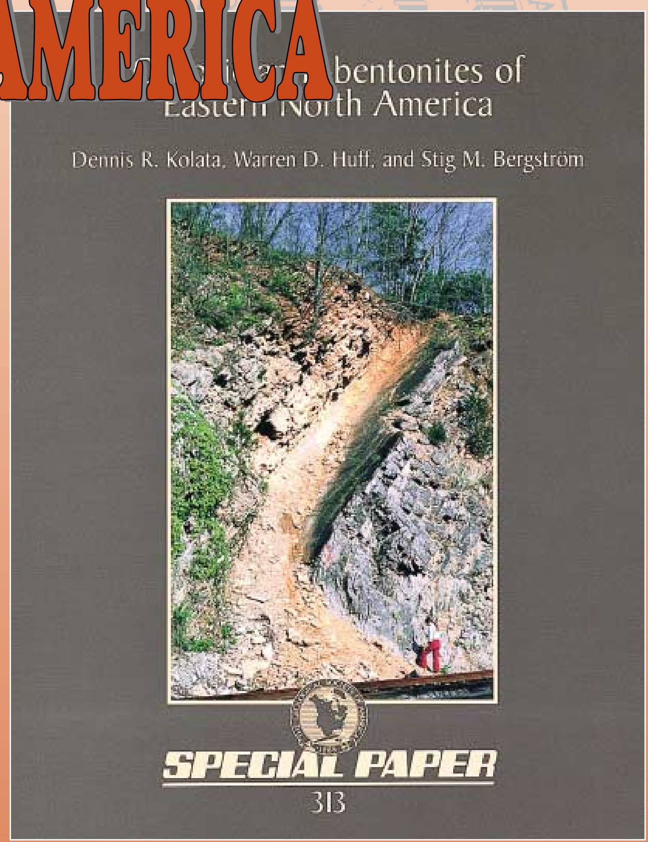
ORDOVICIAN K-BENTONITES OF EASTERN NORTH AMERICA

by D. R. Kolata, W. D. Huff, S. M. Bergström, 1996



The Ordovician stratigraphic succession of eastern North America contains at least 60 altered volcanic ash beds, K-bentonites, one or more of which are distributed over an area of 1.5 million square km. Most Ordovician K-bentonites are not widely distributed, but a few can be correlated for hundreds or thousands of kilometers by chemical fingerprinting techniques, tracing on wireline logs, and matching of detailed outcrop descriptions. K-bentonites are a potential source of diverse geologic information. Because the beds were deposited in a geologic instant over large areas, they constitute nearly isochronous rock units useful in precise correlations applicable to biogeographic, paleogeographic, paleoecologic, tectonomagmatic, geochronologic, and sedimentologic investigations in both local and regional scales. The volume presents the most comprehensive set of data currently available on the occurrence and characteristics of Ordovician K-bentonites in eastern North America. The authors (1) summarize the mineralogies and chemical compositions that help distinguish individual beds and provide information regarding the tectonomagmatic setting of the source volcanoes; (2) document the geographic and stratigraphic distribution of the 60 or more Ordovician K-bentonites in eastern North America; (3) determine the relative positions of K-bentonites within an established biostratigraphic framework; and (4) determine which beds or bed complexes have potential event-stratigraphic significance.

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