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GSA TODAY

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The Late Cretaceous Vertebrate Fauna of Madagascar: Implications for Gondwanan Paleobiogeography

David W. Krause, *Department of Anatomical Sciences, State University of New York, Stony Brook, NY 11794, dkrause@mail.som.sunysb.edu*
Raymond R. Rogers, *Department of Geology, Macalester College, 1600 Grand Avenue, St. Paul, MN 55105, rogersr@macalester.edu*
Catherine A. Forster, *Department of Anatomical Sciences, State University of New York, Stony Brook, NY 11794, cforster@mail.som.sunysb.edu*
Joseph H. Hartman, *Energy and Environmental Research Center, University of North Dakota, Grand Forks, ND 58202, jhartman@plains.NoDak.edu*
Gregory A. Buckley, *Roosevelt University, Evelyn T. Stone University College, Chicago, IL 60605, gbuckley@roosevelt.edu*
Scott D. Sampson, *Utah Museum of Natural History and Department of Geology and Geophysics, University of Utah, Salt Lake City, UT 84112, ssampson@umnh.utah.edu*

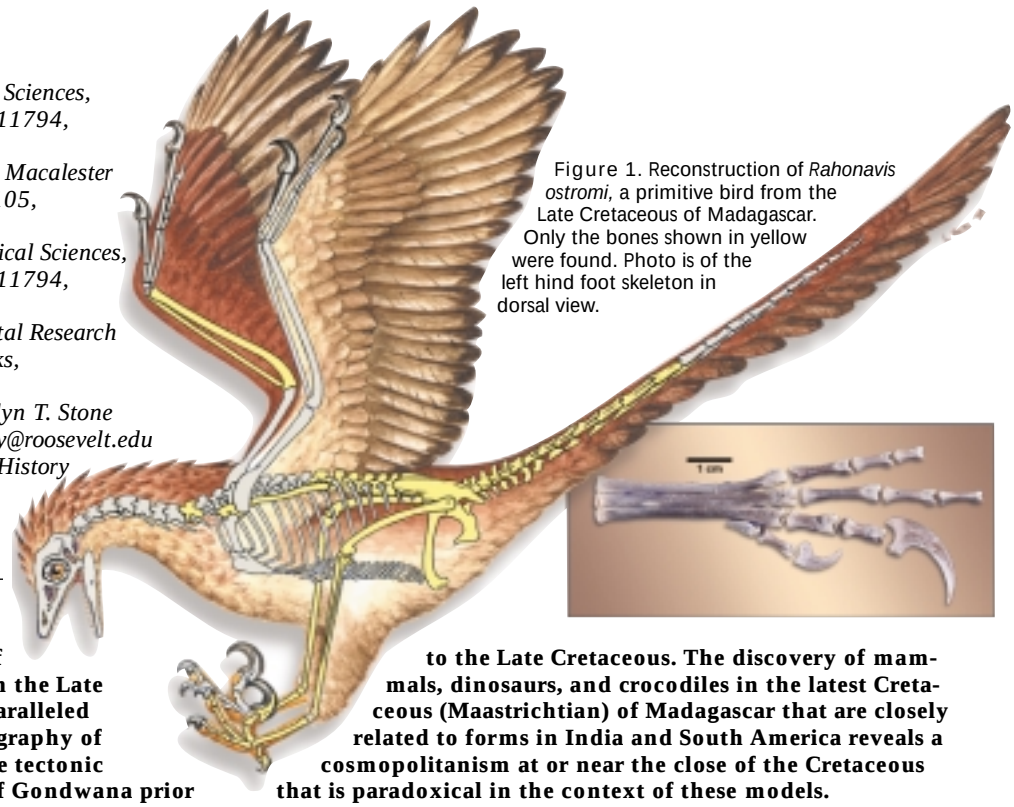

Figure 1. Reconstruction of *Rahonavis ostromi*, a primitive bird from the Late Cretaceous of Madagascar. Only the bones shown in yellow were found. Photo is of the left hind foot skeleton in dorsal view.

ABSTRACT

A rich, newly discovered assemblage of exquisitely preserved vertebrate fossils from the Late Cretaceous of Madagascar provides an unparalleled opportunity to investigate the paleobiogeography of Gondwanan landmasses. Most current plate tectonic models depict widespread fragmentation of Gondwana prior to the Late Cretaceous. The discovery of mammals, dinosaurs, and crocodiles in the latest Cretaceous (Maastrichtian) of Madagascar that are closely related to forms in India and South America reveals a cosmopolitanism at or near the close of the Cretaceous that is paradoxical in the context of these models.

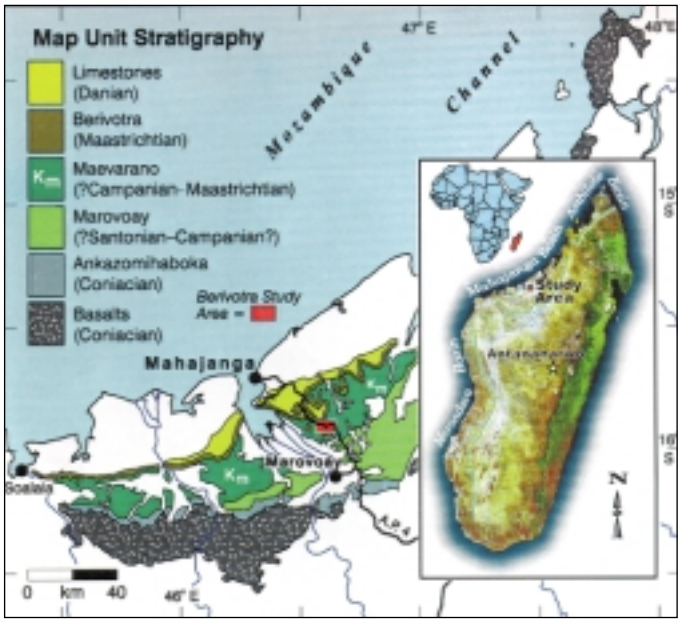

Figure 2. Upper Cretaceous stratigraphy of the Mahajanga Basin. Inset: base map of Madagascar from Satellite Atlas of the World, 1998, National Geographic Society, Washington, D.C., 222 p.

INTRODUCTION

The southern supercontinent of Gondwana fragmented into isolated landmasses during the Late Jurassic and Cretaceous, with dramatic consequences for the associated terrestrial and freshwater vertebrate faunas. Reconstructions of the timing and sequence of this fragmentation are based almost entirely on geophysical evidence and remain poorly tested paleontologically, primarily due to a sparse fossil record. The Mahajanga Basin Project, initiated in 1993 and conducted jointly by the State University of New York at Stony Brook and the University of Antananarivo (Madagascar), has recovered a diverse assemblage of vertebrates, including the primitive bird *Rahonavis ostromi* (Fig. 1), from the Upper Cretaceous Maevarano Formation, Mahajanga Basin, northwestern Madagascar (Fig. 2). This assemblage is one of the richest and best preserved yet known from the Mesozoic of Gondwana. It provides a new opportunity to elucidate distribution patterns among Cretaceous vertebrates from Gondwana and, thereby, to test competing plate tectonic and biogeographic hypotheses.

MALAGASY VERTEBRATE FOSSIL RECORD

The Malagasy record of terrestrial and freshwater vertebrates prior to the Late Cretaceous is sparse but improving, consisting of a diversity of primitive fishes, amphibians (including the frog-like

Madagascar *continued on p. 2*

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In Memoriam

Louis C. Conant
Cupertino, California
June 2, 1999

Francis J. Pettijohn
Glen Arm, Maryland
April 23, 1999

Please contact the GSA Foundation for information on contributing to the Memorial Fund.

Madagascar *continued from p. 1*

Triadobatrachus), and reptiles, as well as spotty occurrences of dinosaurs, therapsids, and crocodiles (Fig. 3; Flynn et al., 1998; Krause, 1999). Depéret (1896) was the first to record Late Cretaceous vertebrates from the island. He described isolated turtle remains and, on the basis of fragmentary bones and teeth, named two dinosaur species from the Maevarano Formation—the meat-eating theropod *Megalosaurus crenatissimus* and the plant-eating sauropod *Titanosaurus madagascariensis.* Intermittent collecting over the course of nearly a century in the same field area by expeditions from France, Madagascar, and Japan yielded additional fragmentary specimens of turtles and dinosaurs, as well as isolated elements of a fish, a snake, two crocodiles, and a purported lizard (see summary in Krause et al., 1997a).

There are no undisputed records of Cenozoic terrestrial and freshwater vertebrates from Madagascar prior to the late Pleistocene, primarily owing to the overwhelming predominance of marine rocks during the era (Krause et al., 1997a). As a result, the biogeographic origins of the highly endemic and imbalanced extant fauna, perhaps best represented by lemurs, remains shrouded in mystery. The late Pleistocene and Holocene record only increases the level of endemism, as it includes several giant lemurs, pygmy hippopotami, the aardvark-like *Plesiorycteropus,* and several other taxa unique to the island.

MAHAJANGA BASIN PROJECT

The Mahajanga Basin Project has focused on the same small set of Maevarano Formation badlands around the village of Berivotra that served as the setting for prior paleontological field efforts. The primary objectives of our four expeditions (1993, 1995, 1996, 1998) have been to discover terrestrial and freshwater vertebrate fossils and to place them in a sound phylogenetic, stratigraphic, paleoenvironmental, taphonomic, and paleobiogeographic context.

Maevarano Formation

The Maevarano Formation is well exposed in the Berivotra region, where

J. John Sepkoski 1948–1999

Paleontologist J. John (Jack) Sepkoski Jr., University of Chicago, died May 1, 1999, of heart failure. He was 50.

Sepkoski's research and activity in paleontology played a major role in reshaping the discipline during the past 25 years. His major contributions included documenting and analyzing large-scale patterns of origination and extinction, major changes in the diversity of life over time, and the environmental and ecological context of biotic diversification. He had taught at the University of Chicago since 1978. He was a member of the Geological Society of America.

Sepkoski served as president of the Paleontological Society, co-editor and associate editor of *Paleobiology*, and associate editor of *Acta Palaeontologica Polonica*. He founded the Paleontological Society International Research Program (PalSIRP), to assist paleontologists in Eastern Europe and in the former Soviet Union. Donations in his honor may be made to PalSIRP, c/o Thomas W. Kammer, Treasurer, Paleontological Society, Dept. of Geology and Geography, West Virginia University, P.O. Box 6300, Morgantown, WV 26506-6300.

ENVIRONMENT MATTERS

Institute for Earth Science & the Environment

Make a Difference—Become a Mentor

Did you receive career advice or guidance as an undergraduate student? Did you benefit from the opportunity to learn about different careers in the geosciences? Undergraduate and graduate students are hungry for career mentoring in the applied geosciences. Many have not had the opportunity to learn about what lies beyond graduation *outside of academia*. Your wisdom is priceless to students! Please consider sharing your experience and advice with students as they prepare to venture into the real world.

The Institute for Earth Science and the Environment is currently seeking mentors for the Roy J. Shlemon Mentor Program in Applied Geology and the John F. Mann Mentor Program in Applied Hydrogeology. The Shlemon Mentor Program presents an opportunity for a panel of applied geoscientists to engage students in a discussion of careers in the applied geosciences. We are seeking mentors from all disciplines in the applied geosciences to spend 4–6 hours with students during the GSA Section meeting of your availability. Mentors are needed for GSA Section meetings in the spring of 2000.

The Mann Mentor Program is an opportunity for a mentor team (a junior and senior mentor) to spend 4–8 hours at two or three universities in your area. The team will candidly discuss what it is like to be a hydrogeologist—how to get a job, challenges in the field, case histories, and billable hours. The team will also be present to meet with students individually to offer invaluable career advice. IEE is currently seeking two mentor teams for the spring of 2000.

At recent workshops, students openly expressed their gratitude to mentors for spending time and energy to share career information. One young woman was so impressed by what she gained that she talked about how she might be a mentor to younger undergraduate women. Please consider this not only an opportunity to discuss your job highlights and challenges, but also an opportunity to truly be a valuable role model and mentor in the budding career of a future geoscientist. For more information, please contact Stacey Ginsburg at 303-447-2020, ext. 194 or sginsburg@geosociety.org. ■

~100 m of the unit is accessible in surface exposures (Fig. 2). The formation is entirely nonmarine and consists of strata that accumulated on a semiarid, low-relief alluvial plain that was bounded to the southeast by crystalline highlands and to the northwest by the Mozambique Channel. The predominant lithology is coarse-grained, poorly sorted sandstone, which ranges from pervasively cross-stratified to massive. Massive beds tend to show conspicuous evidence of pedogenesis, including well-preserved root traces and caliche. A distinctive 15–20-m–thick interval of extremely fossiliferous sandstone facies caps the formation in the vicinity of Berivotra. Virtually all of the vertebrate fossils known from the Maevarano Formation have been recovered from these upper beds, which accumulated in a shallow channel-belt system.

The nonmarine Maevarano Formation and the marine Berivotra Formation were previously considered to be stacked in layer-cake fashion, the Campanian-Maastrichtian boundary being at their contact (e.g., Besairie, 1972). This interpretation, and similar interpretations of lower rock units, oversimplified the geological history of the Mahajanga Basin and hindered accurate comparisons between Madagascar's record of Late Cretaceous vertebrates and those from other Gondwanan localities. Our work reveals instead that the Maastrichtian marine transgression that led to deposition of the Berivotra Formation was demonstrably diachronous, and that the Maevarano Formation accumulated, at least in part, during this same transgressive event (Rogers and Hartman, 1998). Vertebrate-bearing facies of the upper Maevarano Formation are accordingly reinterpreted as Maastrichtian, and perhaps late Maastrichtian.

Vertebrate Assemblage

We have now established the presence of at least 32 species of terrestrial and freshwater vertebrates in the Maevarano Formation, thus quadrupling the previously known species diversity from the Late Cretaceous of Madagascar. These efforts have provided the first pre–late Pleistocene records of Malagasy frogs, birds, and mammals, and the first records of several groups of vertebrates, fossil or extant, from the island (Krause et al., 1994; Forster et al., 1996; Asher and Krause, 1998; Gottfried and Krause, 1998; Gottfried et al., 1998). Despite varied collecting methods and intensive effort, the purported presence of lizards (Russell et al., 1976) has not been confirmed and is suspect.

Fishes, frogs, turtles, and snakes are now represented in some considerable diversity in the Maevarano assemblage, but their diversity pales in comparison to that of crocodiles, which are represented by as many as seven different species. The crocodiles range in size from the small and gracile *Araripesuchus* to the large and ponderous *Mahajangasuchus* (Fig. 4; Buckley and Brochu, 1999). The 1998 field campaign resulted in the discovery of a bizarre new pug-nosed form with mitten-shaped teeth.

Two species of sauropod dinosaurs have been discovered, both of which belong to the enigmatic Titanosauridae. Each is represented by skeletal material that is among the most complete known

Madagascar *continued on p. 4*

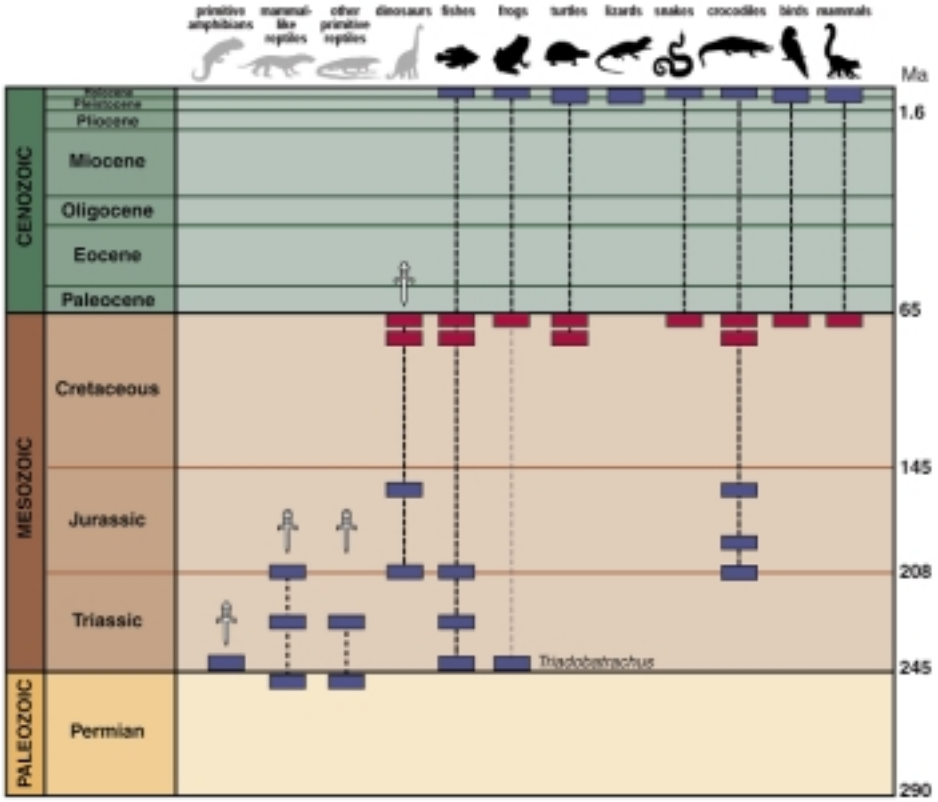

Figure 3. Temporal distribution of the terrestrial and freshwater vertebrates of Madagascar. Late Cretaceous occurrences are from the Maevarano Formation (upper red rectangles) and the Ankazomihaboka beds (lower red rectangles).

Madagascar *continued from p. 3*

for titanosaurids. Perhaps the most spectacular fossil discovery of the Mahajanga Basin Project to date is an exquisitely preserved and virtually complete skull of the mid-sized theropod dinosaur *Majungatholus atopus*, the name now assigned to Depéret's *Megalosaurus crenatissimus* (Fig. 5; Sampson et al., 1998). The skull is complemented by a second specimen consisting of a nearly complete axial skeleton of a juvenile individual. At least one other smaller and as yet unidentified theropod is present in the Maevarano Formation. No ornithischian dinosaurs are represented in the fauna.

Birds are represented by at least five taxa (Forster et al., 1996, 1998). The most significant specimen is a partial skeleton of *Rahonavis ostromi* (Fig. 1), a close relative of the Late Jurassic *Archaeopteryx*. *Rahonavis* provides strong confirmatory evidence for the dinosaurian origin of birds in that its hind foot bore a robust, hyperextendable killing claw on the second digit, just as in its theropod predecessors. Multiple, independent analyses of fibrous material adhering to the claw of the second digit has revealed that it is keratin from the claw sheath (Schweitzer et al., 1999). This represents by far the oldest documented record of keratin.

Mammals are represented by four species: two possible therians, a multituberculate, and a new species of sudamericid gondwanathere (Krause et al., 1994, 1997b; Krause and Grine, 1996).

MADAGASCAR PLATE TECTONICS AND BIOGEOGRAPHY

Plate Tectonic Models

There is now general consensus that, prior to rifting, Madagascar lay adjacent to present-day Somalia, Kenya, and Tanzania (see Coffin and Rabinowitz, 1992; Storey, 1995). Sea-floor spreading between the conjugate rifted margins of east Africa and northern Madagascar began in the Late Jurassic. Madagascar moved south-southeastward along the transform fault known as the Davie Fracture Zone until reaching its current position some 400 km off the east coast of Mozambique in the Early Cretaceous (130–125 Ma). Madagascar remained in contact with the Indian subcontinent (through the intervening Seychelles island group) until approximately 88 Ma, at which time the Indian subcontinent and Seychelles block separated from Madagascar and began moving rapidly northeastward toward Eurasia (Storey et al., 1995; Plummer, 1996).

The timing of separation between the Indian subcontinent and Antarctica-Australia, and thus intervening physical connections between Madagascar and South America, is more controversial (Fig. 6). Traditional geophysical interpretations posit a plate reorganization event at about 135–120 Ma that resulted in cessation of movement between Africa and Madagascar-India-Antarctica-Australia and the initiation of separation between India-Madagascar and Antarctica-Australia. Roeser et al. (1996, p. 262), for instance, found evidence for a seaway "along most if not all of the coast of East Antarctica" shortly after chron M0 (124 Ma). Lawver et al. (1992, p. 18) stated that by 110 Ma, "Madagascar, India, and the southern Kerguelen Plateau had cleared Antarctica, and a wide, open seaway existed along that part of the present-day East Antarctic margin." Hay et al. (1999), however, have hypothesized a much longer-lived connection between the Indian subcontinent and Antarctica-Australia across the Kerguelen Plateau, perhaps as late as 80 Ma. The discrepancy in interpretation has crucial implications concerning the biogeographic history of Late Cretaceous terrestrial and freshwater Gondwanan vertebrates (Krause et al., 1997a, 1997b; Sampson et al., 1998).

Biogeographic Scenarios

Madagascar is of unusually high paleobiogeographic interest and intrigue because: (1) it occupies a somewhat central geographic position within Gondwana and was among the first, and last, landmasses to be involved in fragmentation of the supercontinent; (2) it has been isolated from all other Gondwanan landmasses for more than 85 m.y.; (3) it has a highly endemic and imbalanced modern biota;

Figure 4. Postcranial skeleton and lower jaws of the broad-mouthed metasuchian crocodile *Mahajangasuchus insignis* in dorsal view.

and (4) its fossil record of terrestrial and freshwater vertebrates is spotty at best (Fig. 3).

Late Cretaceous vertebrate fossils from Madagascar historically have been most frequently compared to those from the Indian subcontinent, Africa, and South America. The sauropod *Titanosaurus madagascariensis*, for instance, was transferred to the South American genus *Laplatasaurus* and also identified in the Late Cretaceous of India. The theropod *Majungasaurus crenatissimus* (now *Majungatholus atopus*) was identified in the Late Cretaceous of both Egypt and India, and a fragmentary dentary from the Early Cretaceous (Albian?) of Morocco was identified as that of cf. *Majungasaurus* sp. Similar patterns have been noted for nondinosaurian vertebrates (e.g., crocodiles, snakes) as well.

Many of these identifications, based on fragmentary, isolated specimens, are suspect, and were made before the paradigm of plate tectonics held sway. The reigning stabilist paradigm prompted workers in the late 19th and early 20th centuries to invoke ephemeral land bridges between South America and Africa, Africa and Madagascar, and Madagascar and the Indian subcontinent to explain these distributions (e.g., Blanford, 1890). Alternatively, Huene and Matley (1933), who viewed *Laplatasaurus madagascariensis* as showing affinities between India and South America, speculated upon a polar route including Antarctica.

Even later, under a mobilist paradigm, land bridge scenarios were used to explain such distributions, but not without disagreement. While Dietz and Holden (1970) maintained that the Indian subcontinent was an isolated landmass in the Indian Ocean for the entire Jurassic and Cretaceous, Smith and Hallam (1970, p. 960), on the basis of fossil marine invertebrates, envisioned a terrestrial connection between Africa, Madagascar, and the Indian subcontinent until "at least the close of the Cretaceous." Similarly, Colbert (1973, 1984), Sues (1980), Taquet (1982), Briggs (1989), Russell (1993), and others postulated land bridges that allowed dispersal of Cretaceous dinosaurs from Madagascar and/or India to South America through Africa, rather than through Antarctica as proposed by Huene and Matley (1933). In support of this assessment, Le Loeuff (1991) performed a biogeographic analysis of Late Cretaceous Gondwanan vertebrates, which showed closer affinity of the then poorly known Maevarano Formation vertebrate assemblage (Fig. 2) to that of Africa than to that of any other landmass.

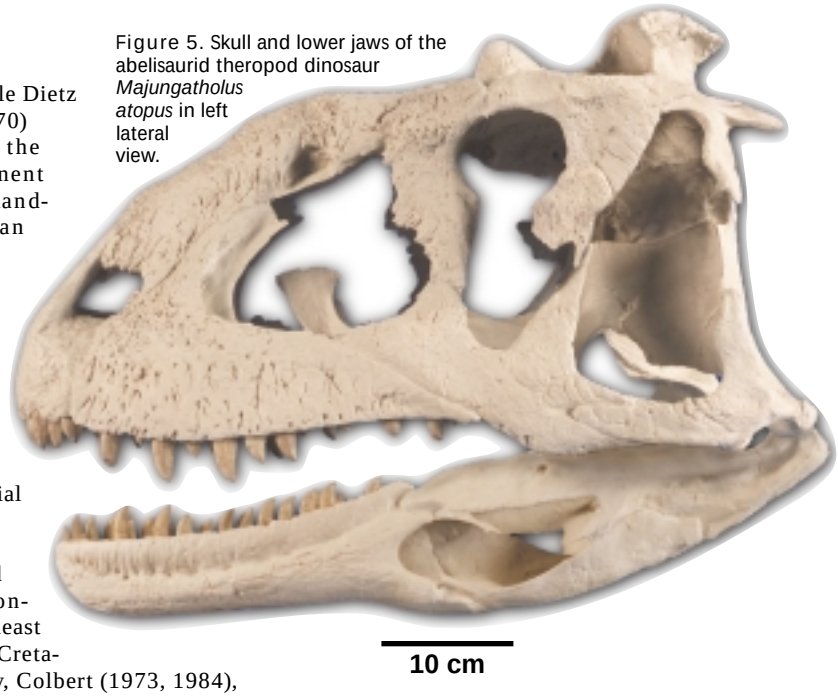

Figure 5. Skull and lower jaws of the abelisaurid theropod dinosaur *Majungatholus atopus* in left lateral view.

With regard to the biogeographic origins of the extant terrestrial and freshwater vertebrate fauna of Madagascar, many workers have speculated that the ancestral stocks were present on the island since the Paleogene, the Late Cretaceous, or even earlier, prior to its rifting from Africa (see review in Krause et al., 1997a). Although it appears that certain taxa (e.g., some birds, bats, and frogs) may be of Indian-Malaysian origin, the consensus is that most taxa arrived by random dispersal (rafting, swimming, and/or island hopping) across the 400 km span of the Mozambique Channel from Africa. McCall (1997, p. 664) recently suggested that "large areas of the Mozambique Channel

Madagascar *continued on p. 6*

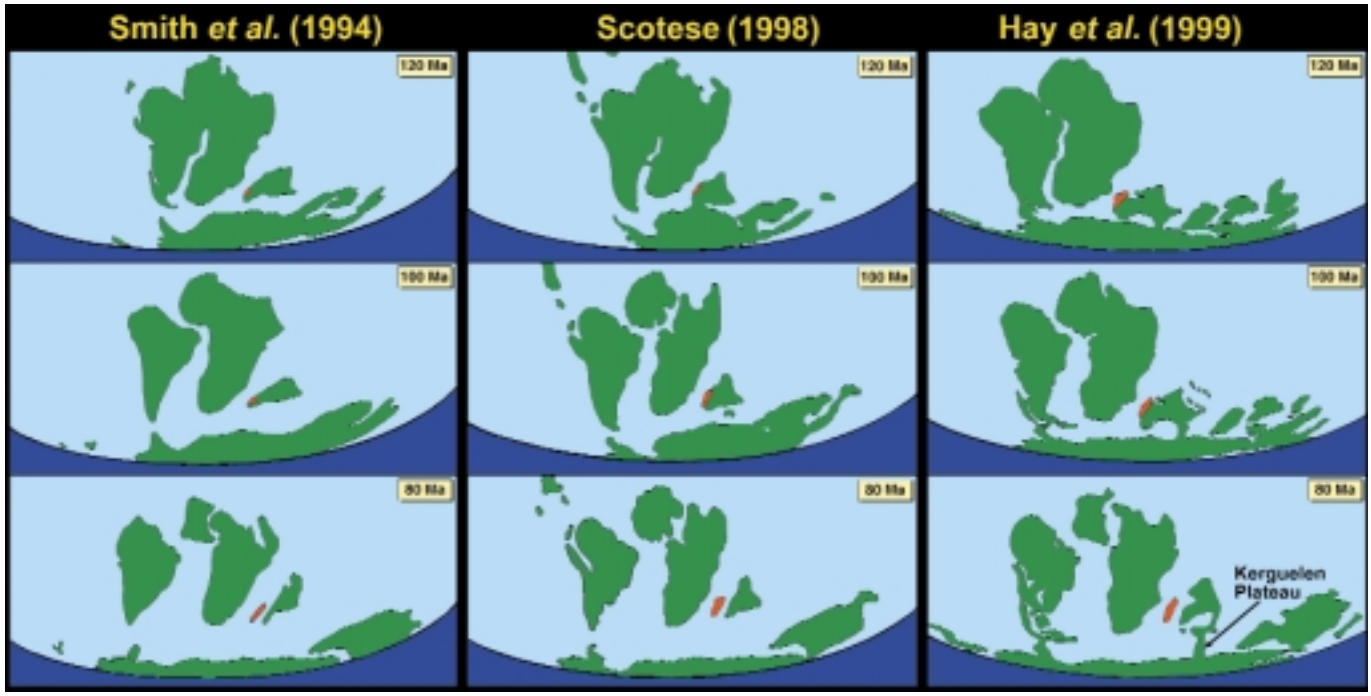

Figure 6. Paleogeographic reconstructions of major Gondwanan landmasses at 120, 100, and 80 Ma modified from authors shown. Land areas in green, except Madagascar, which is indicated in red.

Madagascar *continued from p. 5*

were dry land" during the Paleogene as a result of uplift along the Davie Ridge and that these large areas served as a land bridge for mammalian colonization of Madagascar from Africa. Rage (1996) envisioned a Late Cretaceous land bridge to the east, extending from Madagascar to the Seychelles to the Indian subcontinent to Laurasia, to explain the modern-day presence of iguanid lizards, boine snakes, and perhaps even lemurs on the island.

Biogeographic Significance of the Maevarano Formation Vertebrate Assemblage

The exquisite and relatively complete preservation of skeletal material of Late Cretaceous vertebrates from the Maevarano Formation allows the opportunity to make much better phylogenetic determinations of many taxa that were previously represented only by fragmentary, isolated specimens. This, plus the discovery of several new taxa, has obvious and important consequences for testing paleobiogeographic hypotheses. Two taxa from the Maevarano Formation in particular, gondwanatherian mammals and abelisaurid theropods (and possibly a third, peirosaurid crocodiles), reveal an interesting biogeographic pattern.

Sudamericid gondwanatheres are a highly distinctive but phylogenetically enigmatic group of mammals first known from the Late Cretaceous and Paleocene of Argentina (Krause and Bonaparte, 1993). Their recent discovery in both the Maevarano Formation of Madagascar and the Deccan volcanic-sedimentary sequence of India revealed a previously unknown degree of cosmopolitanism among Gondwanan mammals at the end of the Cretaceous (Krause et al., 1997b). A similar geographic distribution was recently demonstrated among theropod dinosaurs with the discovery of the skull of the abelisaurid *Majungatholus atopus* (Sampson et al., 1998). The skull provides strong evidence that *Majungatholus* is closely related to taxa in both Argentina (*Carnotaurus*) and India (*Indosuchus*). Interestingly, prior to discovery of the skull, *M. atopus* was only known from an isolated skull fragment that had been referred to the Pachycephalosauridae (Sues and Taquet, 1979; Sues, 1980), a group of ornithischian dinosaurs known as "bone-heads" previously reported only from Laurasia. The new, complete skull demonstrates that the fragment of *M. atopus* is that of a theropod and not a pachycephalosaurid. The biogeographic enigma of pachycephalosaurids in the Late Cretaceous of southern Gondwana is thus resolved (Sampson et al., 1998). Finally, peirosaurid crocodiles, whose tentative identification in the Maevarano Formation remains to be confirmed, are otherwise known with certainty only from the Late Cretaceous (Senonian) of South America (Price, 1955; Gasparini et al., 1991).

The presence of closely related terrestrial and freshwater animals in Madagascar, the Indian subcontinent, and South America near the end of the Cretaceous is seemingly incompatible with paleogeographic reconstructions (e.g., Smith et al., 1994; Scotese, 1998) in which India-Madagascar is viewed as having been isolated from all other Gondwanan landmasses by 120 Ma (Fig. 6). Rather, this distribution accords with the reconstruction by Hay et al. (1999), which posits a subaerial link between India-Madagascar and Antarctica across the Kerguelen Plateau that persisted well into the Late Cretaceous (Fig. 6).

The Maevarano Formation assemblage also yields substantial, though negative, evidence with regard to the biogeographic origins of the highly endemic and imbalanced modern fauna. We have found no evidence in the Maevarano Formation to support the hypothesis that the basal stocks of extant Malagasy vertebrate taxa were present on the island in the Late Cretaceous (Krause et al., 1997a, 1998). None of the fish, frog, turtle, snake, crocodilian, bird, or mammal taxa now known from the Maevarano Formation appears closely related to the higher taxa of vertebrates on the island today. The basal stocks of the modern taxa must have arrived sometime in the Cenozoic, presumably by crossing a significant marine barrier, a possibility made even more feasible by the recent observation of Caribbean iguanas traversing a distance roughly equivalent to the minimum width of the Mozambique Channel on floating logs (Censky et al., 1998). McCall's (1997) contention that there is geological evidence for a Cenozoic land bridge between Africa and Madagascar along the Davie Ridge is unfounded (see Krause et al., 1997a). Although seamounts that may have been emergent do exist, they would have been but small dots of land in a vast seaway some 400 to 1000 km wide.

PROSPECTUS

A densely sampled fossil record coupled with well-supported phylogenetic hypotheses and sound paleogeographic models are the fundamental building blocks of paleobiogeographic analysis. Although the record of terrestrial and freshwater vertebrates from the Mesozoic of Gondwana has improved dramatically in the last two decades, it is still sparse. One of the key stumbling blocks for testing the paleobiogeographic hypotheses outlined here is the virtual lack of terrestrial and freshwater vertebrates from the post-Cenomanian Late Cretaceous of Africa. Major gaps in the fossil record of other Gondwanan landmasses, including Madagascar (Fig. 3), remain as well.

The Mahajanga Basin Project will continue to exploit the fossil riches of the Maevarano Formation and to test biogeographic hypotheses on the basis of new finds. The number of new taxa discovered in our most recent field season demonstrates that many more await discovery. Our efforts will also extend explorations into other horizons in the basin, most notably the underlying Ankazomihaboka beds (Fig. 2), which have already demonstrated their potential through reconnaissance forays in 1996 (Curry, 1997) and 1998. The Ankazomihaboka beds overlie Coniacian basalts, which have been dated to 87.6 ± 0.6 Ma and purportedly signal the time of separation between Madagascar and the Indian subcontinent (Storey et al., 1995).

Finally, the results of the Mahajanga Basin Project provide focus for future geophysical research. In particular, the paleobiogeographic hypotheses outlined in this report underscore the need for more research in the southern Indian Ocean, with attention being directed toward resolving the time of separation between India-Madagascar and Antarctica and the role that the Kerguelen Plateau may have played in connecting those two landmasses in the Late Cretaceous. Paleontologists and geophysicists have much to gain by working synergistically to provide reciprocal illumination on the sequence and timing of Gondwanan fragmentation.

ACKNOWLEDGMENTS

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Todd Berggren, GSA Information Technology Manager

Together at Last!

To meet the needs of our members and handle that pesky Y2K problem, GSA headquarters has made several recent changes to its network and, most important, its database systems. Starting in June, we went "live" with a software package called iMIS, the industry leader in association software, combining all solutions to association needs.

Before the conversion to iMIS, GSA had more than 20 unique databases residing on several different computing platforms and using different system software. Over a short period of time, and with the help of other staff at headquarters, we combined all these databases into iMIS.

With this core database system, we now have a central area for:

- **membership management**
- **meetings management**
- **exhibits management**
- **committee management**
- **fund raising**
- **dues and subscriptions**
- **postal automation software**

and much more.

Using iMIS, GSA will streamline many of its business practices to the benefit of our membership as we launch into the 21st century.

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Earth System Science: An Interdisciplinary Approach

Donald R. Johnson, Martin Ruzek, Mike Kalb, *Universities Space Research*

Earth System Science

Earth system science views Earth as a synergistic physical system of interrelated phenomena, governed by complex processes involving the geosphere, atmosphere, hydrosphere, and biosphere. Fundamental to the Earth system science approach is the need to emphasize relevant interactions of chemical, physical, biological, and dynamical processes that extend over spatial scales from micrometers to the size of planetary orbits, and over time scales of milliseconds to billions of years. In building on the traditional disciplines to study Earth, the system approach has become widely accepted as a framework from which to pose disciplinary and interdisciplinary questions in relationship to humankind. Earth system science forms the foundation of NASA's Earth science vision as well as the basis of the NSF geoscience long-range planning effort as part of the nation's global-change research objectives.

Within the concept of Earth as a complex and dynamic entity involving the disciplinary spheres for land, air, water, and life, no process or phenomenon occurs in complete isolation from other elements of the system. While this system view is elegant and satisfying philosophically, the challenge to researchers and educators attempting to quantify the breadth of the system's elements, states, and processes within the classroom is enormous. No individual, academic department, or university is capable of developing and offering the enormous depth and breadth of knowledge such a paradigm demands. Only by joining faculty from different disciplines within and among universities can the diversity and complexity of Earth system science be fully appreciated.

The challenge for educators to develop and offer courses in the classroom that provide this deeper understanding is demanding. Earth system science seeks to construct an overarching interdisciplinary framework of process and state of the system, and at the same time retain the strength of traditional disciplines for understanding fundamentals and complex interactions. Colleges and universities have been attracted by this holistic approach to studying Earth and adopt Earth system science as a theme. In developing and offering introductory and advanced courses that are relevant to the broader interests of faculty and students, the challenge is to provide the necessary depth and breadth needed to serve as a foundation for advanced study among majors, and lay the foundations for sustainability and informed stewardship in striving for an Earth-aware society.

ESSE Program

As Earth system science emerged as a framework for addressing the scientific dimensions of global change, NASA, the Universities Space Research Association (USRA), and university scientists concluded that mechanisms were urgently needed to stimulate collaboration among scientists and departments within universities, among universities, and between university and government science centers. As a result of those discussions, USRA formulated the Cooperative University-based Earth System Science Education (ESSE) concept that created a university-based cooperative effort in earth science curriculum development and interdisciplinary course offerings. The framework was designed to overcome traditional barriers and foster interdisciplinary science education.

Twenty-two U.S. universities were selected in 1991 to participate in the original ESSE program. In 1995, the program was extended to bring an additional 22 colleges and universities into it through the year 2000. This second phase extends the emphasis of the program across the broader interests of global change by including disciplinary interests from the intersection of human dimensions with the climate system. Thousands of students are enrolled in ESSE courses each year, and more than 100 faculty and teaching assistants are directly involved.

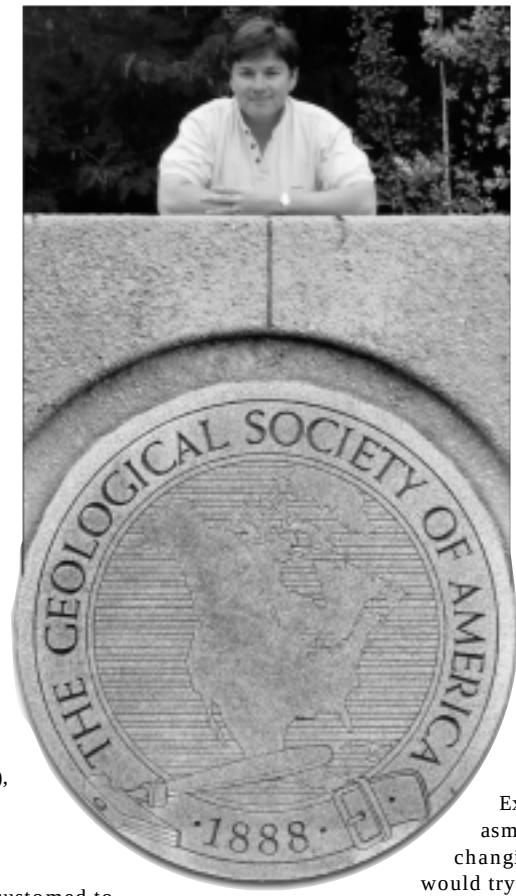
ESSE emphasizes classroom education collaboration, a network of faculty and students focused on the scientific and human dimensions of global change, and a shared repository of teaching resources. ESSE participants design and offer survey and senior level courses on Earth system science topics. A scientist-faculty exchange component of the program brings to the classroom expertise and perspectives different from those at the host campus. Sharing of materials is accomplished via the ESSE Web site (http://www.usra.edu/esse/essonline). An electronic list server focusing on the interests of the broader Earth system science and global change education community has also been established as a forum for discussion of relevant topics and questions for the participants. Hands-on workshops and tutorials are held each year for faculty and teaching assistants to exchange and develop content and familiarize participants with new software tools and methods for the classroom. An overarching objective of ESSE is to develop interdisciplinary courses and topical modules for the classroom through collaboration among universities and other partners.

Learning Modules

ESSE participants have identified a series of 14 interdisciplinary topics as the basis for the creation of "learning modules" (see the ESSE Web site). Topics were purposely selected to cross disciplinary boundaries and offer an integrated perspective of Earth system science. A module subtopic, or submodule, is populated with resources or instructional materials designed to impart specific concepts or skills. Each topical module is a collection of individual submodules that can stand alone for use in the classroom or laboratory for explaining key concepts, or be used along with other submodules to support a larger effort.

SAGE Remarks *continued on p. 9*

New CEO Sara Foland Focuses on GSA Budget, Partnerships, Globalization



Sara Foland, who officially began work as GSA's new chief executive officer on July 6, 1999, has ideas for redirecting the Society and is wasting no time in implementing them. Her reorganization of the headquarters staff in Boulder, Colorado, is aimed at providing better service to GSA members and encouraging partnerships with other geological associations.

Foland's focus for GSA flows naturally from her educational and work experience: she earned Bachelor of Science degrees in geology and chemistry—as well as an Executive Master's in business administration—from Indiana University and a Master's in geology from the University of Montana. She is now working on a Ph.D. through the University of California, Santa Cruz; her dissertation concerns tectonics of the northern end of the San Andreas fault system. She worked for Amoco in geotechnical and leadership positions, and during her 16 years there she was also involved with universities and secondary and primary science education programs. Most recently she was CEO and president of Farallon Energy Group Ltd. (in Denver), a new-venture, independent oil and gas company.

CHALLENGES

As an applied geologist, Foland is accustomed to meeting budgets, and that will be an immediate and ongoing effort for her at GSA headquarters. "I want to be an effective liaison with the GSA Council and fiscal groups, and to develop, with those groups, the means to make changes that will benefit GSA members," she said, "and I plan to work with the Committee on Investments to balance the funds GSA invests in."

DIRECTIONS

Where must GSA head to be competitive with other geoscience associations? According to Foland, "We need to leverage strategic partnerships with other organizations, to avoid redundant effort and make the best use of available resources." She cited the need to learn more about GSA members in order to offer to them the services (such as meetings) and products (publications, for example) they want. GSA's new centralized database, in the iMIS system, and regularly scheduled membership surveys will speed up this information gathering greatly, she said. "We also need to look at what we do at headquarters, to be the most efficient we can with time and money."

GOALS

Foland says she wants to be able to "leverage our financial strength and core competencies, especially in publications and meetings, so that GSA becomes THE geological society, an organization that all geoscientists want to be members of and that funders of geoscience initiatives want to contribute to."

Her own performance objectives include balancing the Society budget, designing and beginning an annual planning process tied to the GSA Strategic Plan and its mission and vision, working with members and staff to define GSA's image and values, promoting communication between headquarters staff and GSA members, and taking GSA global, so that it develops an international presence.

IMPRESSIONS

Foland praises GSA governance (Council, Executive Committee) and staff for their "enthusiasm, recognizing the need for change in this quickly changing world, and willingness to hire someone who would try new things." Members of the search committee say they were impressed with Foland's fiscal acumen, experience in applied geoscience, and ongoing activity as a practicing geologist.

ENERGY FACTOR

Foland, a Denver resident, is a member of the American Association of Petroleum Geologists, American Association of University Women, American Geophysical Union, Rocky Mountain Association of Geologists, Sigma Xi, and Society of Exploration Geophysicists, as well as GSA (since 1983). She is on the boards of several philanthropic organizations and is a trustee for the University of Montana Foundation. She has a private pilot certificate (commercial rating) and enjoys fly fishing, skiing, and golf. ■

SAGE Remarks *continued from p. 8*

ESSE participants are in various stages of developing these modules and testing their effectiveness in a classroom situation.

Peer Review

To assist with the formal quality control and recognition of Earth system science learning resources, ESSE has proposed a peer-reviewed on-line *Journal of Earth System Science Education* (JESSE) for the purpose of creating a common repository of quality Earth system science education resources for undergraduate and graduate classroom instruction. JESSE peer review will offer to the authors of these materials recognition for their commitment to education, and may assist in institutional reward and tenure decisions. An editorial-advisory board will refine and implement the review process and establish review criteria, including content accuracy, pedagogical effectiveness, and presentation format. If financial support is forthcoming, an innovative and open peer review process will be implemented, encouraging reviewer-developer communication, with provision for confidential exchange.

Outcomes

Several outcomes have emerged from the ESSE program that are evident from the direct faculty involvement. The offering of courses and development of content for Earth system science requires genuine collaboration, sharing knowledge across disciplines and exploring together those aspects of the system between traditional disciplinary boundaries. Several hundred faculty, lecturers, and teaching assistants in the United States, Canada, and Central and South America form a coordinated interdisciplinary partnership of institutions and individuals to develop the breadth and depth of scientific knowledge required for offering the course content of Earth system science in the classroom. ■

WASHINGTON REPORT

Bruce F. Molnia, *bmolnia@erols.com*

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. These reports present summaries of agency and interagency programs, track legislation, and present insights into Washington, D.C., geopolitics as they pertain to the geosciences.

Meet Charles Groat, Director of the U.S. Geological Survey (Part 1)

Charles G. Groat became the 13th director of the U.S. Geological Survey on November 13, 1998. Secretary of the Interior Bruce Babbitt described Groat as having "the right mix of academic background, skills, and experience for providing leadership to the USGS." Babbitt continued, "There is a pressing need for good science to guide safe and informed decisions. The U.S. Geological Survey plays a critical role in science in this country and, indeed all over the world." Groat, Babbitt has said, "has a fine scientific mind, and he will bring the Department an impressive array of management, research and scientific advocacy skills that will make him an invaluable asset and serve all Americans well."

Groat, 58, has had a distinguished career in the earth science community—more than 25 years of direct involvement in geological studies, energy and minerals resource assessment, groundwater occurrence and protection, geomorphic processes and landform evolution in desert areas, and coastal studies. Prior to joining the USGS, he was Associate Vice President for research and sponsored projects at the University of Texas at El Paso (UTEP). Prior to that, he was UTEP's director of the Center for Environmental Resource Management, director of its environmental science and engineering Ph.D. program, and a professor of geological sciences.

From 1992 to 1995, Groat served as executive director of the Center for Coastal, Energy, and Environmental Resources at Louisiana State University. He served as executive director of the American Geological Institute from 1990 to 1992. From 1983 to 1988, Groat was assistant to the Secretary of the Louisiana Department of Natural Resources, where he administered the Coastal Zone Management Program, and the Coastal Protection Program. From 1978 to 1990, he held positions at Louisiana State University and the Louisiana Department of Natural Resources, including serving as professor for the Department of Geology and Geophysics and as Director and State Geologist for the Louisiana Geological Survey. From 1976 to 1978, he was an associate professor at the University of Texas at Austin, in the Department of Geological Sciences, and associate director and acting director of the Bureau of Economic Geology.

Among his many professional affiliations, Groat is a member of the Geological Society of America, the American Association for the Advancement of Science, the American Geophysical Union, and the American Association of Petroleum Geologists. A native of Westfield, New York, Groat received an A.B. degree in geology from the University of Rochester in 1962, his M.S. degree from the University of Massachusetts in 1967, and his Ph.D. in 1970 from the University of Texas at Austin.

GSA TODAY: What was your perception of the USGS prior to beginning as director?

Groat: Ever since I got out of graduate school and went to work, I've had contact with the USGS because I was with the state geological surveys. Even the years that I was out of the state survey and with the universities I was working with the USGS at various times. But it is interesting how you look at the USGS from the outside following gaps in contact. I have seen changes of perspective and how it relates to other parts of the geoscience world. In the early days of being a state geologist and working with the USGS, the culture was kind of "us and them." They [USGS] had their own agenda and didn't appear to have much respect for "us," the state surveys. I came back in the 80s, and there was still some of that, but there was more cooperation in programs such as some of the coastal initiatives. Geological mapping was starting to come along, and there were pods within the USGS and pods within the states that were finding ways to do programs together. Now I see a real solid attempt and interest in building this close working relationship with groups outside of the USGS who have use for the products, who can be potential partners, or who have common objectives. Some parts of the organization [USGS] don't see our science going in that direction; they feel that there are legitimate reasons that some science ought to be done for its own sake. Many others feel that the applications are as important as the basic kind. So I think that it truly has gone from one view of an organization to one in transition, to one that is still in transition but certainly is building on its best attributes, which are quality science and objective science. All through the contacts that I and many others have had with the USGS from early on, the credibility of this organization has always been perhaps its greatest asset, because people trust it. They trust its science and they hold it as objective.

GSA TODAY: Now that you have been on board for nearly half a year, has that perception changed?

Groat: It has changed only in detail. I came in right at the time that the Strategic Plan was developed. I had first hand involvement in where the Survey was trying to go, where it was planning to go, but without detail. Since then I've become more involved in what that really means, what is happening in the divisions, and what's happening with our budget. So my perception has changed only in the sense that I understand both the challenges to make some of these things happen and, maybe even more important than that, the tremendous opportunities that are out there if we are successful. The one feeling I've had, whether it's the USGS, the state survey, or academic geoscience, is that we've never been able to insert ourselves into arenas where we should be big players. Maybe it's because of our tendency to want to be scientists in the field doing our thing. That is an oversimplification, but we have never forced our science into the public arena to the extent that we could have or that some of the engineering organizations have, for example. What we can offer in science for policy-making and decision-making is tremendous. The potential is so great, and it is wonderful to see us headed in that direction, but we have a long way to go.

GSA TODAY: What would you do to make the USGS a household word?

Groat: We have to work a lot harder to just begin convincing people that it's important that they know what we do, because it's important that they use what we produce. We have to raise our profile with the people who support us and who build our programs through financing. This should include a genuine effort to get ourselves into everyone's mind from school kids and the people on the street to the technical and policy audiences we should be serving. Doing this causes some to say that if you put all this emphasis on what we are and on selling our products, then we become an information agency rather than a science agency. I think we really have to become an information group, but not at the expense of science. A big piece of becoming an information group is targeting our identity and our products and our capabilities to the right audiences. That is hard work and that is a lot further than a science-only organization ever felt that it had to go or ever built a capability to do. If we are truly interested in our applications, we have to emphasize our products and be recognized as their producer.

GSA TODAY: Secretary Babbitt has stated, "There is a pressing need for good science...." How would you interpret this with respect to the USGS?

Groat: Babbitt has an intense interest in science, and his attempts to make us more a science agency in support of and on behalf of the Department of the Interior (DOI) bureaus is a sign that he is serious about it. He really feels science needs to be more of a factor in decision-making processes within the department and outside the department. His statement reinforces the importance of our role.

GSA TODAY: Nearly all federal terrestrial and marine science now is performed by either NOAA [National Oceanic and Atmospheric Administration] or the USGS. Do you foresee any efforts to combine those two agencies into a single federal science of the earth agency?

Groat: My impression is that we are seen as a much more science-oriented organization as a whole than is NOAA. Particularly with a move toward integrated science, the idea of bringing oceanography and atmospheric sciences together with traditional solid earth, and now biological, sciences, and forming this total-picture kind of science package is one that would resonate with a lot of people.There have been past efforts to create a Department of Science type of organization within the federal government, and they always run into such practical obstacles as Authorizing and Appropriations Committees turf and clients turf.

GSA TODAY: In the last year, there has been a major effort by several members of Congress to double the federal science budget. Specifically, the DOI has been excluded from that because of past lack of confidence in the department over grazing issues and mining law reform. Is there any way that the USGS will be able to overcome its association with the other aspects of the DOI and be included with the other federal science agencies?

Groat: I think the other reason for exclusion was that since the BRD [USGS Biological Resources Division—the former National Biological Service] is now part of the DOI, it brings endangered species issues in, and these are not popular on the Hill. Through the efforts of the American Geological Institute (AGI) and other supporters, we were amended back into the process. Will science funding ever be doubled? There isn't any clear sign people are willing to support science to that degree. Is there a willingness in our own department to honor science to the degree that it lets us leap above the 3%–4%–5% a year budget growth and really make science grow within the department? I wouldn't argue to double, necessarily, but I think that we need some 15%–20% changes to do more than keep up with inflation.

GSA TODAY: The USGS is now the largest biological science organization in the federal government. Does this present any potential problems to the geological future of the USGS?

Groat: I don't think that it does. BRD adds a research dimension, a science dimension that is important. The other thing they brought that will strengthen the USGS is their service attitude. They came out of organizations where they were expected to provide science to meet the road very directly. The view that our science does need to meet real needs will be good for us in the long run. On the other side, we will encourage them to have more of a science core that isn't strictly tactical. The addition of BRD greatly enhances our ability to integrate science, and that is very important for our future success.

GSA TODAY: In addition to biology and geology, the USGS has the largest water resources and civilian mapping capability in the U.S. government. How do you balance and integrate these four diverse capabilities?

Groat: I don't see balance as a major issue. I think the integration is hardest to do in practice and easiest to do in concept. The growing complexity of the issues we must deal with and the need to understand cycles and systems that are multidimensional are becoming more evident every day. That is where the great scientific challenges are today, understanding systems and integrating societal issues—the socio-economic piece—into it. There are still people within the disciplines who feel threatened by this, because they feel it will compromise the quality of their science and perhaps the reason they got into science in the first place, which is to be their own master and follow their own lead. But if we are talking about substantial growth and what science is going to contribute in the future, particularly in the earth and life sciences, it is going to have to be integrated. Even in the field, in our own organization, when a hydrologist, a geomorphologist, and a biologist are brought into the same room to discuss a problem, the synergism is automatic. There just isn't any problem with this. The problem is when you come up the management structure further, and we start worrying about budget processes and assessment rates and turf and control, and those sorts of things that are parts of academic departments, colleges, or USGS divisions. That is where the real barriers and challenges come in making integrated

Washington Report *continued on p. 12*

Exxon Short Course at the 1999 GSA Annual Meeting

Clastic Facies and Sequence Stratigraphy for Graduate Students Only

Saturday, October 23 and Sunday, October 24, 8:00 a.m. to 5:00 p.m.
Sponsored by *Exxon Production Research Company*

This course is designed to teach graduate students the principles, concepts, and methods of sequence stratigraphic analysis in clastic strata. Sequence stratigraphy uses an integrated approach to studying depositional systems and is critical to developing a framework for analysis of reservoir-aquifer connectivity in both hydrocarbon and environmental applications. Focusing on the fundamentals of sequence stratigraphy, this course provides participants with hands-on experience in depositional facies analysis using outcrop and core together with well-log and seismic data.

Limit: 30. No fee. Preregistration required. For information: Art Donovan, Exxon Production Research Company, (713) 973-3148, fax 713-973-3340, art.d.donovan @exxon.sprint.com; or Morgan Sullivan, Exxon Production Research Company, 3120 Buffalo Speedway, Houston, TX 77098, (713) 431-6396, morgan.d.sullivan @exxon.sprint.com.

PENROSE CONFERENCE SCHEDULED

Great Cascadia Earthquake Tricentennial

June 4 – 8, 2000

The year 2000 marks the tricentennial of the last great (magnitude 8 or larger) earthquake at the Cascadia subduction zone, located along the Pacific coast of North America. Coastal and offshore geological work has confirmed that many great subduction earthquakes have struck this region in the last several thousand years. In addition, geodetic studies have shown that the subduction zone is accumulating strain that will be released in one or more future earthquakes.

Further understanding of this earthquake potential is required for seismic hazard characterization, engineering design, emergency planning and response, and other mitigation efforts in the western parts of British Columbia, Washington, Oregon, and northern California, which are home to some 6 million people. Particularly needed are (1) reliable estimates of magnitude and frequency of occurrence, (2) assessments of the severity of seismic hazards, (3) effective transfer of such information to engineers, public officials, and others involved in hazard mitigation, and (4) consequent measures to reduce future losses of life and property.

These issues will be explored during a four-day Geological Society of America Penrose Conference at Seaside, Oregon, in the tricentennial year of the 1700 Cascadia earthquake. The conference will bring together 75 earth scientists, engineers, public officials, and hazard-mitigation professionals to critically review current knowledge about great Cascadia earthquakes, clarify the hazards posed by future earthquakes such as strong ground shaking and tsunamis, discuss appropriate strategies for reducing losses from these earthquakes, and identify new research directions. Seaside was chosen as the venue for the conference because of its location at the center of the Cascadia subduction zone and its proximity to both major population centers in the Pacific Northwest and the field trip site. The town is situated on the spectacularly scenic and geologically interesting Oregon coast.

The conference will be multidisciplinary and multinational in scope. Efforts to reduce losses from future Cascadia earthquakes extend far beyond earth science into engineering and public policy. The efforts also cross boundaries between political jurisdictions, for the Cascadia subduction zone spans more than 1000 km of the Pacific coast, and useful perspectives come from subduction zones in Central and South America, Alaska, and Asia.

The conference will consist of three days of discussions, prompted by talks and posters, and a one-day field trip. Sessions

Washington Report *ontinued from p. 11*

science a more important part of what scientific organizations do. We have to make sure that for the scientist, the reward system supports doing that kind of work. This doesn't mean that all discipline-based, focused science will go away in the USGS or any place else. We can't and shouldn't get away from understanding basic phenomena or basic characteristics that underpin complex systems and interpretations.

GSA TODAY: There is a clear-cut demarcation between each of the four USGS science divisions; Biological Resources, Geologic, National Mapping, and Water Resources. Do you see a time in the near future when that arbitrary demarcation will disappear?

Groat: No, I really don't. I believe structure is less of an issue than leadership. If you come up with a list of reasons as to why this structure hinders things we aspire to do, there aren't alternatives that are clearly better at this point. The trauma, the destruction, the agony, and the number of years it would take us to work our way through all of that—we could lose too much momentum and capability. I think that we have a much better chance of structuring programs to meet changing needs by having leaders in those divisions and in my office who have progressive attitudes and scientists who believe that this is the way to go. You can make the present structure work if there is the will and the leadership to do it.

GSA TODAY: Several years ago, the USGS reinvented itself with a focus on four themes: Environment, Hazards, Information Management, and Resources. Do you see any need for changing these four themes and if so, how would you do it?

Groat: I think that they are broad enough. If you look to where our science has gone and the ability for our science to serve, those themes are pretty good umbrellas to work from. I've been more interested in seeing how the coordination takes place to make those themes work in practice. How hazards, for example, are not just a Geologic Division program. Flooding problems have a Water Resources Division focus but there are also biological and geological dimensions. If those are going to be themes that we build our Strategic Plan and our future around, then how do we build our programs around those in a way that serves the themes well by integrating division involvement? I think the themes are solid ones, and I don't think that they are limiting in any way.

GSA TODAY: The USGS response to Hurricane Mitch, where you have hazards, environment, and information management scientists all working together and all four divisions actively participating, serves to show that there is a synergism that can develop that pulls the right pieces out of the USGS to deal with a specific disaster. Is this a model for the future?

Groat: With the existence of the Center for the Integration of Natural Disaster Information (CINDI), the mapping piece and the remote sensing piece were already there. Then you bring the science in; you go to the Geological Division. BRD at first didn't think that they had much of a role to play there, but when they got in they found that they did. So how do we identify those pieces and make sure that they are there in an efficient way and get the enthusiasm and the interest up? It's not so much the structure as it is the attitude and the willingness to do that. The Hurricane Mitch response has provided a good laboratory for making this interaction work.

GSA TODAY: In the last few years, the USGS has become more regionalized. Is that a trend that you see continuing?

Groat: I think one of the reasons the regional emphasis has grown is because nearly everything that we do in the field has a regional basis. If we are concerned about partnering and about customers and stake holders being involved in both the planning and the implementation of programs, we have to be where they are. That is where real needs are generally identified, more so than at the Washington level. So there is a real operational reason to be efficient and effective at the regional level. That raises the question to what degree do you manage programs at the regional level. We have learned that using a regional focus is an effective way of getting people together to do things. Another part of the regional piece is how concentrated should we be regionally? Do we

will deal with hazards posed by great Cascadia earthquakes and the mitigation of these hazards; past earthquakes and tsunamis, tectonics, and present-day seismicity and strain accumulation. Evidence for past Cascadia earthquakes and tsunamis will be examined and discussed during a canoe trip along nearby Lewis and Clark River. The field trip will include a visit to historic Fort Clatsop and examination of cores from Bradley Lake, Oregon, which contain a 7000-year record of tsunamis produced by great Cascadia earthquakes. A public forum on Cascadia earthquakes and tsunamis will be held just before or during the conference and will provide participants an opportunity to hear concerns of coastal residents.

The format of the meeting is designed to ensure critical thought and interaction among participants. Formal lectures will be limited, and most of our time will be spent in group discussions and poster sessions. There will also be opportunity for informal discussion and relaxation during evenings.

The conference is limited to 75 participants. We encourage participation of graduate students working on Cascadia great earthquake topics; limited subsidies will be provided to selected students. The registration fee, which covers lodging, meals, the field trip, and all other conference expenses except personal incidentals is not expected to exceed U.S. $700. Participants will be responsible for transportation to and from Seaside. Further information will be provided in the letter of invitation.

Interested scientists, engineers, public officials, hazard-mitigation professionals, and graduate students are invited to participate. Because the time allocated for formal talks is limited, most participants will be expected to present a poster. Significant time will be reserved for poster discussion. Selection of participants will be made by the conveners and based on a submitted abstract, previous publications or experience, and topical and geographical areas of expertise.

Co-conveners are *John J. Clague,* Dept. of Earth Sciences, Simon Fraser University, Burnaby, BC, V5A 1S6, Canada, and Geological Survey of Canada, 101-605 Robson St., Vancouver, BC V6B 5J3, Canada, jclague@sfu.ca; *Brian F. Atwater,* U.S. Geological Survey at Dept. of Geological Sciences AJ-20, University of Washington, Seattle, WA 98195, atwater@ u.washington.edu; *Kelin Wang,* Pacific Geoscience Centre, Geological Survey of Canada, 9860 West Saanich Road, Sidney, BC V8L 4B2, Canada, wang@pgc.nrcan. gc.ca; *Yumei Wang,* Oregon Department of Geology and Mineral Industries, 800 NE Oregon St., No. 28, Portland, OR 97232, meimei.wang@state.or.us; and *Ivan G. Wong,* URS Greiner Woodward Clyde Federal Services, 500 12th St., Ste. 200, Oakland, CA 94607, Ivan_Wong@urscorp.com.

Application deadline is December 1, 1999. Invitations will be mailed to participants at the end of January 2000. Potential participants should send a letter of application to John Clague, Dept. of Earth Sciences, Simon Fraser University, Burnaby, BC V5A 1S6, Canada. The application should include a brief (less than 250 words) abstract of the poster or talk the applicant would present at the conference. To facilitate conference organization, participants are asked to state what they perceive to be the most important questions requiring resolution. ■

have a Reston–Denver–Menlo Park concentration, or do we have a few more centers tied to programs—dispersing ourselves a little more, with certain critical masses tied to programs that are regionally important? The region and what its dominant program needs are would dictate what we would have there. A place like Menlo Park might have a hazards focus complemented by other regionally relevant programs. Another part of the regional picture that is still evolving is the part driven by the efficiencies of co-locating with other organizations who have complementary capabilities and interests, where we can partner and share the costs and the benefits of working together.

GSA TODAY: Gordon Eaton, your predecessor, characterized the future of the USGS in terms of customers, outreach, and relevance. How does this characterization fit your perception of the future of the USGS?

Groat: I agree with Gordie that the success of our programs will depend on our ability to incorporate those. The negative spin on this has been more internal—people feel we are going to change what we are and what strengths we build on, to accommodate those elements. Building these does not change our whole reason for existence. If we aren't successful in developing all of those areas, our future will be pretty dim. Our Strategic Plan emphasizes the role of all three.

To be continued. ■

USGS Publishes Papers on Loma Prieta Earthquake

The U.S. Geological Survey has completed the professional papers *The Loma Prieta, California, Earthquake of October 17, 1989,* prepared in cooperation with the National Science Foundation. USGS Professional Papers 1550–1553 comprise 16 chapters. The 2,773-page publication contains 162 manuscripts. Coordinators were William Bakun and William Prescott for volume 1550, Thomas L. Holzer for volumes 1551 and 1552, and Dennis S. Mileti for volume 1553. The publication is sold as individual chapters, as follows.

Professional Paper 1550—*Earthquake Occurrence:* A, Main-Shock Characteristics; B, Forecasts; C, Preseismic Observations; D, Aftershocks and Postseismic Effects; F, Tectonic Processes and Models.

Professional Paper 1551—*Strong Ground Motion and Ground Failure:* A, Strong Ground Motion; B, Liquefaction; C, Landslides; E, Hydrologic Disturbances; F, Marina District.

Professional Paper 1552—*Performance of the Built Environment:* A, Lifelines; B, Highway Systems; C, Building Structures; D, Earth Structures and Engineering Characterization of Ground Motion.

Professional Paper 1553—*Societal Response:* A, Loss Estimation and Procedures; B, Public Response; C, Fire, Police, Transportation, and Hazardous Materials; D. Recovery, Mitigation, and Reconstruction.

The publications are available from: **USGS Information Services, Box 25286, Denver, CO 80225. Also see http://greenwood.cr.usgs.gov/propaper.html, or call 1-800-HELPMAP.**

GSA DIVISIONS—DO YOU BELONG?

GSA's twelve divisions provide a home for like-minded scientists within the Society as a whole, as well as a focus for cross-disciplinary discussion and interaction. In particular, the divisions help develop the scientific program for the annual meetings, provide opportunities for students to participate in the meetings, and help fund student research.

This is the third article on GSA's Divisions (see May *GSA Today*—v. 9, no. 5, p. 18—for the first and July *GSA Today*—v. 9, no. 7, p. 17—for the second). If you would like to become a part of a GSA division, call Membership Services, 1-800-472-1988.

Geophysics Division

G. Randy Keller, *Division Secretary-Treasurer*

A major goal at GSA is better integration of geophysics into all aspects of the organization, and the Geophysics Division is at the forefront of this effort. For example, the division's major award, the George P. Woollard Award, is given annually to recognize outstanding contributions to geology through the application of the principals and techniques of geophysics. Membership in the division is by no means limited to those who would characterize themselves as geophysicists. Geophysics is a very broad field, and our aim is to be inclusive and to encourage interactions that bring out new ideas and thus opportunities. For example, few would have envisioned the role geophysics plays today in archeology and environmental studies.

Encouraging and supporting students is a priority in the division, and the Allen V. Cox Award is given each year to the outstanding student research grant project that involves the principals and applications of geophysics. We welcome donations to the endowment that helps to fund this award. If dues income is large enough, we fund an additional student research project in geophysics. Support for students consumes >90% of the division's annual expenditures.

The division plays a major role in encouraging, sponsoring, and organizing geophysical contributions at the annual meeting, and we are always looking for help and ideas. The same is true for short courses. We believe that a strong geophysical presence at the annual meeting is a key to increasing the level of participation of geophysicists in GSA activities. In addition, members of the division often organize geophysical sessions and activities at GSA section meetings.

Another goal of the division is to foster interactions and communication between geophysicists and those interested in geophysics. Each year the division holds a joint social function with the Structural Geology and Tectonics division. The division's Web page is evolving and serves as a link to major geophysical research projects around the world. The goal is for this Web site to act as a ready link to important sources of geophysical information.

Structural Geology and Tectonics Division

Stephen Marshak, *Division Chair, smarshak@uiuc.edu*

The Structural Geology and Tectonics Division emerged from an after-dinner conversation at a GSA Penrose Conference held near New Paltz, New York, in 1980. Participants recognized that despite intense interest in structure and tectonics fostered by the plate tectonics revolution, there was no representation of the discipline at GSA. Once established, the division grew to have a membership of more than 1500, making it the largest GSA Division, even though it's one of the youngest.

The division sponsors numerous activities designed to foster interest in structure and tectonics and to improve communication among researchers, teachers, and students working in the discipline. Every year, the division gives the Career Contribution Award to a distinguished geologist who has had a major impact in structure and/or tectonics over many years. We also offer a Best Paper Award to highlight recent contributions in print, and two student research awards to recognize exciting research in progress by graduate students. At the GSA Annual Meeting, in addition to holding a business and award meeting and a reception, we sponsor theme sessions, symposia, field trips, and short courses to draw attention to subjects of interest to division members. The division offers subsidies to assist students in participating in division-sponsored field trips. Twice a year, we publish a newsletter that includes updates on research sponsorship at NSF, as well as information on members, and we sponsor a Web page that outlines division activities and announces upcoming meetings. We are improving links with our European colleagues by contributing to the International Association of Structural Geologists, and by cosponsoring an upcoming meeting of the Tectonic Specialist Group in the UK.

Because of concern over diminishing resources for funding research, the division has taken an increasingly active role in drawing attention to past research accomplishments and future research directions in structure and tectonics. A division-sponsored committee produced a "white paper" about current research activities in structure and tectonics. This document was provided both to division members and to funding organizations.

There's no better way to keep current with what's happening in structure and tectonics than to join the division and visit the Web site.

Quaternary Geology and Geomorphology Division

Ardith K. Hansel, *Division Chair, hansel@isgs.uiuc.edu*

The second largest GSA division, the Quaternary Geology and Geomorphology Division (QG&G) will be 45 years old in 2000. The division brings together a diverse and interdisciplinary group of more than 1,350 earth scientists who study the Quaternary record and surficial processes. At the GSA Annual Meeting, our scientists present ideas and discuss problems, honor colleagues for their research and publications and advise the officers and committees of GSA about Quaternary geology and geomorphology.

The division's award program promotes research and recognizes excellence in Quaternary geology and geomorphology. Two awards assist students: the J. Hoover Mackin Research Grant for Ph.D. research and the Arthur D. Howard Grant for M.S. research. The Distinguished Career Award recognizes demonstrated excellence and contributions to Quaternary geology and geomorphology. QG&G is also active in selecting recipients for two GSA awards, the Kirk Bryan Award, for a published paper of distinction advancing the science of geomorphology, and the Gladys W. Cole Memorial Research Award, for support of research on semi-arid and arid terrains. Two new awards have been established. This year, the first Farouk El-Baz Award will recognize an outstanding contribution in desert research. In 2000, the first Don J. Easterbrook Distinguished Scientist Award will honor unusual excellence in published research in Quaternary geology and geomorphology.

Quaternary geology and geomorphology is an integral and growing part of GSA. Check out the QG&G technical program and field trips at the 1999 GSA Annual Meeting in Denver in October. Awards are presented at the annual reception held on Tuesday evening. You are invited to join QG&G. We are always looking for new members, especially students.

Geoscience Education Division

Nancy West, *Division Chair, nancyww@mindspring.com*

The Geoscience Education Division spans disciplines represented in the Society. Any geoscientist with an interest in teaching—formally or informally—is welcome to join. The division's

GSA Divisions *continued on p. 15*

CALL FOR GEOLOGICAL PAPERS FOR 2000 GSA SECTION AND ANNUAL MEETINGS

NORTHEASTERN SECTION
March 13–15, 2000
Regency Hyatt Hotel,
New Brunswick, New Jersey

Abstract Deadline:
November 29, 1999

Submit completed abstracts to:
Kenneth G. Miller
Dept. of Geological Sciences,
Wright Lab
Rutgers University
610 Taylor Rd.
Piscataway, NJ 08854-8066
(732) 445-3622
kgm@rci.rutgers.edu

SOUTHEASTERN SECTION
March 23–24, 2000
Westin Francis Marion Hotel,
Charleston, South Carolina

Abstract Deadline:
December 8, 1999

Submit completed abstracts to:
June E. Mirecki
Department of Geology
College of Charleston
Charleston, SC 29424-0001
(803) 953-8278
mireckij@cofc.edu

SOUTH-CENTRAL SECTION
April 3–4, 2000
Center for Continuing Education,
Fayetteville, Arkansas

Abstract Deadline:
December 8, 1999

Submit completed abstracts to:
John Van Brahana
Department of Geology
University of Arkansas, Ozark Hall 118
Fayetteville, AR 72701-1201
(501) 575-2570
jbrahana@jungle.uark.edu

NORTH-CENTRAL SECTION
April 6–7, 2000
Indiana State Government Center,
Indianapolis, Indiana

Abstract Deadline:
December 20, 1999

Submit completed abstracts to:
Robert D. Hall
Department of Geology
Indiana University–Purdue University
723 W Michigan St.
Indianapolis, IN 46202-5132
(317) 274-7484
rhall@iupui.edu

ROCKY MOUNTAIN SECTION
April 17–18, 2000
Missoula Community Theater,
Missoula, Montana

Abstract Deadline:
January 15, 2000

Submit completed abstracts to:
Marc Hendrix
Department of Geology
University of Montana
Missoula, MT 59812-1019
(406) 243-5278
marc@selway.umt.edu

CORDILLERAN SECTION
April 27–29, 2000
Robson Square Conference Centre,
Vancouver, British Columbia

Abstract Deadline:
January 10, 2000

Submit completed abstracts to:
Peter Mustard
Department of Earth Sciences
Simon Fraser University
Burnaby, BC V5A 1S5, CANADA
(604) 291-5389
pmustard@sfu.ca

GSA ANNUAL MEETING
Reno, Nevada
November 13–16, 2000

Check out the April 2000 issue of ***GSA Today*** for Call for Geological Papers.

ABSTRACT FORM REQUEST FOR 2000 MEETINGS

To: GSA Abstracts Coordinator, P.O. Box 9140, Boulder, CO 80301-9140, or e-mail ncarlson@geosociety.org

- Please send _____ copies of the GSA abstract form for 2000 meetings only. This form may not be used for the Annual Meeting.

Name _____

Address _____

City _____ State_____ ZIP _____ Country _____

GSA Divisions *continued from p. 14*

mission is to foster discussion and participation of members in earth science education.

As scientists interested in education, we can influence instruction in the formal settings of colleges and schools. The division has sponsored theme sessions and symposia to help instructors at all levels improve their teaching. Sponsorship has been shared with sister organizations: NAGT, NESTA, and GSA's Education, Outreach, and Policy Department. Participation in these sessions and membership in the division is growing, reflecting an expanding interest in teaching.

Our membership includes more than 50 K–12 teachers for whom teaching is a primary professional concern and opportunity. This is especially important as the new National Science Education Standards recognize the earth sciences to be as important as chemistry, physics, and biology in K–12 classes.

Members can contribute actively by participating in initiatives such as the Society's Partners in Education Program (PEP). In this program, geoscientists develop a partnership with precollege and informal educators, to the benefit of both.

The division participates in selecting the Biggs Award, and the awardee receives recognition at the division's annual meeting. The Biggs Award is given to a college professor with fewer than 10 years experience who demonstrates excellent teaching in the earth sciences. In 1999, the recipient will be recognized at the NAGT luncheon and education awards ceremony. ■

Rock Stars

INTRODUCTION

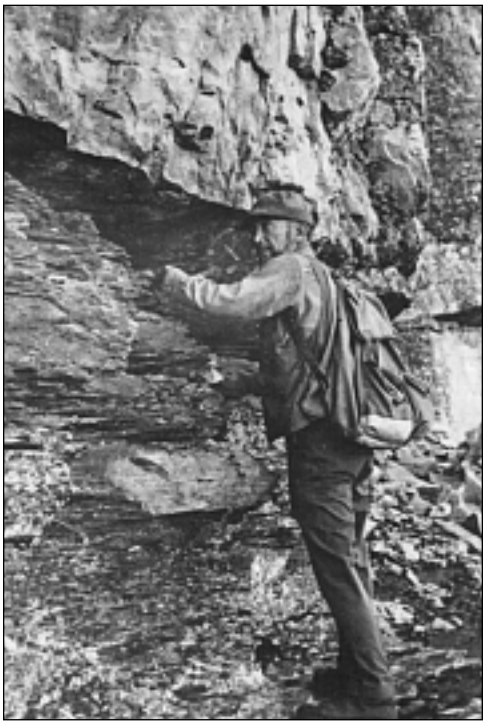
Bernard of Chartres, an 11th-12th century philosopher and teacher, said that we are like dwarfs on the shoulders of giants, so that we can see more than they and for a greater distance, not by any virtue of our own but because we are carried high and raised aloft by their stature.

All of us have our geological heroes, those giants on whose shoulders we stand. To encourage recognition of these luminaries and to provide inspiration for students and young professionals, the GSA History of Geology Division presents Rock Stars, brief profiles of our geological giants. If you have any comments on profiles, please contact Robert N. Ginsburg, University of Miami, RSMAS/MGG, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, E-mail: rginsburg@rsmas.miami.edu.

—Robert N. Ginsburg, History of Geology Division

Preston Cloud: Peripatetic Paleontologist

J. Thomas Dutro, Jr., *U.S. Geological Survey, Washington DC 20560-0137*



In the field, north Bow River slope, Canada, 1968.

Few scientists change the direction and focus of their entire discipline in a lifetime, let alone every few years. Even fewer make the transition from bench scientist to successful science manager and back again. Add a mission, in the waning stages of a career, to alert the public to the dual dangers of burgeoning population and steadily decreasing natural resources, and you have the peripatetic Preston Cloud (1912–1991).

Early Years

Preston Ercelle Cloud, Jr. was born in West Upton, Massachusetts, September 26, 1912; he was the third of seven children in a family headed by an itinerant engineer-draftsman. By the late 1920s, the family was in Waynesboro, Pennsylvania. Preston Cloud loved the outdoors life that led him to hunting and hiking and scouting. He became an Eagle scout, and he graduated from Waynesboro High School in 1929. Cloud escaped the early depression years by enlisting in the Navy in 1930. The feisty young sailor released some of his frustrations through boxing, and he soon became bantamweight champion of the Pacific Fleet Scouting Force. Discharged from the Navy in 1933 in California, he spent that summer hiking and working his way back east.

Cloud in the U.S. Navy, about 1931.

Becoming a Paleontologist

Cloud's resourcefulness, drive, and abilities made him successful in college and graduate school. He took any odd job he could find in 1933, the depth of the Depression, and earned enough money for his first semester at George Washington University.

There, his mentor was Ray Bassler, a part-time professor and curator of paleontology at the National Museum. Bassler, impressed by Cloud's enthusiasm and ability to absorb information rapidly, found work for him at the museum. By his second year, Cloud was working full time as a technician and attending classes at night. He also impressed G. Arthur Cooper, world-famous paleontologist and stratigrapher, and became a preparator in the paleontology laboratory; there he absorbed Cooper's lore and skill in studying fossil brachiopods. Despite full employment at the museum, Cloud completed his B.Sc. and graduated in 1938. In that same year, he published his first paper on brachiopods with Cooper, beginning his career in paleontology.

Cooper had called Yale Professor Charles Schuchert's attention to the hard-working, conscientious Cloud and made certain that he was admitted to Yale as a graduate student in geology with adequate financial support. Cloud started graduate work on brachiopods at Yale, supervised by Carl Dunbar, completed his dissertation on the Silurian and Devonian terebratuloid brachiopods in record time, and graduated in 1940 (the Geological Society of America published his dissertation as a monograph in 1942).

After a year of teaching at Missouri School of Mines, Cloud returned to Yale for postdoctoral work, but in 1941 he was recruited by Josiah Bridge of the U.S. Geological Survey. Cloud worked in a field party studying manganese deposits in Maine as part of a wartime mineral exploration program. This appointment began an association with the USGS that lasted until his death half a century later. The next year, Cloud was appointed party chief of the Alabama bauxite project.

In 1943, Cloud accepted an invitation to join Virgil Barnes of the Texas Bureau of Economic Geology in the Ellenburger Project, studying the stratigraphy and sedimentology of this important early Paleozoic carbonate complex. The resulting monograph established Cloud as a carbonate stratigrapher and paleogeographer; these disciplines were added to his paleontologic background and developed later when he was party chief of the USGS work on Saipan during the geological study of the Trust Territories in the late 1940s.

From 1946 to 1948, Cloud was professor of invertebrate paleontology at Harvard, filling the vacancy left by the death

of Percy Raymond. He resumed work on brachiopods and the Ellenberger manuscript, but was discouraged by the lack of support for expanding the teaching and research facilities in Cambridge. He resigned and returned to the USGS in 1949, to become chief of the Branch of Paleontology and Stratigraphy.

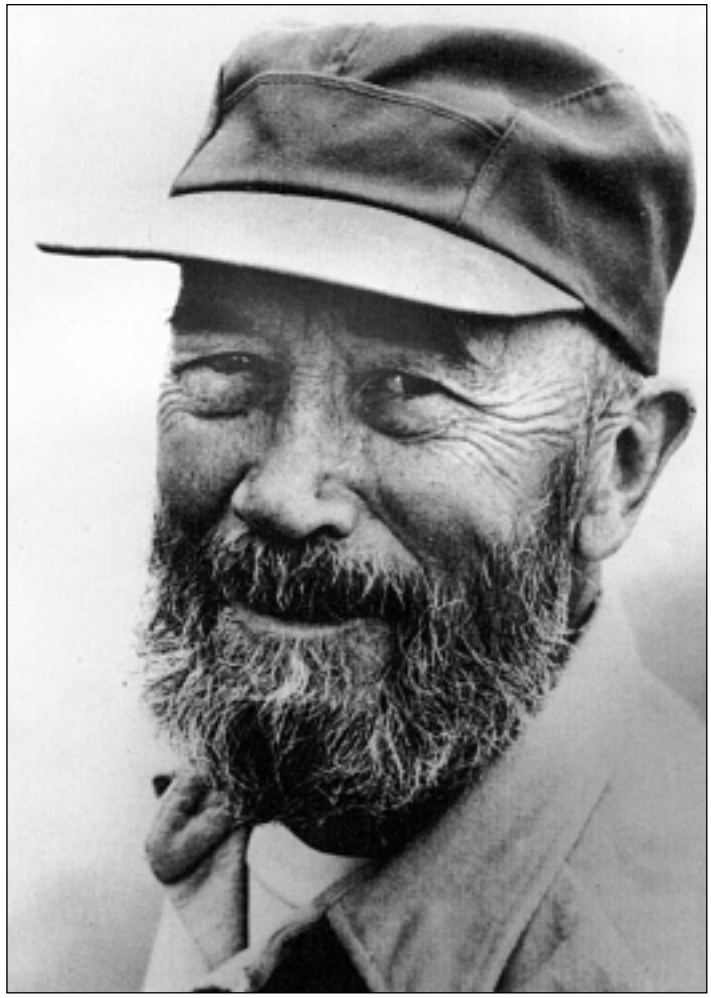
Survey Years

Cloud was the major influence in developing careers of many young paleontologists in the USGS for a quarter-century after World War II. A hard and exacting taskmaster, Cloud organized a paleontology and stratigraphy unit that acted as a ready-response team for inquiries about paleobiological and sedimentological problems. Burgeoning USGS activities, reflecting the increase in minerals exploration after 1949, required, in Cloud's view, an expanded cadre of specialists who could take on any and all challenges. He scoured the rosters of other USGS branches for people who could be useful for his new branch. With the full backing of Chief Geologist Bill Bradley, Cloud had these people transferred and, in some instances, retrained to fit into his organization. At the same time, he recruited more promising young graduates to fill gaps in his plan. With these swashbuckling tactics, he increased the size of the branch from about 15 to more than 60 in six years. Cloud's persistence built an internationally recognized paleontologic research organization that was the pride of the USGS for a quarter-century.

After a decade, Cloud decided to revitalize his research in carbonate rocks, particularly those of biogenic origin, including reefs, and he set to work completing studies, begun in the late 1940s, of Pacific atolls. This interest in marine carbonates led him to initiate and organize the first USGS programs in marine geology. Now, three decades and two reorganizations later, marine geology is a major program. But Cloud missed the USGS decision-making maelstrom of the early 1960s. One morning at coffee in his lab, he suddenly interjected, "I just can't get back to atoll problems; my telephone doesn't ring anymore!" It was clear that he would soon leave the USGS.

Off To Academe

Cloud took an academic post about as far away from the oceans as he could get in North America. From 1961 to 1965, he was at the University of Minnesota as full professor of geology, chairman of the Department of Geology and Geophysics, and head of the School of Earth Sciences. The frigid weather, combined with his restlessness, led to another move—this time to California. After only three years as professor at the University of California, Los Angeles, Cloud finally settled into a permanent position at Santa Barbara. In 1968, as professor of biogeology, he resumed studies on the origin of life and Precambrian physicochemical conditions that made organic evolution possible. By 1974, he had convinced the USGS director, his old friend Vince McKelvey, to build and equip a unique "clean laboratory" at Santa Barbara for the study of early microorganisms, and to rehire Cloud as the head of a project to carry out the research. Together with a long-held and expanding concern over population growth and natural resource conservation, this work filled his very active life until his death, in 1991, of amyotrophic lateral sclerosis ("Lou Gehrig's disease").



Preston Cloud in the late 1980s.

Cloud and the Cosmos

After leaving the USGS in the 1960s, Cloud focused his energy on developing hypotheses about the origin and evolution of life on Earth. Essential to this research were his paleontologic expertise and appreciation of geologic time. His work on carbonates had involved him in the study of the Precambrian, including the geochemistry of early oceans and atmospheres. Much of his work after 1974 centered on the pre-Phanerozoic Earth, and his conclusions are presented in *Cosmos, Earth, and Man* published by Yale University Press in 1978.

Cloud's realization of the vulnerability of life on Earth grew as he reflected on the human impact on the environment. He also knew, from his early work on mineral resources and later studies of energy sources and pollution, that sustainability was a major problem for the future if human tendencies to ravage Earth were not curbed. He made several projections of natural resource needs as related to the exponential population growth over the last decades of the 20th century, summarized in the chapters "Posterity's World" and "Perchance to Dream" in his 1978 book.

Cloud summarized the dilemma as follows: "...the quantities involved have become so large and the doubling times [of population] so short that the lead time for action between general perception of a threatening situation and the onset of crisis or even catastrophe has become dangerously small." The world situation since 1978 has only become more threatening—not less so.

Coda

Preston Cloud's research interests were kaleidoscopic—from invertebrate paleontology and brachiopod systematics to carbonate petrology and coral reef ecology, to marine geology and oceanography, to Precambrian stratigraphy and the origin of life, and finally, to concern for the whole Earth environment and our future relationship to it. He was a brilliant, energetic, and feisty researcher, teacher, leader, and friend.

For Further Reading

Cloud, Preston, 1978, Cosmos, Earth, and man: A short history of the universe: New Haven, Connecticut, Yale University Press, 372 p.

Cloud, Preston, 1988, Oasis in space: Earth history from the beginning: New York, Norton, 508 p.

Crowell, John C., 1995, Preston Cloud, September 26, 1912—January 16, 1991: National Academy Press Biographical Memoirs, v. 67, 22 p. ■

LETTERS

Aboriginal Cultures and Earth Science

Gary Huckleberry's comments (*GSA Today*, April 1999, p. 14) on the Indigenous Earth Sciences Project (IESP; Riggs and Marsh, 1998) offer caution to the uninformed. However, as a tribal-college geologist and a participant in the two IESP conferences thus far concluded, I can assure him that the distinction between empirical and revealed knowledge is not lost on us. We are interested in diverse means of earth study, but we don't propose to "mix science and religion."

Ethnobotany, ethnomathematics, and archaeo- and ethnoastronomy have shown that aboriginal cultures contain a wealth of scientific knowledge of their natural environments (e.g., Williamson and Farrer, 1992). To these established sciences, my colleagues and I, who include Native Americans and non-Natives, propose to add ethnogeology: study of the indigenous, empirical geological knowledge and practices of extant ethnic groups.

Our work is an adjunct to a broad synthesis of ethnography and pedagogy underway at some tribally controlled schools and affiliated institutions. The intent is to enhance K–16 curricula by appropriate integration of traditional knowledge into all subjects. Such knowledge can be brought into the mainstream when it is culturally and epistemologically appropriate (Semken, 1997). More indigenous and Western-trained scholars are needed—a strong impetus for collaborations such as IESP.

Strictly ethnogeological works are still few (see the March 1997 *Journal of Geoscience Education* for examples). Native science is place-centered, and will always be most valuable to the nations whence it comes. If it extends no further, the effort is still worthwhile because cultural connectedness enhances minority-student interest in science (Ridgway et al., 1996). However, many ethnoscientific ideas, such as those dealing with environmental management, might be applied globally.

Studies of Native geoscience have attracted support from DOE (environmental restoration), NASA (effects of climate change on Native homelands), and the USGS and NSF (science education). The Navajo Nation Division of Education and my college have placed integration of ethnoscience at the core of an NSF Rural Systemic Initiative to improve regional science and math education.

We don't know if ethnogeology will prove as fruitful as its predecessors in the life and space sciences. But surely it is wrong to preempt study and discourse with an assertion that Native Americans, living for millennia as close to geological phenomena as anyone can, have only geomythology.

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Ridgway, K., Dowse, M., Geary, E. E., Maxson, J., Semken, S., Stephenson-Hawk, D., and Winkler, J., 1996, How can we increase diversity, recruitment, and retention of students in the Earth and space sciences, *in* Ireton, M. F. W., et al., eds., Shaping the future of undergraduate Earth science education: Washington, American Geophysical Union, p. 39–43.

Riggs, E. M., and Marsh, D. G., 1998, The Indigenous Earth Sciences Project: Exploring the synthesis of southern California Native American traditional knowledge and the earth sciences: GSA Today, v. 8, no. 12, p. 12–13.

Semken, S. C., 1997, NAGT/GSA symposium on geoscience education in Native American communities: Journal of Geoscience Education, v. 45, March, p. 104–105.

Williamson, R. A., and Farrer, C. R., editors, 1992, Earth and sky: Visions of the cosmos in Native American folklore: Albuquerque, University of New Mexico Press, 299 p.

Steve *Semken*
Diné College
Shiprock, Navajo Nation, NM 87420-0580
http://Shiprock.ncc.cc.nm.us

Grand Canyon Redux

The article in the April 1999 issue of *GSA Today* by Ivo Lucchitta and Luna B. Leopold fails to provide a timely, innovative, or balanced report about floods and sandbars in the Grand Canyon. They proposed that controlled-flood releases from Glen Canyon Dam be timed with natural floods of the sediment-rich Little Colorado River to replenish sandbars in the Grand Canyon reach of the Colorado River. Their proposal is not new; it was discussed for years by scientists of the Glen Canyon Environmental Studies and was published in 1995 (ref. 1). Moreover, the Grand Canyon reach is not sediment deficient (ref. 2), as Lucchitta and Leopold claimed. The sediment supply is critically short, however, in Glen and Marble Canyons upstream of the Little Colorado River; the proposed flood would only exacerbate this deficiency.

Balance is lacking in the section "The Recent Geologic Past," where Lucchitta and Leopold presented their version of Holocene alluvial chronology of the Colorado River and described a possible correlation between pre-dam flood stages and terrace levels. As primary sources, they cited Lucchitta et al. (1995), "Lucchitta and colleagues," and "Lucchitta et al., USGS data." However, a substantially different Holocene chronology and relation of flood stage to terrace sequence was published (ref. 3) before the Lucchitta et al. 1995 paper. This work was the basis of three additional publications (ref. 4); Lucchitta and Leopold cited none of these. Considering only one difference, our results show that latest Holocene alluvium is widespread. Therefore, this time was largely aggradational, not strongly erosional as Lucchitta and Leopold inferred.

Readers interested in a more complete rendition of the flood stage, terrace sequence, and alluvial chronology stories should consult all the pertinent papers and then judge the various interpretations. Timely information about ongoing sandbar research is available at several Web sites (ref. 5).

References Cited

1. U.S. Department of Interior, "Final Environmental Impact Statement" (Salt Lake City, Utah, Bureau of Reclamation, 1995).

2. Andrews, E. D., Sediment transport in the Colorado River basin (Washington, D.C., National Academy Press, 1991), p. 54–74.

3. Hereford, R., Fairley, H. C., Thompson, K. S., and Balsom, J. R., USGS Open-File Report 93-517 (1993), and Hereford, R., USGS Open-File Report 93–53 (1993).

4. Hereford, R., Thompson, K. S., Burke, K. J., and Fairley, H. C., GSA. Bulletin, v. 103, no. 3 (1996); Hereford, R., USGS Miscellaneous Investigations Map I-2449 (1996); Hereford, R., Burke, K. J., and Thompson, K. S., USGS Miscellaneous Investigations Map I-2608. (1998).

Letters *continued on p. 19*

Birdsall-Dreiss Distinguished Lecturer for 2000 Announced

Scott Bair, Ohio State University, is the 2000 Birdsall-Dreiss Distinguished Lecturer, sponsored by the GSA Hydrogeology Division. At the request of interested institutions, he will present one of two lectures targeted for audiences broadly interested in earth sciences. Bair received a B.A. degree from the College of Wooster, and M.S. and Ph.D. degrees from Pennsylvania State University. He worked six years at Stone & Webster Engineering Corporation before going to Ohio State, where he is one of four faculty in the hydrogeology group. He has published numerous research articles involving subsurface fluid flow and is a recipient of Ohio State's highest teaching award.

TALK TOPICS

Contamination of Woburn Wells G & H—What the Experts Said at Trial, What We Know Now

In 1982, eight families in Woburn, Massachusetts, filed suit against three companies alleging that improper disposal of industrial chemicals contaminated groundwater that flowed to two municipal wells, and prolonged ingestion of the contaminated water led to leukemia and other health disorders. This story is the subject of the book and movie *A Civil Action,* which focus on the legal aspects of the federal trial. The crux of the jurors' verdict, however, lies in their understanding the scientific testimony presented by the plaintiffs' and defendants' expert witnesses. Even though the experts' opinions were based on the same data sets, their testimony concerning the complexity of the geologic setting, role of the Aberjona River and wetland, groundwater flowpaths, and arrival times of contaminants at the municipal wells was divergent and conflicting. Using trial data, plus more recent data from Superfund remediation activities, we constructed a geologic framework and groundwater flow and transport models to assess unresolved issues from the trial and to evaluate proposed causes of the childhood leukemia cluster. Our results contradict the jury verdict concerning capture zones of the municipal wells and arrival times of contaminants. Simulations show that worst-case groundwater conditions correspond to gestation periods of the leukemia victims' mothers. This finding supports the statistical inference that the children did not contract leukemia from ingestion of contaminated water during childhood, but rather from a predisposition to leukemia developed in utero. Includes slides and exhibits.

Variable-Density Fluid Flow in the Midcontinent Basins and Arches Region: Applications to Hazardous Waste Injection and Sustainable Freshwater Resources

Regional aquifers in the midcontinent basins and arches region are typical of many areas containing a diverse assemblage of lithologies that have been deformed at various stages in their geologic history and now transmit fluids of varying density. Geologic, specific-gravity, fluid-pressure, and permeability data were used to construct variable-density flow and transport models. These models help us to evaluate controls on regional flow patterns in a deep basin sandstone used as an injection zone for hazardous wastes and to examine temporal changes in solute distributions in an extensive carbonate aquifer caused by regional depressurization of the shallow freshwater zone and updip migration of brine. Results show that flow patterns in deep flow cells are influenced by major structural features, such as the Cincinnati Arch, which control locations of regional groundwater divides, whereas flow patterns in shallow flow cells can change from intraformational to cross-formational, owing to partitioning of larger flow cells into smaller flow cells as brine in the deeper parts of an aquifer is displaced by infiltrating meteoric water. These results are important to the location of hazardous-waste injection facilities, migration of injected wastes, and sustainability of freshwater resources. Includes slides and animations.

TO SIGN UP

Contact Scott Bair (231 Mendenhall Lab, 125 South Oval, Columbus, OH 43210, (614) 292-6197, bair.1@osu.edu) directly to request a visit to your institution. The Hydrogeology Division is particularly interested in including liberal arts colleges in the itinerary. The division pays transportation expenses, and the host institution provides local accommodations. ■

Letters *continued from p. 18*

5. www.uc.usbr.gov/amp; gcmrc.gov; vishnu.glg.nau.edu/gces;az.water.usgs.gov; flag.wr.usgs.gov.

Richard Hereford
U.S. Geological Survey
Theodore S. Melis
Grand Canyon Monitoring and Research Center
Kathryn S. Thompson
Flagstaff, Arizona 86001

Response from Ivo Lucchitta and Luna Leopold

According to Hereford et al., we have neither the standing nor the expertise to justify our paper, whose contents they also allege to be old news. In addition, we are chided for not citing Hereford and for relying on unpublished data.

Together, we have many decades of experience working on the Colorado River in Grand Canyon, which has yielded information vital to our proposal, including hydrologic data, the aggradation-downcutting history of the river, and detailed information on shorelines and corresponding discharges.

The issue of sediment input from tributaries has indeed been discussed previously, but in the general terms that tributaries can contribute sediment. Missing are vital specifics such as the stage of the Colorado River resulting from sediment-laden floods on a tributary, the stage needed to park sand on shore in a durable way, and the recurrence intervals of usable tributary floods. If what we propose has long been known, then why the "beach-building test floods," which confirmed the results of the 1993 natural flood on the Little Colorado, the subject of our analysis? This flood showed that enormous amounts of new sand could be introduced into the system.

We did not cite Hereford's papers because they are not of the essence to our proposal; we did cite O'Connor et al., which is.

The aim of our paper is the good of the Grand Canyon. We have proposed a simple and practical way of improving the sand balance in most of the Grand Canyon. The costs are minimal, so operators of Glen Canyon Dam may find the concept practical and palatable. Beaches below the confluence, now consigned to gradual erosion, will be restocked. Beaches above the confluence may well be restocked by making similar use of floods on the Paria River. ■

GSAF UPDATE

Donna L. Russell, *Director of Annual Giving*

Many Ways to Give to GSA

There are several ways to give a major gift to the Foundation today that could help offset the cost of subsidizing each and every membership, fund a student research grant, or allow the Foundation to continue to support the new and exciting programs at GSA. The simplest way to give a donation is cash. Alternatives such as appreciated stock, bequests, personal property, and insurance policies can make it easier to give a meaningful gift to GSA.

Because of the recent bull market on Wall Street, sale of many of the stocks purchased prior to the market rise would subject the seller to a heavy capital gains tax. More and more Americans are finding themselves "cash poor" but "asset rich." If you give appreciated stock to a tax-exempt entity:

- you incur no capital gains tax, and
- you can write off the amount given.

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You may also name the GSA Foundation in your will. If you are among the 40% of Americans who do not have a will, you may allow your state to make decisions about your assets. A will gives you control of how your estate is settled. After providing as you wish for loved ones, you can leave a specific amount of property, a percentage of your estate, or "what's left" to the Foundation.

You may also increase the impact of your gift through a corporate matching gifts program. Please let us know if there are matching possibilities to your contribution and we will do the rest.

Finally, one of the best ways to give to GSA is through word of mouth. Please let us know if you have any colleagues, friends, or family you think would enjoy GSA membership and/or becoming a donor.

Foundation Receives Bequests

Recently, two members chose to honor the Society and contribute to furthering the science through their estate plans.

One bequest, totaling almost $200,000, was from the estate of Clyde T. Hardy, a 49-year member of GSA, who died at age 77 in October 1998. An emeritus professor of geology at Utah State University, he worked his entire teaching career in geology. As he wished, the gift has been added to the Unrestricted Fund.

The other bequest, $43,000, was received from the estate of Horace R. Blank. A 32-year member of GSA, Blank died in 1984 at the age of 86; his wife and trustee of his charitable trust died in 1998, thereby passing a share of his estate to the Foundation. As requested, this gift has been added to the Research Grants Fund, and will be given to the Committee on Research Grants for disbursement in 2000.

Pardee Coterie for Planned Givers

The GSA Foundation's Pardee Coterie will meet again at the annual meeting in Denver. The Pardee Coterie (co-te-rie, a group of persons with a unifying common interest or purpose) recognizes those who have made planned gifts that will support GSA and its programs. Members of the coterie and a guest usually meet once each year for a meal and a talk or discussion on a topic of current interest to scientists and supporters of geology. The group is distinctly informal—no bylaws, no officers, no committees.

Those who have made planned gifts to the Society or the Foundation, such as bequests, the Pooled Income Fund, charitable remainder trusts, or gift annuities, have automatically been included in the Pardee Coterie roster of members. If you have included GSA in your will or are contemplating planned gifts, please notify the Foundation by calling or by mailing the accompanying coupon. ■

THE NON-STEADY STATE OF THE INNER SHELF AND SHORELINE

COASTAL CHANGE OVER DECADES TO MILLENNIA IN THE LATE QUATERNARY

MEETING ANNOUNCEMENT AND CALL FOR PAPERS

A scientific research conference - November 9–12, 1999
at the University of Hawaii, Honolulu

The University of Hawaii, School of Ocean and Earth Science and Technology, and IGCP #437 "Coastal Environmental Change During Sea-Level Highstands" are pleased to invite research presentations on any aspect of:

- Changes in sea-level over the late Quaternary;
- Processes of coastal sediment exchange, storage and bypassing (erosion and accretion);
- Patterns of biolithologic accretion and dissolution (reefs, various bioherms);
- Coastal environmental geochemical and geophysical processes and records;
- Coastal atmospheric, oceanographic, and tectonic events and histories.

Abstract Deadline: September 1, 1999

KEYNOTE PRESENTATIONS BY
Richard Fairbanks Transitions between states of global change
Larry Edwards Geochronology of interglacial shorelines
Kelvin Berryman The many faces of tectonics and its role in shaping late Quaternary shorelines
Richard Peltier Global Glacial Isostasy and Coastal Evolution
Colin Woodroffe Morphodynamic response of shorelines to interglacials
Paul Hearty The Antarctic "Wild Card" during late Quaternary sea-level highstands

A special volume of original research papers is planned
Participants are asked to consider submitting a full manuscript in early 2000, to be considered for publication.

Please submit your e-mail and surface mail addresses to the following for additional information
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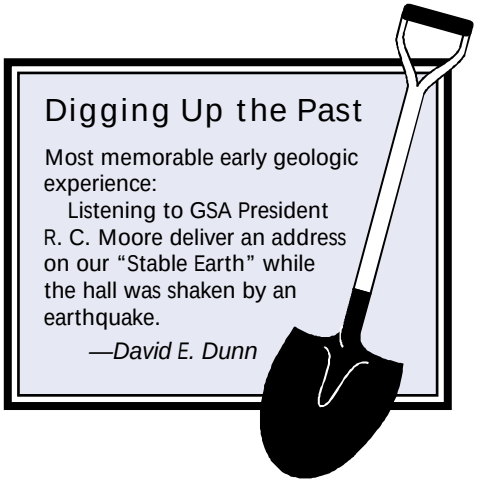

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Appalachian State University
E-Mail: hagemansj@appstate.edu

Dr. David M. Harwood
University of Nebraska, Lincoln
E-mail: dharwood@unl.edu

Dr. Steven M. Holland
University of Georgia
E-mail: stratum@gly.uga.edu

Dr. Claudia C. Johnson
Indiana University
E-mail: claudia@indiana.edu

Dr. David L. Meyer
University of Cincinnati
E-mail: david.meyer@uc.edu

Bruce Runnegar
University of California, Los Angeles
Email: runnegar@ucla.edu

Dr. Charles E. Sarda
Auburn University
E-mail: savrdce@mail.auburn.edu

1999-2001 DISTINGUISHED LECTURERS

Prof. Laurie Anderson, Louisiana State University, E-mail: glande@lsu.edu
Dr. Emily CoBabe, University of Massachusetts, Website: http://www.geo.umass.edu/biogeo/biogeo.html
Dr. Kirk R. Johnson, Denver Museum of Natural History, E-mail: kjohnson@dmnh.org
Dr. David des Marais, NASA Ames Research Center, E-mail: ddesmarais@mail.arc.nasa.gov
Dr. Paul E. Olsen, Lamont Doherty Earth Observatory, E-mail: polsen@ldeo.columbia.edu
Dr. Wylie Poag, Woods Hole, E-mail: wpoag@usgs.gov

Wonn Soh
Tracy C. Sole
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Matthew A. Young
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New GSA Student Associates

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Karen D. Blair
Laura J. Blake
Jacob E. Bleacher
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Ted S. Bogardus
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Melisa L. Borino
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Jaime L. Brown
Megan R. Brown
Carrie R. Brugger
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Sheryl Bunting
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Ned E. Bushong
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STUDENT NEWS AND VIEWS

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

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

The Best Student

In June I attended the Gordon Research Conference on Coastal Ocean Modeling, in New London, New Hampshire. During coffee break one day, I saw a man walking among the attendees, introducing himself. When my turn came, I realized he was the chair of the conference, Dr. Christopher Mooers from University of Miami. I thought, "He must be 'Mooers, C. N. K.'" A paper referenced in one of my textbooks had been co-authored by "Wang, D.-P. and Mooers, C. N. K." I remembered this because "Wang, D.-P." is Professor Dong-Ping Wang, my Ph.D. adviser. So I found myself saying, "You wrote a paper with my adviser... It's referenced in a book I have...." To which Dr. Mooers replied, "Yes, I've written several papers with him. In fact, I was his Ph.D. adviser."

I realized then that I had been vaguely thinking of "Mooers, C.N.K." as my adviser's colleague at some point, but it had not occurred to me that he or she may have been my adviser's adviser. Had it ever occurred to me that my adviser had been, at some point, a student himself? I found it hard to imagine him as a student. So later in the conference I asked Dr. Mooers: What was my adviser like as a student? Had he changed? His answer was: "Well, he was the best student I ever had. Extremely bright, very knowledgeable, curious about everything. Would that be how you would describe him now?" Yes. Maybe I'd had a hard time picturing him as a student not because he had changed but, on the contrary, because he had not changed fundamentally since his student days.

What left an impression on me in a different way, however, was the fact that Dr. Mooers had referred to my adviser as the best student he ever had. This reminded me of an incident in my department from a few months ago. Occasionally, a speaker at our weekly seminar is a former student of our department. While such a speaker was being introduced one day, one of our professors remarked that he was the best student the department had ever had. While talking to other students later, I learned that I was not the only one who had been slightly disconcerted by this statement. Here we are, pursuing our studies, and to be told that this person was the best student our professors had ever seen is not particularly encouraging. No, the professor had not said that there will never be another student better than him, but did that make much of a difference? It reminded me of the slight dismay I felt upon reading the question, "How does this student rank among all the students you have ever taught?" on recommendation forms for college applications. (Great, not only am I being compared to my classmates, but all other students my teacher has ever taught, and heaven knows how long he has been teaching.) On the other hand when Dr. Mooers referred to my adviser as his best student ever, it did not bother me at all, partly because he and I belong to different programs and partly because the "student" in question was my adviser. I did not feel myself being compared to other students, as I did in the case of the speaker. Thinking about the two "best students" brings me back to the oft-repeated maxim: the only competition is against oneself. This is the backbone of the student honor code at Bryn Mawr College, my alma mater. This was one of those cases where the conclusion I reached was something I'd heard before (although, of course, it makes a world of difference that this time, I came up with it myself).

My job as student correspondent is to bring up issues and concerns of student readers, both graduate and undergraduate. Listed below are some of the potential topics I thought of when applying for this position. Any comments on these and any other topics will be greatly appreciated.

1. If you run into any trouble—be it strained relationships with professors, or administrative snags, are the steps to be taken made clear to you by your school or department? Or would you have to figure them out on your own? Last spring, my university's travel office lost my receipts from a conference I attended, and thus could not reimburse me. When I sent a copy of the receipts, they told me that they needed the originals (which, of course, they had lost). As I walked in a maze of hallways, being sent from one office to another, I realized I would never have to read another Franz Kafka novel; I was living in one.

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Student News *continued from p. 27*

2. If you've ever gone through, or are currently in the midst of, a job search, what or whom (career offices, personal contacts, professors, etc.) have you found most helpful? How flexible would you be in pursuing jobs that are not directly related to your field of study? A friend of mine from college, who will soon complete her Ph.D. program in physics, wants to work in finance. Although my plans for after receiving my Ph.D. are more traditional than my friend's—teaching and research—the idea of working in a field not directly related to one's degree is an intriguing one.

3. What extracurricular activities do you pursue? Are they primarily for de-stressing, or a much more significant part of your life? I go to kendo (Japanese fencing) practice three to four times a week, and to me it's worth the two-hour drive, especially with the national tournament and a promotion test fast approaching. I'm also supposed to write my dissertation proposal in a couple of months. This makes life a little more than hectic than it already is, but would I be happier if I had less of research or kendo practice in my life? Of course not, since I wouldn't be doing either if I didn't want to.

Student Correspondent Kyoko Ohashi is a Ph.D. candidate in the Coastal Oceanography program of the State University at Stony Brook, New York. She received an A.B. in physics from Bryn Mawr College and her M.S. in meteorology from Rutgers. She also teaches a coastal ecology program for elementary school students in Stony Brook. Reach her by e-mail at stumatts@geosociety.org. ■

Remembering Francis J. Pettijohn

Francis Pettijohn, who died in spring 1999 at age 94, had a major impact on the development of sedimentary geology in the last half of this century. His monograph *Sedimentary Rocks* inspired generations of young sedimentologists, and his students are leaders throughout North America.

At the 1999 GSA Annual Meeting, the GSA History of Geology Division will host a gathering of his associates, former students, and friends to remember this unrepentant field geologist on Sunday, October 25, from 3 to 5 p.m., in the Convention Center.

BOOK REVIEWS

Samuel Howell "Doc" Knight: Mr. Wyoming University. *By Frederick W. Reckling and JoAnn B. Reckling. University of Wyoming Alumni Association, Laramie, 1998, $22.95 (hard cover), $17.95 (soft cover).*

Few of us are so fortunate as to make the acquaintance of a legendary person the likes of Samuel "Doc" Knight (1892–1975) on whom *Time* Magazine bestowed the title "Mr. Wyoming University." Never has a department of geology and even a university owed more to one faculty member. The Recklings have contributed a charming, well-researched, and well-written little book honoring and memorializing this charismatic "Renaissance Man"; the book will be especially appreciated by the legions of his acquaintances and former students, but it will also make enjoyable reading for other geologists and historians. I had the pleasure of "experiencing" Doc Knight both at the University of Wyoming in Laramie, where I was a graduate student, and at UW's renowned geology field camp, and I can testify that the Recklings do a fine job of conveying the accomplishments and nature of this amazing man.

Doc Knight was a superb classroom teacher and taught introductory geology to thousands of students, many of whom revered him. Repeatedly referred to by alumni are his three-dimensional chalk talks and his perfect freehand circles on the blackboard. He developed an outstanding and nationally recognized geology department. He took much pride in establishing (in 1925) one of the top geology field camps in the country, in the beautiful Medicine Bow Mountains (Snowy Range) west of Laramie. Appointed head of the geology department (1916) and later (1933) state geologist as well, Doc organized a successful collaborative effort in Laramie among the geology department, the USGS, and the State Geological Survey of Wyoming. This was a major contribution to the field of geologic research and human relations. He established UW's excellent Geological Museum and designed and constructed the life-size copper-plated *Tyrannosaurus*—a landmark there. In 1954 he was chosen the University of Wyoming Distinguished Alumnus and was awarded an honorary Doctor of Laws. A succinct chronology of his many other accomplishments is presented following the warm Foreword (by Jane and David Love) and the Preface and Acknowledgments (by the Recklings).

Part I contains 10 chapters, the first and ninth dealing with the Knight family (several members with various levels of geological background), but most concerning Doc and his achievements, with as much emphasis on the human as academic side.

Part II contains only three chapters: Military Letters (to wife Edwina); Reminiscences, Recollections and Anecdotes; and a Collection of Verse by Samuel Knight. The book terminates with a bibliography, a good index, and a two-page spread about the Recklings.

In addition to describing his noteworthy geological achievements, the book emphasizes the personality of the man and his relations with others, including several university presidents who benefited from Doc's efforts in so many areas of campus life. In 1963 the student newspaper referred to him as the university's "most beloved and respected member." The anecdotal aspects are especially well done. As a summer camp alumnus ('53) I recall his Saturday morning chalk talks,

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Pardee Keynote Sessions
(all invited speakers)

This year's program features eight special symposia of broad interest to the geoscience community, the Pardee Keynote Symposia. On Monday, October 25 we will feature:

K03 Maintaining a Livable Earth: Conversations Among Concerned Geologists, *Monday Morning*

GSA Committee on Critical Issues; Institute for Environmental Education

Jill S. Schneiderman, Vassar College, Poughkeepsie, New York; Susan W. Kieffer, Kieffer Institute for Science-Based Education, Palgrave, Ontario. ORAL

Selected authors of essays for a book for the general public concerning the relevance of geology to environmental decisions will present brief narratives to demonstrate that without geological knowledge, solutions to environmental problems will not be forthcoming. The symposium will be an interactive session involving extensive discussion with audience members.

K06 Globally Warm Climates of the Early Cenozoic: Evidence, Causes, and Biotic Consequences, *Monday Afternoon*

Paleontological Society

Scott L. Wing, Smithsonian Institution, Washington, D.C.; Lisa C. Sloan, University of California, Santa Cruz. ORAL

Globally warm climates are an enduring geological enigma, pitting our understanding of the processes that generate climate against our interpretation of past conditions based on geological, paleontological, and geochemical data. Speakers in this symposium will discuss recent research that illuminates the possible causes and biotic effects of globally warm climates in the early Cenozoic.

BOOK REVIEWS *(continued from p. 28)*

especially the frustration of attempting to copy his amazing blackboard drawings depicting the geologic history of a region. He was also an artist with his eraser in modifying these sequences of illustrations, leaving us note takers in the dust if we wanted complete diagrams! I recommend this book with enthusiasm, and I congratulate the Recklings for a job very well done.

Donald H. Zenger
Pomona College
Claremont, CA 91711

Aquifer Hydraulics: A Comprehensive Guide to Hydrogeologic Analysis. *By Vedat Batu. John Wiley & Sons, New York, 1998, $95, 727 p.*

This book is intended to serve as a guide for hydrogeologists involved in the analysis of aquifer tests. The main focus is to present mathematical solutions and methods of analysis of pumping-test data for determination of aquifer hydraulic characteristics. As a primer, the book should be helpful to hydrogeologists using commercially available software packages who would like additional background material. It is reasonably well written and organized, starting with a chapter on aquifer hydraulics for the uninitiated and, in subsequent chapters, proceeding systematically through various, but not all, classical well-hydraulics problems for flow in porous media. Important analytical treatments for flow to a well in fractured-rock formations are intentionally omitted. A diskette is provided for generating type curve data for a few selected solutions.

The book does not provide aquifer test design criteria, information on how to conduct pumping tests, detailed guidance for data interpretation, or suggestions as to which of the model options might be

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preferred in any given situation. This was not its intent. Unfortunately, in my view, Batu has focused almost entirely on classical solutions, many of which have restrictive assumptions, and has ignored many recent advances in well hydraulics. Perhaps a second edition will correct these deficiencies.

Allen Moench
U.S. Geological Survey
Menlo Park, CA 94025

Terroir: The Role of Geology, Climate and Culture in the Making of French Wines. *James E. Wilson. University of California Press (Berkeley), in association with Wine Appreciation Guild (San Francisco), 1998, $39.95, 336 p.*

The French word *terroir* has many meanings and is difficult to define; stated as scientifically as possible, it encompasses all the natural factors that go together to produce fine wines in a given region. This includes not only geology and climate, but also the history of wine grape growing and the culture of each region. Geologist James Wilson has written a wine book that is based on sound geologic, hydrologic, and climatological observations and reasoning. He presents a tremendous amount of geologic detail on the various major wine regions of France; much of the discussion is based on personal observations, including a seismologic study he conducted, of the shallow subsurface of some vineyards in Burgundy. The book is really encyclopedic; if there is a certain wine that you are fond of, you will find ample discussion of its terroir.

The first of the two parts of the book is a summary that discusses the habitat of wine, or what makes good grapes; the second part presents a very detailed discussion of each of the 11 major wine regions of France: Champagne, Alsace, Burgundy, Aquitaine, Bordeaux, the Southwest, the Loire, the Kimmeridgian Chain, Auvergne-Bourbonnais, the Rhone and Southeast, and Languedoc-Roussilon. Many cross sections and detailed geologic maps and 42 excellent color plates, mostly of vineyards, enliven the descriptions. Wilson explains all geologic and climatologic concepts for the nonspecialist.

After reading the book, I felt that an underappreciated factor in winemaking is hydrology. Drainage is ever so important, especially because French law forbids irrigation of the quality vineyards. This means that the best grapes are grown on slopes with sufficient rainfall and the appropriate texture and structure for good drainage. A too dry or too wet soil does not make great wine. An ideal soil is sufficiently thick and has a coarse gravelly texture, with fractured bedrock for the deeply burrowing vine roots. The truly great wine grapes of Bordeaux are in fact grown on mounds of gravel. Of course, other factors are also important. The soils should contain sufficient clay and organic matter and have the appropriate neutral-to-basic pH to provide the necessary macronutrients for growth. Climate is of obvious importance: sufficient rain at the right time (not during harvest) is necessary, and sunshine (but not too much, as occurs in the regions bordering the Mediterranean) is also critical.

Overall this is a fine book for any person interested in wine. It is technically sound, and the sections on the history and culture of French wine making are especially enjoyable. This book complements other wine books in that factors affecting *wine grape growing* are emphasized, rather than just *wine-making.*

Robert A. Berner
Yale University
New Haven, CT 06520-8109

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1999 Annual Meeting

October 25-28
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Photos by John Karachewski: Large photo shows the Continental Divide—Sawatch Range, Collegiate Peaks Wilderness, Colorado; small photo taken near James Peak, Colorado.

Call For GSA Short Course Proposals for Future Meetings

Due December 1, 1999

The GSA Committee on Continuing Education invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines. Short courses may be conducted in conjunction with all GSA annual or section meetings. We are interested in receiving proposals for the 2000 Annual Meeting (Reno) or the 2001 Annual Meeting (Boston), particularly, but not exclusively, in the following disciplines of geology.

Structural Geology: Analysis of veins in low-temperature environments; computer modeling in structural geology; deformation mechanisms; fractals; fault gouge studies–pseudotachylites; metamorphic processes and deformation strain analysis; tectonic regimes

Economic Geology: Applications of structural geology to mineral deposits

Petroleum Geology: Exploration technology; petroleum exploration and exploitation

Environmental Geology: Environmental assessment; environmental law—geologist's role; environmental or engineering problems associated with karst landscapes, including subsurface investigation procedures, sampling and testing—site characterization; evaluating groundwater resources for long-term municipal water supplies; groundwater modeling; Phase II and Phase III environmental site assessment; wellhead protection area (capture zone) delineation

Geochemistry: Geochemical modeling; geophysics-geochemistry or structural geology–geochemistry; isotope applications in ecological-geological systems

New Mapping Techniques and Technologies: ARC INFO; GPS technologies in geological research; mapping and GPS mapping

Pedagogy and Teaching Methods: Multimedia for use in the classroom; pedagogy

Proposals must be received by December 1, 1999. Selection of courses for 2000 will be made by February 1, 2000. For those planning ahead, we will also consider courses for 2001 at that time.

For proposal guidelines or information, contact
Edna Collis, GSA headquarters, (303) 447-2020, ext. 134, ecollis@geosociety.org

2000 Annual Meeting Reno, Nevada

November 13–16
Reno-Sparks Convention Center

General Chair
Richard A. Schweickert, University of Nevada
richschw@mines.unr.edu

Technical Program Chair
Robert Karlin, University of Nevada
karlin@mines.unr.edu

Due Date for Pardee Keynote Symposia and Topical Proposals:
January 10, 2000

For More Information:
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Fax: 303-447-0648
E-mail: meetings@geosociety.org
Web site: www.geosociety.org

Call for Field Trip Proposals

We are interested in proposals for single-day and multi-day field trips beginning or ending in Reno, and dealing with all aspects of the geosciences.

Please contact the Field Trip Co-Chairs:

Mary Lahren, lahren@mines.unr.edu

Paula Noble, noblepj@unr.edu

Steve Peters, speters@usgs.unr.edu

All co-chairs can be contacted at the University of Nevada, Department of Geological Sciences, Mackay School of Mines, MS 172, Reno, NV 89557-1038, (775) 784-6610, fax 775-784-1833

FUTURE GSA MEETINGS

2001	Boston, Massachusetts, November 5–8
2002	Denver, Colorado, October 27–30
2003	Seattle, Washington, November 2–5

2000 GSA SECTION MEETINGS

NORTHEASTERN SECTION—*March 13–15, 2000,* New Brunswick, New Jersey. Information: Robert E. Sheridan, (732) 445-2015, rsheridan@worldnet.att.net

SOUTHEASTERN SECTION—*March 23–24, 2000,* Charleston, South Carolina. Information: Michael P. Katuna, (843) 953-5589, katunam@cofc.edu

SOUTH-CENTRAL SECTION—*April 3–4, 2000,* Fayetteville, Arkansas. Information: Doy L. Zachry, Jr., (501) 575-3355, dzachry@comp.uark.edu

NORTH-CENTRAL SECTION—*April 6–7, 2000,* Indianapolis, Indiana. Information: Robert D. Hall, (317) 274-7484, rhall@iupui.edu

ROCKY MOUNTAIN SECTION—*April 17–18, 2000,* Missoula, Montana. Information: Donald W. Hyndman, (406) 243-2241, dhyndman@selway.umt.edu

CORDILLERAN SECTION—*April 27–29, 2000,* Vancouver, British Columbia. Information: Peter S. Mustard, (604) 291-5389, pmustard@sfu.ca

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.**

1999 Meetings

September

September 26–29, Association of Engineering Geologists 42nd Annual Meeting, Salt Lake City, Utah. Information: Jeffrey Keaton, (520) 282-2706, jkeaton@agraus.com.

October

October 25–28, 7th Arab Conference for Mineral Resources, Cairo, Egypt. Information: Talaat Ben Dafer, Arab Industrial Development and Mining Organization, 7th Arab Conference for Mineral Resources, P.O. Box 8019–United Nations (10102), Rabat, Morocco, phone 212-7-772600/01/04, fax 212-7-772188, AIDMO@ARIFONET.ORG.MA.

2000 Meetings

March

March 6–8, 4th Meeting on the Geology of Northwestern Mexico and Adjacent Areas, Hermosillo, Mexico. Information: Organizing Committee, Apartado Postal 1039, Hermosillo, Sonora, Mexico 83000, phone 62-17-5019, fax 62-17-5340, cmgleon@servidor.unam.mx.

May

May 15–18, Geology and Ore Deposits 2000: The Great Basin and Beyond, Reno-Sparks, Nevada. Information: Geological Society of Nevada, P.O. Box 12021, Reno, NV 89510-2021, (775) 323-4569, fax 775-323-3599, gsnsymp@unr.edu.

August

August 6–17, 31st International Geological Congress, Rio de Janeiro, Brazil. Information: Secretariat Bureau, Casa Brazil 2000, Av. Pasteur, 404—Urca, Rio de Janeiro, RJ Brazil, phone 55 21 295 5847, fax 55 21 295 8094, 31igc@31igc.org, www.31igc.org.

August 16–20, Second International Conference on Debris-flow Hazards Mitigation, Taipei, Taiwan, R.O.C. Information: Ko-Fei Liu, Dept. Civil Engineering, National Taiwan University, No. 1, Sec. 4 Roosevelt Rd., Taipei, 10617 Taiwan, R.O.C., phone 886-2-2365-5405, fax 886-2-2363-1558, kfliu@ccms.ntu.edu.tw.

August 17–21, 5th International Symposium on Environmental Geotechnology and Global Sustainable Development, Belo Horizonte, Minas Gerais, Brazil. Information: Terezinha Galvão, Dept. de Engenharia de Transportes e Geotecnia, Escola de Engenharia da Universidade Federal de Minas Gerais, Ave. do Contorno, 842 sala 104, Belo Horizonte, Minas Gerais, CEP 30 110-060 Brazil, phone 55 31 238-1742, fax 55 31 238-1793, cassia@etg.ufmg.br.

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.

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Positions Open

DARTMOUTH COLLEGE
LOW TEMPERATURE GEOCHEMIST

The Department of Earth Sciences expects to fill a tenure-track position in low temperature geochemistry at the assistant professor level. The successful candidate will be expected to demonstrate excellence in both teaching and research, develop a vigorous, externally funded research program, advise student research at both the undergraduate and graduate student levels in Earth Sciences. The earth sciences department has a VG Sector Mass Spectrometer, High Resolution ICP-MS, and a clean laboratory. Candidates with expertise in radiogenic isotope geochemistry are particularly encouraged to apply.

A curriculum vitae, list of publications, description of proposed teaching and research goals, and the names, addresses, and fax numbers of at least three references should be sent to: Chair, Faculty Search Committee, Department of Earth Sciences, Dartmouth College, 6105 Fairchild Hall, Hanover, NH 03755 (e-mail: earth.sciences@dartmouth.edu).

Evaluation of applications will begin November 1, 1999. The appointment will be effective July 1, 2000.

Dartmouth College is an equal opportunity/affirmative action employer. Women and minorities are encouraged to apply.

THREE TENURE-TRACK FACULTY POSITIONS
DEPARTMENT OF GEOLOGY
BUCKNELL UNIVERSITY

The Department of Geology at Bucknell University invites applications for three assistant professor positions in Hydrogeology, Mineralogy/Petrology, and Sedimentology to be filled at the entry-level beginning Fall semester, 2000. A Ph.D. with some prior teaching experience is strongly preferred; ABD considered. Two of these positions arise due to retirements; the third position results from an expansion of our program. The Department of Geology anticipates that it will be housed in a new building to be occupied by fall of 2001.

Bucknell is a selective liberal arts university with an engineering program. The Department of Geology offers B.A. and B.S. degrees in both Geology and Environmental Geology. Department members value teaching and research in both fundamental and applied geology. For all three positions, we seek broadly trained teacher-scholars who are equally comfortable in the field and in the laboratory and who complement the strengths of our continuing faculty (aqueous geochemistry, geomorphology, and structural geology). Given our exceptional location, we expect candidates to incorporate fieldwork into some aspects of most courses. Opportunities exist for teaching and research collaboration with other departments on campus. In addition to upper-level courses listed below, each candidate will teach introductory courses which contribute to Bucknell's general education program and introductory laboratory courses, which may include engineering, environmental, historical, and/or physical geology, and oceanography. Candidates may also prepare introductory- and senior-level seminar courses or writing-intensive courses. The standard teaching load is two courses with labs per semester. Ability to teach upper-level courses in geophysics or economic geology will strengthen an application for any position.

Candidates are expected to conduct and disseminate independent research in their area of expertise and to supervise undergraduate research. Faculty are encouraged to seek external funds to support research.

Mineralogist/Petrologist. The candidate will teach upper-level courses in mineralogy and hard-rock petrology with laboratory sections. The ability to contribute to departmental and university environmental programs will strengthen an application.

Sedimentologist. The candidate will teach upper-level courses in sedimentology and paleontology with laboratory sections. The ability to contribute to departmental and university environmental programs will strengthen an application.

Hydrogeology/GIS. The candidate will teach upper level courses in hydrogeology and geographic information systems (GIS) with laboratory sections. The person filling this position is expected to contribute to both departmental and university environmental programs. Consulting experience is preferred. The ability to integrate field studies with ground-water flow modeling at a level appropriate to undergraduate students is expected.

Applicants should send a statement of teaching and research interests and experience, resume, and at least three letters of reference to: {appropriate position} Search Committee, Department of Geology, Bucknell University, Lewisburg, PA 17837. Review of applications will begin September 1, 1999, and will continue until the positions are filled. Candidates are encouraged to visit our web site at www.departments.bucknell.edu/geology. Bucknell University encourages applications from women and members of minority groups (EEO/AA).

SOIL GEOMORPHOLOGIST
SCHOOL OF NATURAL RESOURCE SCIENCES
UNIVERSITY OF NEBRASKA-LINCOLN

Seeking candidates for this Assistant Professor, tenure-leading, 12-month position with 60% research, 30% teaching, and 10% Conservation and Survey Division responsibility to teach an undergraduate level course in the general area of soil morphology, classification and survey and teach a graduate level course on an alternating year basis as well as advise undergraduate and graduate students. Research focus should be on soil genesis or geomorphology with possible interests in agricultural and urban land use, soil chemistry and mineralogy, relationship between soil properties, landscape position and water quality. Supervise graduate student thesis and dissertation research. participate in Nebraska Cooperative Soil Survey activities including service as a liaison to NCSS cooperatives, representing CSD in field soil survey activities, and providing scholarly service related to interpretation of soils information. Requires Ph.D. in Soil Science, Geology, or related field. Also requires broad experience with, and an understanding of, soil, water, and ecological resources as they occur on the landscape. Must have advanced knowledge of field and laboratory characterization of earth materials and morphological soil description. An ability to foster and engage in collaborative research is essential. Desirable for applicants to have experience in teaching, demonstrated ability to work with students, and some knowledge of GIS and geostatistical applications in pedology. Review of candidates will begin September 15, 1999, and will continue until a suitable candidate is found. Submit resume, transcripts, and the names and addresses of three references to: Dr. Joseph M. Skopp, Chair, Search Advisory Committee, School of Natural Resource Sciences, University of Nebraska-Lincoln, 303 Biochemistry Hall, Lincoln, NE 68583-0758. UNL is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity; is

Classifieds *continued on p. 35*

Classifieds *continued from p. 34*

responsive to the needs of dual career couples; and assures reasonable accommodation under the Americans With Disabilities Act. Contact Dr. Skopp at (402) 472-9873 for additional information.

SIMON FRASER UNIVERSITY
DEPARTMENT OF EARTH SCIENCES
FOREST RENEWAL BC ENDOWED CHAIR
IN TERRAIN ANALYSIS AND FOREST GEOSCIENCE

A Chair is going to be appointed at SFU to provide academic leadership in the application of geoscience to the province's forest industry. Responsibilities will include research, teaching, graduate student supervision and outreach activities to meet continuing education needs of professionals working in the forest industry. The Chair will be expected to teach two courses: one in 'Introductory Soil and Rock Mechanics,' and the other in a field of forest geoscience. The Chair will be expected to foster forest-geoscience research projects with faculty and graduate students associated with the program. The successful candidate will have a demonstrable record of attracting research funding and a strong publication record.

It is anticipated that the position will be filled at the Full Professor rank, but this will depend on the qualifications of the successful candidate. Candidates will be considered from such fields as: engineering geology, geological engineering, or applied geoscience. A Ph.D. is required, and registration, or eligibilty for registration is APEGBC, is highly recommended.

In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian citizens and permanent residents.

Applicants should submit a curriculum vitae, a letter of intent for this position, a statement of research and teaching interests, and the names and addresses of three referees. Applications or requests for further information should be directed to: Dr. E. J. Hickin, Chair, Department of Earth Sciences, Simon Fraser University, 8888 University Drive, Burnaby, BC V5A 1S6. Phone 604-291-4779; Fax 604-291-4198; e-mail hickin@sfu.ca.

The closing date for applications is September 30, 1999; the anticipated starting date is April 1, 2000.

SEDIMENTARY GEOLOGIST
UNIVERSITY OF CHICAGO

Applications are sought for a one-year research associate position (with the possibility of renewal for a second year) in sedimentology/stratigraphy beginning January 2000, in the Department of the Geophysical Sciences. Applicants should have a Ph.D. and a record of independent scholarship. We hope to appoint a person who will complement and broaden our research programs in paleogeography, Earth history, stratigraphy, taphonomy, paleobiology, and macroevolution. Demonstrated ability and willingness to teach are desired. Please send curriculum vitae, a statement of interests, and the names, addresses (standard and electronic), and phone and Fax numbers of at least three scholars who can supply letters. Review of applications will begin October 1, 1999. Address applications to: Susan Kidwell, Department of the Geophysical Sciences, University of Chicago, 5734 South Ellis Avenue, Chicago, IL 60637. The University of Chicago is an Equal Opportunity/Affirmative Action Employer.

FACULTY POSITION, DEPARTMENT OF GEOLOGY
UNIVERSITY OF MARYLAND, COLLEGE PARK

The Department of Geology at UM is searching for a tenure-track faculty member who has made fundamental contributions in the application of geochemistry to understanding Earth processes. We seek an outstanding scientist whose research interests could be in trace element and/or isotope geochemistry.

Research strengths in the Department of Geology include the broad areas of mineralogy, petrology and geochemistry, in particular of granites and associated mineralization; hydrological processes and integration of geomorphology, hydrology and ecology to understand surface environments; and, isotope geochemistry in support of these areas and in mantle geochemistry, meteoritics, tectonics, carbonate diagenesis, sediment cycling, geochronology, stratigraphy and paleoclimate studies. The Department of Geology encourages interdisciplinary approaches to the study of the Earth and participates in the Earth System Science Interdisciplinary Center. This new Center has been formed through collaboration between the University of Maryland and NASA's Goddard Space Flight Center to advance fundamental knowledge about earth systems through preeminent research and teaching programs.

The Department expects to fill this position by the beginning of the Spring Semester 2000 or as soon as possible thereafter, most likely at the rank of Assistant Professor. Salary will be commensurate with experience. The appointee is expected to develop and maintain an active, externally funded research program, to direct graduate students, and to participate fully in teaching at the graduate and undergraduate levels, including courses in the introductory non-major program.

The University of Maryland is an affirmative action/equal employment opportunity employer. Applications should be submitted by September 20, 1999, for best consideration and should be submitted to: Chair, Search Committee, Department of Geology, University of Maryland, College Park, MD 20742, USA. Applicants should provide a statement describing research and teaching interests, indicating how s/he envisions contributing to the Department's research and teaching activities, and a signed current curriculum vitae. Applicants should arrange to have a minimum of four letters of recommendation sent directly to the Chair of the Search Committee before September 20, 1999. The Search Committee encourages applicants to submit copies of up to two recent publications in support of their candidacy.

DIRECTOR
BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN

The University of Texas at Austin seeks a Director of its Bureau of Economic Geology, one of the largest research units of The University and which also serves as the State Geological Survey. Required is a doctorate in the geological sciences, a record of substantial research, and upper-level management and leadership experience. The applicant must have experience working in a university setting, working with policy issues at the state and national level, and obtaining financial support for major research programs. The successful candidate will have credentials suitable for appointment as a full professor in geological sciences.

The Bureau of Economic Geology is a prominent research and service institution with a long history and a reputation for research excellence and scientific leadership. It is a major publisher of geological reports, especially in the fields of energy and the environment. The Bureau operates yearly on an appropriated budget of $1.2 million, plus $12 to $15 million in grants and contracts from State and Federal agencies, industry, and private foundations. Further details of Bureau programs and organizations can be obtained by visiting the website http://www.utexas. edu/research/beg or by requesting a copy of the Bureau's annual report.

Application, including a resume, letter of interest, and names and addresses of at least three references, should be submitted to Prof. William L. Fisher, Chair of the Director Search Committee, Bureau of Economic Geology, University Station, Box X, Austin, TX 78713-8924. Additional position information can be found at www.utexas.edu/admin/ohr/emp/. Refer to Job Number 99-06-21-10-0382. The position is open until filled, with review of applications beginning in early fall of 1999. Anticipated starting date is January 1, 2000. Salary is negotiable. The University of Texas at Austin is an Equal Opportunity/Affirmative Action employer.

ASBESTOS LAB ANALYST
EVANS ENVIRONMENTAL AND GEOSCIENCES

Requires a bachelor's degree in Geology, one year Polarized Light Microscopy, Laboratory Information Management, Report writing, Quality Assurance & Quality Control, and Management experience. Fax resume to: Evans Environmental and Geosciences, Miami, Florida, at (305) 374-9004.

STATE UNIVERSITY OF NEW YORK
COLLEGE AT ONEONTA — LECTURER

The Department of Earth Sciences at the State University of New York College at Oneonta invites applications for a one-year Lecturer position beginning Fall 1999 pending budgetary approval. This is a full-time position in Surficial Geology/Hydrology. Required qualifications: Ph.D. or ABD; extensive knowledge and experience in environmental applications; emphasis on quality classroom instruction, student mentoring, and the application of instructional technology. Duties include teaching courses in support of undergraduate curricula in Geology, Water Resources, and Environmental Science. To apply: send curriculum vita, statement of interest and qualification for this position, and three current letters of recommendation to: Dr. Jerome Blechman, Search Committee Chair, Earth Sciences Department, Box G, SUNY Oneonta, Oneonta, NY 13820. Review of applications will begin immediately and will continue until the position is filled. SUNY Oneonta is an EEO/AA employer. Women and minorities are encouraged to apply.

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Opportunities for Students

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

Department of Geosciences, University of Arizona, announces the availability of Sloan Scholarships for minority Ph.D. students in the geosciences. The Alfred P. Sloan Foundation and the Department of Geosciences are committed to increasing the number of African- American, Hispanic-American, and Native-Americans receiving Ph.D.s in the geosciences. Sloan scholars receive fellowship support, three summers of research support, a research allowance, and peer and faculty mentoring. Additional support through other fellowships, and teaching or research assistantships is also available. Inquiries and requests for applications to: Graduate Program, Department of Geosciences, The University of Arizona, Tucson, AZ 85721. Or gradapps@geo.arizona.edu and http://www.geo.arizona.edu.

Graduate Assistantships at Florida International University, Miami, are available for fall '99 and spring '00 semesters for qualified Ph.D. and M.S. degree seeking students in the Department of Geology. Fields of research include geochemistry/petrology, stratigraphy/paleontology, structure/tectonics, hydrogeology and environmental geophysics. These assistantships are highly competitive and include an annual stipend of $15,000 plus tuition and fee waivers. Interested students should check out our web site (http://www.fiu.edu/orgs/geology/) or contact Dr. Andrew Macfarlane (Graduate Advisor; e-mail: macfarla@fiu.edu) at the following address: Department of Geology, Florida International University, University Park, PC 344, SW 8th St., Miami, FL 33199. (305) 348-2365, Fax 305-348-3877

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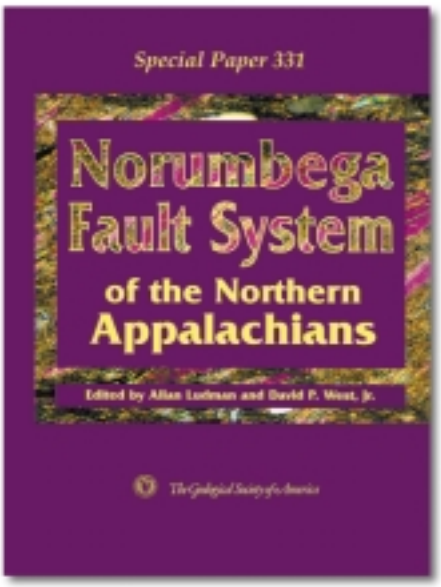

Norumbega Fault System of the Northern Appalachians

edited by Allan Ludman, David P. West, Jr., 1999

Forty kilometers wide and perhaps 1200 km long, the dextral Norumbega fault system is one of the major structures of the northern Appalachians. Differential erosion provides a mid- through shallow-crustal profile of the Norumbega system, offering insight into the mechanics and evolution of modern faults such as the San Andreas.

This volume incorporates field, petrographic, geochemical, geochronological, and geophysical studies in a four-dimensional picture of the Norumbega. Three papers describe deformation style and mechanics from deep, intermediate, and shallow segments of the system; they are followed by two views of how it might continue as far south as Long Island Sound. Four papers address possible tectonic roles of the system, placing it in context with other northern Appalachian faults and examining geochemical evidence for the Norumbega system being a major terrane boundary. Two papers detail the system's 200-million-year multistage deformation history, and the final contribution examines the possibility that the Norumbega is active today.

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