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INSIDE

Rodinia to Gondwana: The Geodynamic Map of Gondwana Supercontinent Assembly

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ABSTRACT

The new *Geodynamic Map of Gondwana Supercontinent Assembly* provides insight into the Neoproterozoic breakup of the Rodinia supercontinent that existed from 1000 to 725 Ma, and the subsequent amalgamation of Gondwanaland. Breakout of Laurentia from Rodinia at 725 Ma marks the reorganization of lithospheric plate motions that resulted in the Pan African–Brasiliano orogeny and assembly of Gondwanaland that lasted from 725 to 500 Ma.

INTRODUCTION

The Geodynamic Map of Gondwana Supercontinent Assembly[1] at a scale of 1:10 million was first presented at the 30th International Geological Congress, in Beijing, in August 1996. The map is a joint endeavor of International Geological Correlation Program Project 288 "Gondwanaland Sutures and Fold Belts" (database generation), the Council for Geoscience, Pretoria, South Africa (Geographic Information Systems [GIS] and digital cartography), and the Bureau de Recherches Géologiques et Minières, Orléans, France (printing). It contains original contributions by 67 coauthors from 11 countries. GIS and digital cartography were managed by L. G. Wolmarans (CGS). The Editorial Committee included: C. Castaing (BRGM), J. L. Feybesse (BRGM), P. G. Gresse (CGS), C. McA. Powell (UWA), G. R. Sadowski (USP), L. Tack (MRAC), and R. Unrug (WSU) (see p. 5).

Here I present the basis for constructing the geodynamic map from which the index and summary maps, Figures 1–3, were derived, and the synoptic insights gleaned from the cartographic visualization of the mobile belts that suture the cratons within Gondwanaland.

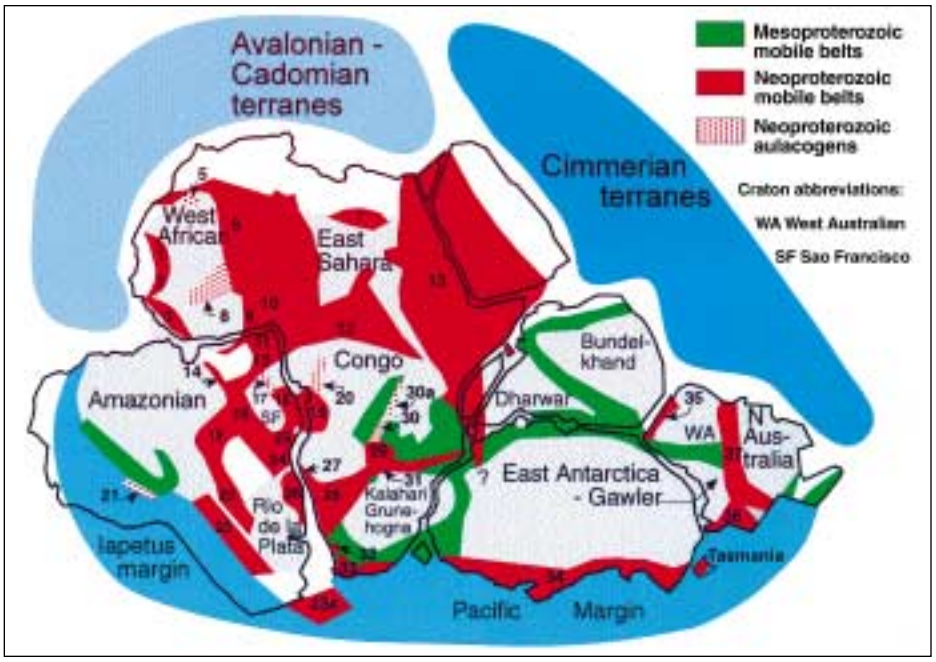

Figure 1. Reconstruction of Gondwanaland after 500 Ma and index map for Neoproterozoic mobile belts of Gondwanaland. Mobile belts include collisional and transpressional orogens and aulacogens. Aulacogens are aborted rifts, undeformed to mildly deformed, terminating inside cratons. Gray = Archean-Paleoproterozoic cratons (pre–1600 Ma); green = Mesoproterozoic (1600–100 Ma) mobile belts; Neoproterozoic (1000–440 Ma) orogens in red, and aulacogens in white with red stipple; geodynamic provinces peripheral to Gondwanaland in shades of blue. Mobile belt index: 1—Mauretanides, 2—Bassarides, 3—Rokelides, 4—Anti-Atlas, 5—Ougarta aulacogen, 6—Trans-Saharan, 7—Tibesti, 8—Gourma aulacogen, 9—Dahomeides, 10—Nigeria-Cameroon, 11—Borborema, 12—Sergipe-Oubanguide, 13—East African, 14—Araguaia, 15—Goias, 16—Brasilia, 17—Paramirim aulacogen, 18—Araçuai, 19—West Congo, 20—Sangha aulacogen, 21—Tucavaca aulacogen, 22—Paraguay-Cordoba, 23—Pampean Ranges, 23a—Northern Patagonia, 24—Ribeira, 25—Rio Doce, 26—Dom Feliciano, 27—Kaoko, 28—Damara, 29—Lufilian, 30—Kundelungu aulacogen, 30a—Bukoban aulacogen, 31—Zambezi, 32—Gariep, 33—Saldania, 34—Beardmore, 35—Pinjarra, 36—Adelaide, 37—Paterson-Peterman Ranges.

GEODYNAMIC MAP SETUP AND PHILOSOPHY

The objective of the *Geodynamic Map of Gondwana Supercontinent Assembly* is to present a synthesis of the accretion of Gondwanaland, which is composed of lithospheric plates that traveled large distances during the Neoproterozoic (1000 to 545 Ma). Latitudinal movements of the cratons that resided within Gondwana were determined from paleomagnetic data, and their relative movements were inferred from events registered in mobile belts in the reconstituted supercontinent. Intercontinental correlations of mobile belts across modern oceans provided a means for reconstruction of supercontinent assembly by geodynamic interpretation of depositional, igneous, tectonic, and metamorphic events. Recognition of the role played by Laurentia in the assembly and breakup of Rodinia—the precursor supercontinent to Gondwanaland—and the application of lithotectonic terrane concepts to the better studied Neoproterozoic mobile belts added complexity to the geodynamic interpretation.

Chronostratigraphic limits for subdivision of the Proterozoic period into Mesoproterozoic (1600 to 1000 Ma) and Neoproterozoic (1000 Ma to the start of the

Map *continued on p. 2*

[1]R. Unrug, editor, 1996, scale 1:10 million, four sheets, total dimensions 1,950 x 1,250 mm, 19 colors; published by Bureau de Recherches Géologiques et Minières, US$50. Order from: Editions BRGM, Ave. Claude Guillemin, BP 6009, F-45060 Orléans Cedex 2, France, fax 33-2-38-64-36-82, or Director, Council for Geoscience, Private Bag X112, Pretoria 0001, South Africa, Attn.: Information Division, fax 27-12-841-1221.

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IN THIS ISSUE

Map *continued from p. 1*

Cambrian) periods follow the time scale approved by the International Union of Geological Sciences (IUGS). The beginning of the Cambrian Period is taken as ~545 Ma for correlation of chronometric and geologic time scales (Plumb, 1990; Brasier et al., 1994).

Archean to Paleoproterozoic (pre–1600 Ma) cratons that rode the moving lithospheric plates, but underwent no deformation during Mesoproterozoic, Neoproterozoic, and Paleozoic orogenies are considered passive elements of the Gondwanaland jigsaw puzzle. No structural details are shown in these cratons, except for Mesoproterozoic and Neoproterozoic cover units, intracratonic basins, and cratonic marginal foreland basins. Structural reactivation and rejuvenation of cratonic basement near younger mobile belts are indicated by special symbols. No geologic details are shown in post-Triassic cover postdating collisional and accretionary events related to Gondwanaland assembly.

The mobile belts are shown in as much detail as practicable at the map scale. Ages of rock units at supergroup, group, suite, and complex rank are shown in color and grouped in two-geon intervals (200 Ma) for the Mesoproterozoic and one-geon (100 Ma) intervals for the Neoproterozoic and Paleozoic. Locations of small igneous intrusions, ophiolitic sequences, eclogites, mafic to ultramafic metamorphic tectonites, glaciogenic sediments, and regions of thermal rejuvenation that are important for map interpretation but too small for cartographic presentation are shown by special symbols. Lithology of sedimentary rock units of supergroup and group rank and protoliths of metasedimentary rocks are shown with symbols indicating basin classification: rift, passive or active margin, oceanic, foreland, molasse, and aulacogen. Symbols for igneous rock units indicate rift-related, synorogenic, postorogenic, and anorogenic magmatic suites. Symbols for metamorphic rock units show foliation trends, nature of protoliths, and metamorphic facies. Structural symbols indicate plate margins, faults, structural trends of folds and foliation, and tectonic transport directions.

GONDWANALAND QUESTIONS

Neoproterozoic organization of continental crust into large supercontinents is the subject of ongoing debate, and various models are evolving as new data become available (Powell, 1993; Dalziel, 1991; Trompette, 1994; Stern, 1994; Rogers et al., 1995b; Unrug, 1995; Yoshida, 1995). The main questions are: Were there one or more Neoproterozoic supercontinents, and when did they (it) form and break up? How were the older cratons arranged within these supercontinents? Where are the sutures marking closure of oceans? Was there a collision between East and West Gondwanaland?

The following discussion of the events that resulted in the agglomeration of Gondwanaland presents a balanced opinion, worked out during compilation of the *Geodynamic Map,* of the map Editorial Committee. The map was compiled from regional contributions by authors currently or recently active in research in the various parts of Gondwanaland. The availability of data along the individual mobile belts varies dramatically, with some African belts having been studied in the most detail. In poorly understood regions, relatively scarce reliable data have been combined with results several decades old. To simplify and focus descriptions on major super-regional relationships, diachronous rifting and collisional events along the margins of older cratons have been grouped. The synthesis presented here, founded on the database generated by the map's co-authors, is offered to invigorate debate on important questions of Neoproterozoic geodynamic evolution of continental crust.

RODINIA BREAKUP AND THE EARLY NEOPROTEROZOIC PAN-THALASSAN OCEAN

Gondwanaland originated during the Neoproterozoic Pan-African–Brasiliano orogeny that resulted in ocean closures and rearrangement, collision, and suturing of the older continental crustal fragments that constituted the Archean-Mesoproterozoic cratons (Fig. 1). The latter were produced by breakup of the precursor supercontinent Rodinia which has been reconstructed according to the SWEAT (Southwest United States–East Antarctic connection) hypothesis (Moores 1991; Dalziel, 1991; Hoffman, 1991). The assembly of Rodinia occurred by amalgamation of Archean-Paleoproterozoic cratons in collisions that produced late Mesoproterozoic (1300 to 1000 Ma) mobile belts (Fig. 2). These pericratonic orogenic belts formed a continuous system (Harris, 1995; Sadowski and Bettencourt, 1996). Truncations of these Mesoproterozoic orogens along younger continental margins form the "piercing points" used to pinpoint orogenic belt continuations and mark relative positions of older cratons in the Rodinia reconstruction (Dalziel, 1992). The North American craton, Laurentia, linked with Siberia (Condie and Rosen, 1994) forms the central keystone of Rodinia. Locations of the North China and South China cratonic blocks are from Li et al. (1995, 1996).

The reconstruction of Rodinia in Figure 2 accounts for all pre-Mesoproterozoic continental crust and Mesoproterozoic orogens except for the small Archean crustal blocks of Tarim, Lut, and central Iran. These blocks were presumably part of Rodinia, but their relative positions are unknown. Thus, Rodinia was a Pangean-size supercontinent, and the rest of Earth's surface was covered by a Panthalassan-size ocean.

EARLY NEOPROTEROZOIC EVENTS AND THE BREAKUP OF RODINIA

Events between 1000 and 720 Ma that postdated the assembly and predated the breakup of Rodinia included widespread shearing and tectonic escape, post-tectonic magmatism, extension, rifting, and intracontinental mobile belt formation. The evolution of most western Gondwanaland Neoproterozoic sedimentary basins can be traced to crustal extension and rifting predating the breakup of Rodinia. The breakaway of Laurentia from East Antarctica and Australia which began the disintegration of Rodinia by cutting the supercontinent in half (see Fig. 2) and creating the Pacific Ocean, is dated at 725 Ma by paleomagnetic data (Powell et al., 1994). Some of the important events preceding this breakup are summarized below and their results shown in Figure 2.

In Australia, formation of rift and sag basins in the Adelaide "geosyncline" had begun by 830 Ma. Correlative sediments were deposited in central Australian basins whose margins were later deformed in an intracontinental mobile belt at 600 to 550 Ma (Myers et al., 1994; Powell et al., 1994). In the Ross orogen of East Antarctica, rifting starting at about 750 Ma (Stump, 1995) led to deposition of a passive margin sequence.

Rifting is also documented in the deformed corridor between the Kalahari and Congo cratons of Africa. In this region, transtensional and transpressive events occurred successively as a series of younging-to-the-east rift basins formed between 1100 and 950 Ma (Unrug, 1995). In the Lurio shear zone in the Mozambique orogen, post-tectonic magmatism lasted until 850 Ma (Pinna et al., 1993). This shear zone extends into the Zambezi belt rift basin, which opened at 880 Ma and was deformed at 820 Ma (Barton et al., 1993; Wilson et al., 1993).

Latest Mesoproterozoic–early Neoproterozoic events are also recognized in the southern segment of the East African orogen. Separation of the Congo and the contiguous East Sahara cratons from Rodinia started at about 1200 Ma, as did the evolution of the sedimentary basin in Kenya. By 820 Ma, a passive margin was developing east of the Tanganyika shield of the Congo craton, and migmatization, early collision, ophiolite emplacement, and metamorphism were occurring in the Kenyan segment of the East African orogen (Shackleton, 1986; Mosley, 1993). In the northern East African orogen, bimodal rift-related magmatism has been dated at 870 to 840 Ma in the Nubian shield and at 880 Ma in the Arabian shield (review in Stern, 1994).

In the Borborema tectonic province of northeastern South America, widespread rifting at about 1000 Ma (Van Schmus et al., 1995) affected a large region of crust. The affected crust contains some Archean inliers, but was principally formed during the Paleoproterozoic Amazonian and Eburnean orogenies. The continuity of South American Neoproterozoic mobile belts across the Atlantic and the rifting ages of 800 Ma in the northern Cameroon region (Toteu et al., 1987) suggest that this general rifting was a long-lasting event. Some of the far-traveled terranes of the West African Tuareg shield, whose positions in Rodinia are unclear, have Archean or Eburnean basement ages and early Neoproterozoic passive margin sequences (Black and Liégois,. 1993) consistent with their having rifted from Rodinia during this event.

Late Mesoproterozoic to early Neoproterozoic rifting events reconfigured the global oceanic realm. The large Arabian-Nubian and Pharusian oceans opened (in modern coordinates) east and west, respectively, of the Congo–East Sahara–Nile craton cluster (Fig. 2). Passive margins developed at about 1000 Ma along the eastern margins of the West African, Amazonian, and Rio de la Plata cratons (Trompette, 1994). The Adamastor ocean opened between the Kalahari, Congo, Saõ Francisco, and Rio de la Plata cratons, and a side branch extended between the Kalahari and Congo cratons. Rifting that is dated at 900 to 800 Ma occurred along the western margin of the Kalahari craton (P. G. Gresse *in* Powell, 1993).

Subduction also occurred during this period. Juvenile crust formed in early Neoproterozoic magmatic arcs has been recognized in the East African orogenic belt in the Arabian-Nubian shield, in the Trans-Saharan belt, and at the margins of the South American Amazonian and Rio de la Plata cratons. A long history of Neoproterozoic magmatic-arc collisions and large-scale additions of juvenile crust is recorded in the northern East African orogenic belt (Stern, 1994). The Trans-Saharan belt contains Neoproterozoic calc-alkaline magmatic arcs with ages of 870 to 840 Ma (pre–Pan-African; see below), 750 to 665 Ma, and 650 to 570 Ma that are related to east-dipping subduction zones (Black et al., 1994). At the eastern margin of the South American Rio de la Plata craton, polyphase magmatic activity in the Pelotas composite batholith started with arc magmatism at 850 to 830 Ma (review in Trompette, 1994). In the Dom Feliciano orogen on the eastern side of the Rio de la Plata craton, the Villa Nova belt contains early Neoproterozoic juvenile crust (Babinski et al., 1996). In the South American Goias massif, southeast of the Amazonian craton, protoliths of orthogneisses have crystallization ages of 899 Ma and metavolcanic rocks have ages of 929 to 877 Ma and 764 Ma (Pimentel and Fuck, 1992).

PAN-AFRICAN–BRASILIANO OROGENY AND GONDWANALAND ASSEMBLY

The Pan-African–Brasiliano orogenic belts (red belts in Fig. 1; Fig. 3) mark the collisional zones between the continental pieces that reassembled to form the Gondwanaland supercontinent after the breakup of Rodinia. In the first stage of this breakup, Laurentia separated from the eastern Australia–East Antarctica rifted margin of the part of Rodinia that later became East Gondwanaland. As Laurentia drifted away, it pushed the cluster of Amazonian–West African–Rio de la Plata cratons (Fig. 2) away from East Gondwanaland. These cratons later collided, creating the Pan-African–Brasiliano orogenic belts of West Gondwanaland (Fig. 3).

Most of the Pan-African–Brasiliano orogenic belts were formed between 725 Ma and 500 Ma by collisional events resulting from the convergence of lithospheric microplates created by the breakup

Map *continued on p. 4*

Map *continued from p. 3*

of Rodinia (Fig. 3). One of the principal belts, the East African orogen (13 in Fig. 1; see Fig. 3), contains the Arabian shield onto which several ensimatic and continental terranes were accreted between 715 and 630 Ma (Stoeser and Camp, 1985). Accretion ages of terranes in Yemen (Windley et al., 1996) are probably similar. Farther south in Tanzania, granulite metamorphism associated with crustal thickening related to collision is dated at 715 to 652 Ma (review in Stern, 1994). In the Aïr region of the Trans-Saharan orogenic belt (6 in Fig. 1), collision related to a west-dipping subduction zone is indicated by magmatic rocks with ages of 730 to 700 Ma (Liégeois et al., 1994). A collision of the West African craton with the terrane agglomeration of the Trans-Saharan belt (6 in Fig. 1) at 600 Ma has been recognized by Black et al. (1994). In the Bassarides and Mauretanides mobile belts (1 and 2 in Fig. 1) at the western margin of the West African craton, collision is dated at 660 to 650 Ma. A younger collisional event in the Anti-Atlas (4 in Fig. 1) is dated at 620 to 600 Ma (Villeneuve et al., 1993). Mobile belts of South America and equatorial and southern Africa show diachronous collisions: 700 Ma in the Dom Feliciano belt (26 in Fig. 1; Fernandes et al., 1992), 630 to 620 Ma in the Ribeira and Oubanguides belt (12 and 24 in Fig. 1; Tassinari and Campos Neto, 1988; Penaye et al., 1993), 560 to 530 Ma in the Rio Doce belt (25 in Fig. 1; Campos Neto and Figueredo, 1995), and 590 Ma in the Damara belt (28 in Fig. 1; K. H. Hoffmann, 1992, personal commun.).

Trompette (1994) drew attention to a second generation of West Gondwanaland mobile belts that originated as post-Rodinian break-up rifts after 650 Ma and underwent compressional or transpressional deformation at about 550 Ma. These belts include the Western Africa Rokelide belt (3 in Fig. 1), which formed by dextral shearing between the Amazonian and West African cratons, and the South American Araguaia(?)-Paraguay-Cordoba belts (14 and 22 in Fig. 1) where authors of the *Geodynamic Map* recognize oceanic crustal and metasedimentary sequences. The Paraguay-Cordoba belt contains a polyphase-deformed, cratonic marginal basin that was intruded by late-tectonic granites at 550 to 500 Ma.

The concept of a single collision between East and West Gondwanaland in the Neoproterozoic appears to be an oversimplification. During the assembly of West Gondwanaland, several lithospheric plates carrying large cratons and a number of smaller lithotectonic terranes were telescoped (Fig. 3). This resulted in closures of intervening oceanic basins, and sequential docking of the terranes onto an evolving Neoproterozoic tectonic collage on the

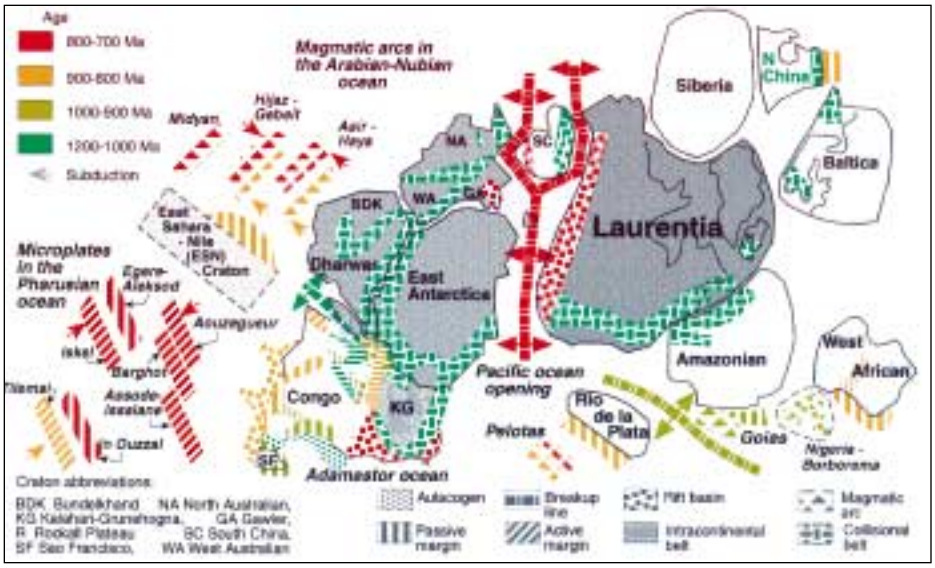

Figure 2. Reconstruction of Rodinia showing early Neoproterozoic events (1000 to 700 Ma). The magmatic arcs and microplates in the Arabian-Nubian and Pharusian oceans are schematic. Medium gray is East Gondwanaland. Green is Mesoproterozoic mobile belts suturing older cratons in Rodinia. Other colors indicate ages of early Neoproterozoic mobile belts and basins. Abbreviations of cratonic names: BDK—Bundelkhand, G—Grunehogna, GA—Gawler, NA—North Australia, R—Rockall Plateau, SC—South China, SF—Saõ Francisco, WA—West Australia.

western side of East Gondwanaland. East Gondwanaland, comprising Australia, East Antarctica, India, and part of Madagascar (compare Figs. 1 and 3), formed a stable Gondwanaland nucleus, which was subjected only to intracratonic deformation.

The authors of the map suggest that the term "Pan-African–Brasiliano orogeny" be applied only to the collisional events that led to the suturing of West Gondwanaland. The term should not be for earlier, extension-dominated Neoproterozoic events related to the breakup of Rodinia.

The assembly of Gondwanaland was complete by earliest Paleozoic time. There could have been a short time in the latest Neoproterozoic when Laurentia, still joined with Siberia and Baltica, was in contact with the Amazonian and Rio de la Plata cratons, which were already part of West Gondwanaland. This combination would form the short-lived supercontinent

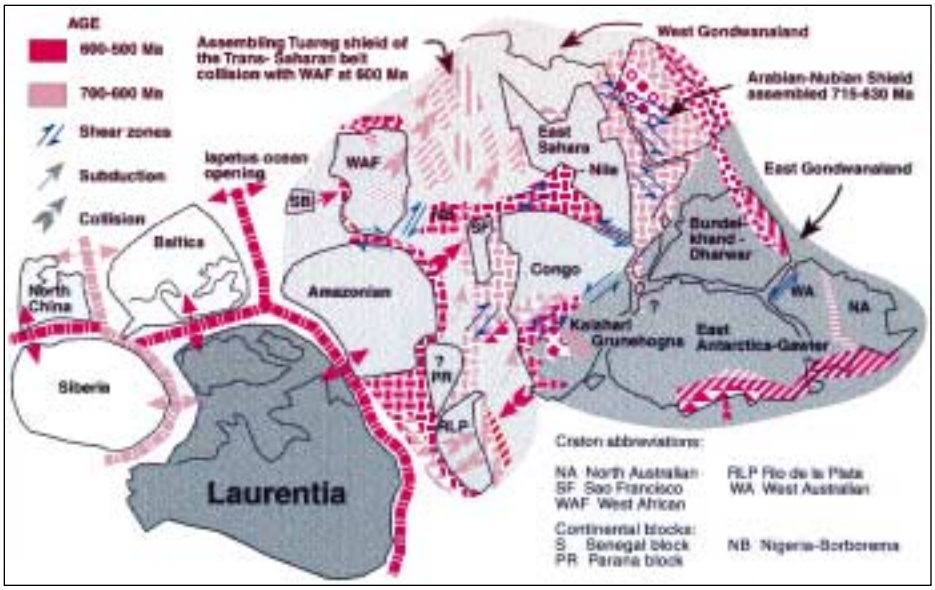

Figure 3. Map showing East Gonwanaland (medium gray), assembly of West Gondwanaland (light gray) from 700 to 500 Ma, and possible Pannotian supercontinent. Pan-African–Brasiliano mobile belts within and on the margins of assembling West Gondwanaland. The Pannotia supercontinent could have existed briefly after the agglomeration of West Gondwanaland and the assembly of Gondwanaland, and before Laurentia separated from the Baltica, Amazonia, and Rio de la Plata cratons. Symbols for geodynamic classification of belts and craton abbreviations as in Figure 2.

called Pannotia (see Powell, 1955). Pannotia would have to have been destroyed by about 540 Ma, when the Iapetus ocean formed as Laurentia separated from the Baltica, Amazonian, and Rio de la Plata cratons (Fig. 3).

LATE- TO POSTOROGENIC EVENTS

Widespread late- to postorogenic magmatism, shearing and lateral tectonic escape and major uplift resulting in deep exhumation of mobile belts are salient features in all of Gondwanaland including the Himalayan basement of greater India. These features are generally attributed to a major thermal event that lasted into the Cambrian-Ordovician and led to widespread resetting of isotopic ages. In the Antarctic shield, which apparently had been stable since the Mesoproterozoic consolidation of Rodinia, Stüwe and Sandiford (1993) have attributed this thermal event to underplating by asthenospheric-derived basaltic magmas and related heat advection. In northern Africa, where wide Neoproterozoic mobile belts developed in the Tuareg and Arabian-Nubian shields and partial dismemberment of the intervening East Saharan–Nile craton occurred during the Pan-African orogeny (Schandelmeier et al., 1994), late- to postorogenic effects are attributed to lithospheric mantle delamination following collision of lithospheric plates. This delamination is suggested to result in thinning or elimination of the lithospheric mechanical boundary layer, recycling of upper-mantle material in the asthenosphere, and direct contact of crust with upwelling asthenosphere (Black and Liégeois, 1993).

A late Precambrian–early Paleozoic suture between East and West Gondwanaland that extended from East Africa into the Sør Rondane Mountains of East Antarctica has been suggested by Rogers et al. (1995a). This suggestion is based on radiometric ages of 550 to 450 Ma for granulite formation and for mylonites that occur in a belt extending from the East African orogen into Madagascar, southern India, Sri Lanka, and East Antarctica. This suture is controversial; others argue that Neoproterozoic to earliest Paleozoic structural events in Dronning Maud Land in Antarctica are minor (Moyes et al., 1993), and that metamorphism in the Sør Rondane Mountains and formation of anhydrous, high-temperature charnockites in southern India at about 500 Ma are better attributed to a distensional or transcurrent tectonic regime and lithospheric mantle delamination (Yoshida, 1995; Bartlett et al., 1995).

PACIFIC MARGIN OF GONDWANALAND

By Paleozoic time, the locus of geodynamic activity had shifted to the margins of Gondwanaland. Accretionary processes were dominant on the Pacific and Iapetus margin, whereas rifting was occurring in the Avalonian-Cadomian and Cimmerian provinces (Nance and Murphy, 1994; Metcalfe, 1993). The Ross-Delamerian magmatic arc was active along eastern Australia and East Antarctica, and the Lachlan-Thomson accretionary-magmatic arc assemblage was forming offshore Australia. West of the South American Rio de la Plata craton, a complex exchange of terranes between the Amazonian craton and Laurentia resulted in the formation of the Famatinian collisional orogen and the transfer of the Precordillera terrane from Laurentia to Gondwana (Dalla Salda et al., 1993). The Pampean exotic terrane and the Arequipa terrane were possibly detached from the western margin of the Amazonian craton (Ramos, 1996), following the late Neoproterozoic breakup of Laurentia and Amazonia.

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Map *continued on p. 6*

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Each month, *GSA Today* features a short science article on current topics of general interest. For guidelines on submitting an article, contact *GSA Today* Science Editor S. M. Kay, Cornell University, (607)255-4701, fax 607-254-4780, E-mail: kay@geology.cornell.edu.

Alternates Receive 1996 Student Research Grants

Each year when the Committee on Research Grants selects student grant recipients, they also select an alternate group of recipients in the event that some of the grantees return part or all of their funds because they have received funding elsewhere or have changed their research plans. As the returned funds become available, they are re-awarded by the Research Grants Administrator to the alternates named by the committee.

In 1996 ten alternates received funding following the initial awarding of grants. They are: Daniel A. Cenderelli, Colorado State University; Ziqiang Chen, Florida State University; Tina M. Dochat, University of Wisconsin—Madison; Ruifang He, University of Quebec—Chicoutimi; Emmanuelle Javaux, Dalhousie University; Rynn M. Lamb, Western Washington University; Richard Allyn Meyers, University of Calgary; James R. Ostdick, California State University—Bakersfield; Andrew John Willis, University of Toronto; and Adam D. Woods, University of Southern California.

Why the Journals Are Late

Changes in the editorial-and-production processing of the *GSA Bulletin* have resulted in delayed publication time for the journal. The *Bulletin* and *Geology* are grouped for mailing, to take advantage of significant savings on packaging, processing, and postage rates; thus, both journals were mailed late for November, December, and January. We are working to get the *Bulletin* back on schedule, and we hope to mail it, as well as *Geology,* on their regular dates (typically, within the first ten days of the month) in March.

Geology and Culture: A Call for Action

Eldridge M. Moores, *GSA President, 1996*

There is a tide in the affairs of men [and women],
Which, taken at the flood, leads on to fortune.
Omitted, all the voyage of their life
Is bound in shallows and in miseries.

—W. Shakespeare, Julius Caesar, IV, iii, 217

INTRODUCTION

The delivery date of this address, October 28, 1996, was the 5999th anniversary, or thereabouts, of the alleged creation of the Earth. So think roughly half of U.S. citizens. I mention this not to criticize these people or Bishop Ussher, who first published the estimate, but to indicate the gulf in perception separating us as geoscientists from many other people as we approach the milennium.

The last half century has been a golden age for geology, a time of major scientific revolutions (e.g., plate tectonics, Earth in space, organic evolution, imaging). And there are still many exciting questions left to be answered. Many of us came of age scientifically in the post-Sputnik era when jobs and funding for research were abundant, and geology was caught up in the excitement of these revolutions.

Times have changed, however. Many younger members of our society were attracted to the field by the excitement of the revolutionary developments and the perceived career opportunities, but now they face a declining job and research funds pool. Many geologists from government organizations, academia, and industry have faced disruption of careers or underemployment as downsizing has hit and the projected shortage of advanced degree holders did not materialize.

It had been my intention to present a talk on pure science as my presidential address. However, events have conspired against such a presentation. The last year has seen the continuation of an ongoing crisis in geology of sufficient severity to make any preoccupation with pure science akin to fiddling while Rome burns.

Manifestations of this crisis include:

1. There is very little knowledge of the geosciences among the public as a whole (as indicated above), although there seems to be a great hunger for knowledge on the part of many nonscientists.

2. There seems to be little knowledge or appreciation of geoscience in Washington in general and Congress in particular.

3. Society in general is moving (or has moved) toward two separate groups, one science literate, of which we are a part, and the other science illiterate and increasingly in the thrall of religious fundamentalism, of whatever stripe. This latter group is growing in numbers and political influence and views much of what we do as anathema (geological time, environmental considerations, renewable vs. nonrenewable resources, etc.)

4. Many other sciences speak much more consistently with a single voice or at least a coordinated public stance; geosciences by contrast are like a covey of quail—going in all directions.

The problem, however, is larger than just geosciences. The "social contract" between science and the public, which has been in effect since the end of World War II, is ending (Byerlee and Pilke, 1995). In the future the scientific community will have to make it more clear how its research benefits society (e.g., Moores, 1996). Funding for research and development in the United States may be cut some 30%, regardless of which party is in control in Washington. Similar situations in Australia, Canada, the UK, and France indicate the international scope of the problem.

Furthermore, as funds become more scarce, many universities and colleges are seeking to downsize. One of the most vulnerable departments seems to be, paradoxically, the local geoscience department, which is viewed by many administrations, apparently, as "irrelevant" in an era of tight money. This past year, I have written, as GSA President, two letters to college administrators (one unsuccessful) in support of departments theatened with abolition, and there have been others (e.g., Feiss, 1996).

How can the geosciences possibly be seen as irrelevant in view of their centrality to resolution of problems of the environment, resource limitation, and global carrying capacity that face society as a whole? Our collective perception is that geosciences are not only exciting, but also essential. How much money could have been saved, for example, if the builders of dams or highways or flood-control systems had factored geology into their plans? How can our own perception be so different from that of the rest of society? What can we do to remedy this situation?

My own journey into several of these issues began a couple of years ago with a question from writer John McPhee: "Why is there so little knowledge of geology on the part of the public as a whole, and why is so little taught in schools when the subject is so interesting?" What follows is a progress report of what I have learned on this journey. It includes brief overviews of the history of science education, relations between earth science and culture, between geological thought and society, and the present-day situation and what we might do about it.

HISTORY OF SCIENCE EDUCATION IN THE UNITED STATES

The present U.S. organization of science education stems from the effort a century ago (National Education Association, 1894) to institute a systematic set of expectations for secondary school education. This committee was the brainchild of Charles Fielding Eliot, long-time president of Harvard and one of the giant figures in U.S. education in the late 19th and early 20th centuries. Eliot's efforts led to the establishment of a Committee of Ten to oversee the development of lists of subject matter that should be taught in classes in grades 9 through 12. The committee's recommendations are the foundation of the curriculum still taught in high school. In science, the recommendations were "geography" in the 9th grade, botany or zoology in the 10th grade, chemistry in the 11th, and physics in the 12th. "Geography" was a mixture of physical geography, geology, and meteorology. The subcommittee that formulated the recommendations on "geography" included one current and two future GSA presidents—T. C. Chamberlain (1894), I. C. Russell (1906), and W. M. Davis (1911).

As teaching developed in the early 20th century, "geography" was replaced by general science, including not only physical geography, geology, and meteorology, but also astronomy, biology, chemistry, physics, and health (Frank Eierton, written communication, 1995). Biology replaced botany and zoology.

In 1894, geology was at the peak of its 19th century development (Baker, 1996). After all, this time followed publication of Darwin's *Origin of Species* (1859), and the exploration of the western United States and Canada in the previous several decades. Yet geology was marginalized in science education. Why? I speculate that

Presidential *continued on p. 8*

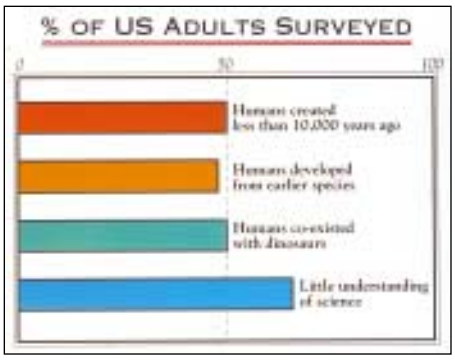

Figure 1. Attitudes of U.S. adults about science (after National Science Board, 1996).

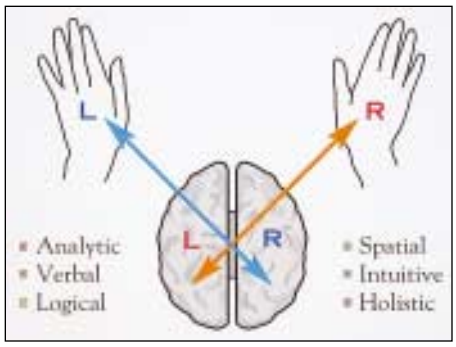

Figure 2. Diagram of brain, showing possible relationship between hands and thought processes (after Edwards, 1979).

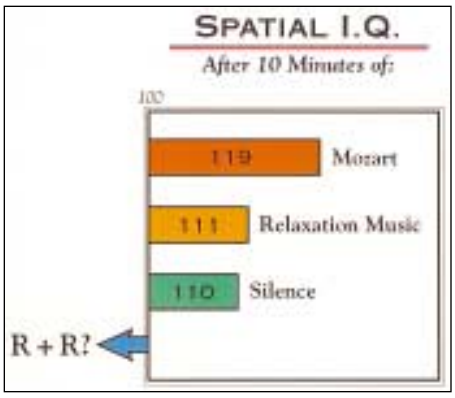

Figure 3. Spatial IQ and music (after Rauscher et al., 1993).

Presidential *continued from p. 7*

geology may have been suffering from some sort of "Kelvin effect." At the time of deliberations of the Committee of Ten, geologists were locked in a controversy with Lord Kelvin and his followers about the age of Earth. Assuming all the heat from Earth was left over from its accretion, Kelvin calculated that Earth was about 100 million years old and possibly not more than 10 m.y. Many geologists—e.g., T. H. Huxley—argued that it was much older. The debate received wide attention in both the scientific community and the public press. Kelvin greatly disparaged the opinion of geoscientists, who could not quantify their intuitive notion for a much older Earth. Kelvin also argued that only knowledge expressible in numbers was science, a restatement of Descartes' dictum that knowledge must be "certain," and preferably expressed quantitatively (Frodeman, 1996). One of his cohorts, Peter Guthrie Tait, said that Kelvin had "removed the blinders from the eyes of the geologists and (set) them back on the path to truth" (Albritten, 1980, p. 190). The subsequent discovery of radioactivity, of course, meant that Kelvin's calculations were off by a factor of about 50 to 500, and that the intuitive, semiquantitative geologic estimates were more accurate than his mathematical "proof."

The Committee of Ten did its work at a time when geology was under a cloud, in both the science community and the public. Its recommendations and the Kelvin debate have resonated throughout the 20th century in the development of a reductionist (science separated into component parts with no overarching view of the whole), hierarchical (one field more "worthy" than another; "pure" better than "applied"; Alvarez, 1991; Baker, 1996) system of science education and science establishment, a "pecking order" in science, with mathematics and physics at the top, geology somewhere on the slope, and social sciences on the bottom. This situation was enhanced by the Manhattan project, which spawned the Faustian bargain among scientists, government, and the military leading to the era of "big science," and the now-defunct social contract between science and society.

As a result, an entire century's worth of students have grown up with no comprehensive view of science and with little or no knowledge of Earth. Despite efforts by the American Geological Institute and others beginning in 1959, geology has never received the attention in primary and secondary school education that it deserves. GSA's own SAGE (Science Awareness through Geoscience Education) program is making great strides and has many programs for increasing geoscience awareness. The problem is huge, however, and SAGE can't do it all. We all need to get involved.

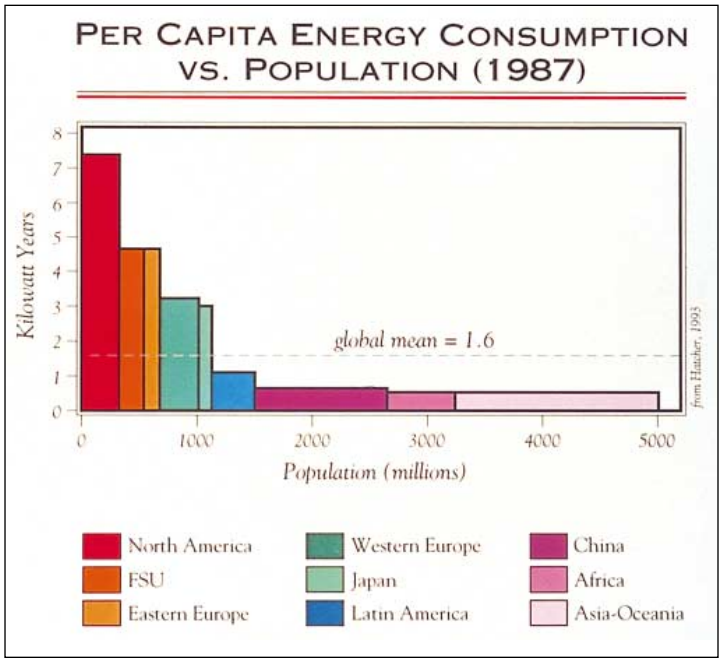

Figure 4. Per capita energy consumption vs. population (after Hatcher, 1994).

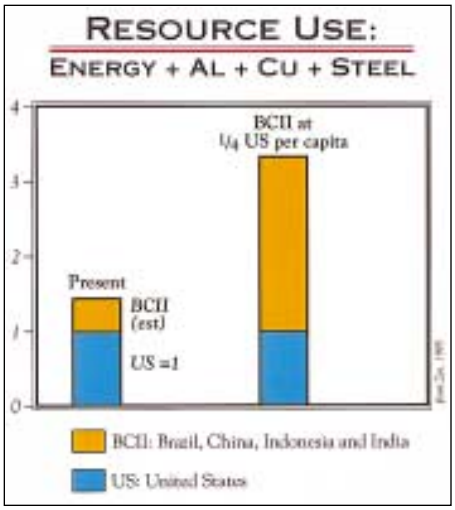

Figure 5. Comparison of total resource consumption at present for United States (normalized to 1) and Brazil, China, India, and Indonesia (BCII) (left column), and projected consumption assuming BCII consumption of 1/4 U.S. consumption and constant population (after Zen, 1995)

EARTH AND CULTURE

This separation of human thought from the earth is a relatively new phenomenon, historically. Earth plays a prominent role in many indigenous cultures. For example, Semken and Morgan (1996) and Murray (1996) outlined the relation between Diné (Navajo) and Cree traditions and geology. Legends of a Mother Earth Goddess are abundant in Europe and Asia. Greek mythology includes a battle between Hercules and Antaeus, the son of Gaia, the earth goddess. As long as Antaeus could maintain contact with the earth, he was unbeatable. Only when Hercules held him above his head was that contact broken, so that Hercules was able to vanquish his opponent. The moral for modern humans is that we should "keep our feet on the ground," and maintain our kinship with the earth (Mather, 1986).

The relation between indigenous cultural traditions and myths and the earth implies an almost subconscious need for a connection with the earth on the part of humans everywhere. This is in accord with my own experience. As a result of John McPhee's best seller, *Assembling California* (McPhee, 1993), I have heard many comments about geology from nonscientists, and I have developed something of a second (mostly volunteer) career taking nonscientists on field trips. This experience has shown me that there is a great deal of interest, even hunger, for geologic knowledge on the part of the average person. Many regret not having had geology in school. Furthermore, if you ask the average 3rd grader what (s)he is interested in, the answer typically includes dirt, rocks, volcanoes, earthquakes, dinosaurs. People are naturally attracted to the earth and are very interested in their surroundings—they need a sense of place.

Yet most of us live in urban areas surrounded by our own edifices and out of contact with nature. Traditionally, teachers have been ill-prepared to teach science; what little is taught is esoteric, not earth-based, and hard to apply to daily life. Certainly, there is no overarching view of the natural world. What is the result? Though people generally express faith in the ability of science to solve societal problems, ignorance of science is widespread—only 6% of U.S. adults are "science literate" (Sarewitz, 1996) and some 64% are science illiterate (Fig. 1).

Most people's knowledge of science is spotty and idiosyncratic, which probably accounts for the growing frustration of the public with the claims of scientists. Furthermore, popular conceptions about Earth history are shocking—approximately 50% believe that Earth is less than 10,000 years old; only 48% recognize that the earliest humans and dinosaurs did not live at the same time; and only 44% recognize that humans developed from earlier species of animals (National Science Board, 1996; Fig. 1). Most people, when asked, remember their science education as "fear and loathing and dead frogs," as one wag put it. I believe that this lack of knowledge of and aversion to science is a direct result of the reductionist-hierarchical system of education. This system has failed us.

The reductionist-hierarchical practice of science has given us much new knowledge of interest and societal importance, and there are many new results to be anticipated. It has produced, however, an increasingly specialized science culture, characterized by a series of disciplines that are "fragmented into little islands of near conformity surrounded by interdisciplinary oceans of ignorance" (Ziman, 1996). With regard to critical science-policy issues, it has outlived its usefulness. One result has been that "willful ignorance of the increasingly convoluted nexus between science, technology, and society seems to be a theme of modern culture" (Sarewitz, 1996, p. 175).

I believe that these misunderstandings and attitudes are dangerous for an increasingly global society needing science-based solutions to its problems. Also, I suspect that this state of affairs exists approximately in proportion to the lack of geoscience in the educational system.

The gulf between our understanding of Earth history and processes and that of our fellow citizens, many of whom are deeply religious, is also of concern. This is analogous to the problem of "two cultures," first enumerated by Snow (1959). Kirtley Fletcher Mather provided some insight into this issue. Mather was an early 20th century geologist, a Harvard professor, a lifelong evolutionist, Baptist, advisor to Scopes in his famous trial, and social activist (Bork, 1994). Mather clearly saw no conflict between his devout Christian beliefs and his acceptance of evolution. His philosophy (Mather, 1986) gives guidance in how to bridge the gulf between the two cultures.

Mather argued that there are two kinds of knowledge: (1) measurable in space and time, or "scientific," and (2) qualitative, or "spiritual," which is subject to evaluation but inherently unmeasurable in space and time. Spiritual knowledge includes aspects of knowledge such as beauty, awe, reverence, ethics, righteousness, loyalty, creativity, and integrity. Mather states that both kinds of knowledge are necessary for wisdom. He further posits that there is a fundamental need for grounding of culture in the earth, a grounding that is generally lacking today.

GEOLOGY, SCIENTIFIC INQUIRY, AND SOCIETY

I believe that it is precisely this point where the gulf between the scientific and nonscientific community originates. Mather's point is generally ignored by many scientists who argue that science is detached from other fields and basically amoral or "premoral" (Sarewitz, 1996, p. 102). One can argue, however, that scientific inquiry makes a moral judgment simply in its choice of topics to investigate. Also, such items of ethics are important—in fact, GSA is sponsoring a conference on the subject in summer 1997.

We are all familiar with the standard scientific method: i.e., statement of problem, hypothesis, experiment, and analysis, the so-called "analytic philosophy" of philosophers of science (Frodeman, 1995). Application to societal problems of knowledge thus gained is widely thought to be linear, specifically by generation of new knowledge, search for applications, development of specific products, and introduction of products into society. This widespread view is not, however, the way that things happen. Science and technology are inextricably intertwined, as are basic and applied research. We geoscientists have lots of experience with such interconnections, which seem foreign to some other scientists. Furthermore, science and technology are "entirely symbiotic … with economics, politics, and culture" (Sarewitz, 1996, p. 97). Widespread disregard of this point by practitioners of science leads to trouble, such as the failure of ambitious basic research proposals, the disparity between claims for societal benefits of basic scientific research and the actual results, and the dwindling political support for science.

Any scientific inquiry includes the processes of deduction, induction, or, as in geology, a combination of both. Arguments that science is strictly rational, and nonintuitive do not specify, however, how the deduction or induction is to take place. Both processes depend upon the nonrational, nonlogical creativity, imagination, and intuition of the scientist. The "Eureka!" of a scientific leap of insight is key to the progress of science, but it is a fundamentally nonlogical, intuitive process. This process of insight unites the work of scientists and artists. Mather (1986) likened it to religious revelation.

Some geology deals with the study of active processes on and within Earth and other planetary bodies. One can perform, say, geochemical experiments in the laboratory or seismic experiments in the field and arrive at quantitative explanatory models of the process in question. This part of geology thus resembles the analytic method of science as practiced by, say,

Presidential *continued on p. 10*

Presidential *continued from p. 9*

chemists and physicists. Of course, any geoscientist knows that Earth is much more complex than any model, and includes many nonlinear, time-dependent, and overlapping processes (e.g., Zen, 1993), and that the criterion of a good model is that it is testable, not that it is right.

Geology is also historical. We are interested not only in ongoing processes, but the history of those processes through time. For this information, we are dependent on the incomplete, mute, geologic record. Because much of this record is missing, much of the historical aspect of geologic inquiry is intrinsically not quantifiable. That doesn't make it less worthy or less interesting, despite Kelvin's comments to the contrary. However, in such situations, insight depends upon the intuition of the geologist. Piecing together geologic history relies upon consideration of many aspects of the problem in a holistic, all-encompassing manner.

In these ways, geologic inquiry differs from the purely analytic method of inquiry. Geologists look at an entire complex system, Earth, in a way that is partly quantitative, but also partly intuitive and involving value judgments. Frodeman (1995) argued that the philosophy thus developed is not a derivative of the more conventional (analytic) philosophy of physical science, but is a unique method of inquiry in its own right, more suited to application to societal problems than "mainstream" analytic philosophy. The geologic philosophy certainly is well suited to analysis of the complex interconnected system that constitutes the environment. Furthermore, complex science-policy issues such as nuclear waste isolation, toxic waste disposal, global climate change, or resource extraction require balancing of scientific information with nonscientific issues values such as ethics, aesthetics, equity, and ideology. In other words, these issues involve integration of scientific knowledge with Mather's "spiritual knowledge." (Harry Hess, 1963 GSA president, and John Maxwell, 1973 GSA president, observed from their World War II experiences that geologists were well suited to intelligence activities because they were accustomed to looking at a whole situation and were comfortable making decisions on incomplete or otherwise faulty information.)

Geologic instruction also shares ingredients with some instruction in the arts. Two key ingredients common in both artistic and geological education are thinking in three dimensions and teaching students to see things that were always there but that they had not seen before. They are probably right-brain activities (see Fig. 2) . Rauscher et al. (1993) have shown that a short exposure to Mozart can increase students' spatial acuity (Fig. 3). I salute the many geoscientists who are active or frustrated artists and musicians. Playing classical music in laboratory sessions might well improve the efficiency of the students' learning processes.

THE SITUATION TODAY

Vannevar Bush's[1] (1945) concept of the "endless frontier" was an extension of the Baconian dictum "nature to be commanded must be obeyed," which itself was an outgrowth of the Biblical admonishment that humanity must seek to dominate nature (Sarewitz, 1996). We may indeed be in a true crisis in the sense of Kuhn (1970) if the old paradigm that describes the interaction of policy and science is no longer valid, and a new one must be found. The new paradigm may be "sustainable development" or "sustainability," defined as "meeting the development needs of the present without compromising the ability of future generations to meet their own needs" (Sarewitz, 1996, p. 193). In other words, we must live within our means, with an eye toward future generations. If this paradigm takes hold, society will have come full circle in our Biblically mandated journey away from our close connection with the earth, and will have returned to a position resembling that of traditional Native American and other indigenous cultures, as mentioned above.

Geoscience today falls perhaps into three distinct areas, all of which depend on the same data, but which interest three quite different communities. All these areas fundamentally deal with the instantaneous rates of processes integrated over varying intervals of the geologic time scale. All of these are global in their reach and bear on the issue of sustainability and carrying capacity:

1. Active surface, near surface, and internal processes. These include hazard assessment and prediction, sustainable interaction with the environment, geohydrology, soil formation and erosion, climate change, volcanism, and any other active process that enables us to interpret history.
2. Natural resource exploration and exploitation. Here the basic *modus operandi* has not changed very much over the past century or so except for the application of increasingly sensitive and efficient imaging, exploration, and extractive technologies to compensate for the declining richness of deposits, the regulatory framework of exploitation, the increasingly international (exo–North America) nature of activity, and the increasing environmental awareness of the extractive industries.
3. Earth history, from astronomy–solar system origin to present day. The plate tectonic, imaging, and planetary exploration revolutions fit most readily within this category. Ironically, all modern revolutions are stepchildren of the Cold War.

All of these parts of geology are active, exciting fields of inquiry. All are integral to issues of global science–policy relations. The public finds these all very interesting when they are informed about them.

WHAT TO DO?

If we agree that we need a scientifically literate population and that geoscience is central to culture, to the outstanding policy dilemmas facing the world community today, and to the development of science literacy, then we need to act. When Mao Tse-tung took over in Beijing in 1949, he allegedly said, "China has stood up." Regardless of how one views events of the past 48 years, China is no longer "sleeping," as Napoleon allegedly described it. As with China, it is time for the geosciences to stand up and assert ourselves. We need to:

1. Get our message across to the rest of the science and policy communities. We have a lot to offer: a perspective on the whole Earth, a sense of ongoing processes, and a distinctive philosophy of inquiry uniquely suited to application to societal problems.
2. Get geoscience education in the schools, starting right down at the kindergarten level. Here, SAGE has made a good start. Predictions are for a need for more than 100,000 K–12 teachers in the next decade. It would be great if many of these new teachers had geoscience backgrounds. The recently published proposed national standards for K–12 education (National Research Council, 1996), including earth sciences, are a promising development in national recognition of a role for earth science in K–12 education. These new standards are going to need close attention and advocacy at the local level if they are to be adopted. *It is time for all of us in the geoscience community to get involved.*
3. Develop adult education classes in general geology and the relationship between geology and the problems facing society.
4. Offer field trips to local sites, wherever they might be. Explain to your audience that the landscape is there for a reason and tell them how it got there. Talk about geologic time.[2]
5. Develop the ability to explain how basic research might have societal benefit. This is not easy. It requires being able to con-

Presidential *continued on p. 11*

[1]Science advisor to Presidents Roosevelt and Truman.

[2]I like to use a 1 mm equals one year analogy. Work out the distances for a human lifetime (1 dm = 4 inches), 1000 yrs (one meter), all of recorded human history (10,000 years max = 10 m), the K/T boundary (65 km = 35 mi), etc. (The age of Earth is about the number of millimeters from New York to San Francisco, Vancouver to Montreal, or Prince Rupert to Mexico City).

Presidential *continued from p. 10*

dense a comprehensive scientific description into jargon-free but representative one-liners (see Moores, 1996, for one recent attempt). It will also mean removing one's pure-research blinders from time to time, even attempting to formulate one's proposed new research with an eye toward possible societal benefit. Another useful technique may be a narrative-logic approach, communicating in a series of scenarios (Frodeman, 1996).

6. We could take a page from the astronomers. They are united in their stance toward the public, in contrast to the geoscientists, and they work at popularizing their science. For example, a recent NASA publication on proposed future exploration (Dressler, 1996), begins with a section entitled "Astronomy: Its Rewards for Science and Society." In this section, Dressler stated (p. 2), "Astronomy is inspirational. Of all the sciences it remains the most accessible and approachable." I would dispute this statement. Geoscience is also inspirational and arguably more accessible and approachable. After all, we stand on Earth. *It is up to us to make this point.*

7. Those of us who have the aptitude and necessary fortitude can get involved in the public and political arena. Here, GSA's Institute for Environmental Education (IEE) can help. It has provided media workshops and is developing a Geology and Environment Public Outreach Program (GEPOP) of individuals who are capable of effective interaction with policy makers.

8. Institute college curricula that emphasize global geoscience as a general science major for people intending to go on into such fields as law, teaching, or business. Such a course of study ideally would involve development of a different set of courses from those required of geology majors. It could be quite popular and beneficial. It would help to build the science-literate populace that we need. In addition, in view of the need for additional K–12 teachers in the next decade, it's potentially a good way to increase student enrollments in geology courses, and to reduce the pressure on geoscience departments for downsizing or elimination.

9. Develop a Society-wide program to internationalize and to increase our diversity. Geology is increasingly global in scope, and this should be reflected in Society activities. In addition, geoscience is one of the least diverse professions. Increasing diversity is not only a question of simple equity, but also a way to develop a more accurate world-view of outstanding problems than we currently possess. This is a difficult task and will require a carefully constructed, multifaceted approach, working with primary and secondary educators, especially in areas of rural or urban poverty.

10. Work for more effective integration of basic and applied research perspectives. Because GSA includes individuals active in both the extractive and environmental fields and industries, we can provide society a perspective on bringing together these disparate points of view to focus on the problem of sustainable development.

Accomplishing this task of getting our place in the sun will not be easy. It may meet resistance from individuals from fields higher in the "science pecking order" attached to the more conventional scientific point of view. But the potential rewards for our field in terms of public awareness, acceptance, and support, as well as for society as a whole, are profound.

FINAL THOUGHTS

In the global society to which we all are rushing, sustainability and Earth's carrying capacity are critical issues. North American per capita resource use and waste generation are much greater than for any other region (Fig. 4). Zen (1993, 1995) pointed out the implications of this when he examined the prospect of developing nations coming up to the North American comsumptive levels. Bringing only four countries—Brazil, China, India, and Indonesia, which together aggregate about 40% of Earth's 5.5 billion people—up to *one-quarter* of the U.S. per capita level of consumption would *double or triple* the environmental load on Earth. It doesn't seem possible. Yet, who are we to persuade these countries not to strive for what we have? Society somehow needs to work out a way for these and other countries to prosper without environmental ruination and to find a way ourselves to prosper with less draw on Earth's resources. We geoscientists can help in this quest. *Geoscience should become the central science of the 21st century! Let's get going!*

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GSAF UPDATE

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

From the Ground Up

The Geological Society of America Foundation exists to fund research, student support, public education, and other programs the Society believes are necessary to advance the science of geology, the scientific growth and development of its members, and the application of geology to the wise use of Earth.

As we turn the page to a new year, the Foundation's mission bears repeating and remembering. We are reminded almost daily of the sad state of the sciences in America. The Third International Mathematics and Science Study, which compared a representative sample of 13-year-old students from 41 countries, showed American students scoring slightly above the average in math and slightly below the average in sciences (testing physics, chemistry, life sciences, and earth sciences). The *good* news is that the earth sciences were included in the study!

Recently seen on a bumper sticker:
REMEMBER—
MOTHER NATURE BATS LAST

In his address at the GSA Annual Meeting, 1996 President Eldridge Moores asked his audience to consider why the geosciences are not a central focus of national attention and education in view of their intrinsic relation to the problems of environment, resources, and global carrying capacity that face humankind.

The country's scientific groups and organizations productively serve their own interests by defining what they can contribute to remedies. This, then, is what the Foundation's mission means in practical terms:

- improving public awareness and appreciation of the breadth and relevance of the geosciences,
- and generating interest in formal educational emphasis on the geosciences,
- in order that geologists be accorded the respect and voice they deserve—and that the public deserves—in discussions and decisions about the thoughtful exploration and management of all planetary resources.

In short, earth science education has never been more critical. The future requires a population of informed citizens and committed geoscientists prepared to meet the coming challenges in thoughtful and creative ways.

Your support of GSA's programs is equally critical. In another survey, measuring philanthropic trends in the United States, the Gallup organization found that the average donations of those who give are increasing. The *bad* news is that fewer people are giving. In this environment, a new commission headed by former Secretary of Education Lamar Alexander is exploring philanthropy and its importance in American culture. One aim of the commission is to determine the feasibility of ending government involvement in community institutions and filling the void with private charity.

To all who are involved with organizations such as GSA, this study is but the next indicator that changes are under way and that we must take much more seriously our responsibilities to the educational and service programs we value.

Ear to the Ground

Mankin Reelected GSAF Chairman

Convening at the October 1996 GSA Annual Meeting, the Trustees of the GSA Foundation tapped Charles J. Mankin to serve another term as chairman. Charlie joined the board in 1987 and has played a key role in the increase of gift revenue to the Foundation.

Well known among GSA members, he enjoys widespread recognition as a forceful spokesman for the earth sciences both in government and in industry. In addition to GSA, Charlie is active in Sigma Gamma Epsilon, the American Association of Petroleum Geologists, and the American Insitute of Professional Geologists.

Bailly Retires from GSAF Board

Longtime GSA leader Paul Bailly retired from the Foundation Board of Trustees upon completing a five-year term last October. Paul's list of contributions to his profession is outstanding. He is a past president of GSA and of the Society of Economic Geologists. He was the American Institute of Mining Engineers Henry Krumb lecturer and received that organization's Jackling Award. He has also served on advisory committees for the Colorado School of Mines, Stanford University, and the University of Minnesota.

Possessing extensive national and international business and leadership experience, Paul brought to his trusteeship important perspectives in the geological sciences and industries. His dedication to the Foundation's programs and activities merit heartfelt praise and appreciation. ■

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continued on p. 13

On a cliff-edge, Hoover Mackin suggested a reason for the geology exposed. I concurred. He almost knocked me off the cliff. "You know better—give me another reason!" Hoover was an avid proponenet of multiple hypotheses.

—Howard H. Waldron

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WASHINGTON REPORT

Bruce F. Molnia

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

Department of Energy Report Details Lower Cost Estimates for Cleaning Up U.S. Nuclear Weapons Mess

"Our new analysis provides strong evidence that the department's cleanup strategy under President Clinton is delivering more at less cost."

— Hazel R. O'Leary, Secretary of Energy

Last fall, the Department of Energy (DOE) released the 1996 Baseline Environmental Management Report (BEMR). In its four volumes and executive summary, spanning more than 1,500 pages, the BEMR presents new estimates of the costs necessary to clean up 150 former weapons complex sites in 33 states and Puerto Rico.

During World War II and the Cold War, the United States developed a massive industrial complex to research, produce, and test nuclear weapons. This complex included uranium mines, nuclear reactors, buildings for chemical processing, machining plants, maintenance facilities, and laboratories. The products of this industrial complex include tens of thousands of nuclear warheads and more than 1,000 nuclear explosion tests.

The complex continued operations through the late 1980s. Now, more than five years beyond the end of the Cold War, we find that the legacy of our nuclear industrial complex is "thousands of contaminated areas and buildings, and large volumes of "backlog" waste and special nuclear materials requiring treatment, stabilization, and disposal" (BEMR, 1-1).

The latest BEMR cost estimates, projected for a 75-year clean-up life, range from $189 billion to $265 billion (mid-range estimate of $227 billion) and are significantly lower than the original cost estimates of $206 to $360 billion (mid-range estimate of $237 billion) released in 1995. DOE prepared the BEMR in response to the 1994 and 1995 National Defense Authorization Acts, which require the Secretary of Energy to submit a baseline report to Congress, complete with annual updates. The lowering of costs results from applying "less costly but effective" environmental solutions in the areas of decommissioning and waste management and from the use of improved data on waste volumes.

I had much difficulty understanding the meaning or derivation of the "mid-range" or "Base Case" estimate. On the front flyleaf of the "Executive Summary," "Base Case" is simply defined as "an estimation of the life-cycle costs and schedule for projects and activities needed to complete the Environmental Management program's mission." Elsewhere, a more complex and cumbersome definition is presented: "long-range projection of activities, schedule, and associated costs that fully describes the Environmental Management program, as currently projected, from its current state to completion based upon compliance with current laws, regulations, and agreements. The Base Case looks to the future, but does so only with the knowledge, information, and assumptions that are available today. Because these inputs are rapidly changing, the 1996 Base Case is essentially a snapshot in time of a dynamic and complex program. The Base Case is not a budget estimate or a program funding request. Nor is it intended to provide details of specific projects."

The 150 former weapons complex sites detailed in the BEMR are the tip of the Cold War legacy iceberg. At these sites, about 0.5 million cubic meters of high-level, mixed, and low-level nuclear waste remain. This waste, which contains enough plutonium to fabricate thousands of nuclear weapons, must be stabilized, safeguarded, and "dispositioned."

In 1989, the DOE established the Environmental Restoration and Waste Management Program (now the Environmental Management Program [EMP]), to consolidate ongoing remediation and restoration efforts and to initiate a response for inactive production facilities and sites and for accumulated waste, contamination and materials. By 1995, the EMP had become the largest stewardship program in the world, with activities, including cleanup, at 150 sites in Alaska, Arizona, California , Colorado, Connecticut, Florida, Hawaii, Idaho, Illinois, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, North Dakota, Ohio, Oregon, Pennsylvania, Puerto Rico, South Carolina, South Dakota, Tennessee, Texas, Utah, Washington, West Virginia, and Wyoming.

Ideally, by 2070, after the 75 years of the program, "end state" will be achieved. By then, all mission-related activities will have been completed, and most sites will have been made available for alternate land uses. The sites with the highest individual cleanup costs (expressed as percent of the total cleanup estimate) are Hanford, Washington ($50 billion, 22%); Savannah River, South Carolina ($49 billion, 22%); Idaho National Engineering Laboratory ($19 billion, 8%); Rocky Flats Environmental Technology, Colorado ($17 billion, 8%); Oak Ridge National Laboratory and adjacent sites K-25 and Y-12, Tennessee ($25 billion, 10%); Waste Isolation Pilot Plant, New Mexico (4%); Paducah Gaseous Diffusion Plant, Kentucky (2%); Los Alamos National Laboratory, New Mexico (2%); Portsmouth Gaseous Diffusion Plant, Ohio (2%); Nevada Test Site (2%); and West Valley Demonstration Project, New York (2%). Together, these sites account for about 85% of the total cleanup cost estimate.

In a July 1, 1996, letter that accompanied volume one of the BEMR, Alvin Alm, DOE Assistant Secretary for Environmental Management, stated that: "Since the 1996 Baseline Report was prepared, Environmental Management managers have committed to complete clean-up at most sites within ten years.... All facilities would, however, achieve a safe and secure interim end state by the end of the ten-year period.... The ten year vision recognizes that the time table for cleanup suggested in the 1996 Baseline Report is too slow.... One message we have learned from the 1996 Baseline Report analysis is that the longer a cleanup takes, the longer one pays the 'mortgage' costs to support a workforce presence on the site. We should not pay this cost any longer than necessary." ■

The Bucks Start Here

Peter F. Folger, *1995-1996 GSA Congressional Science Fellow*

> *"No money shall be drawn from the Treasury, but in consequence of appropriations made by law"*
>
> —Article I, Section 9, Constitution of the United States

To the casual observer, the congressional appropriations process is complicated, obscure, and conducted behind closed doors or, at the very least, behind a veil of tradition and near-secrecy. Yet, the annual struggle to fund the government is arguably the single most important process to geoscientists who benefit from federal dollars. In a time of crushing pressure to reduce discretionary spending in the face of growing entitlement spending and the drive to balance the federal budget, it behooves earth scientists to pay attention to where the money comes from. Ignore appropriations and, like your teeth, they may go away.

Everyone is now familiar with the consequences of Congress's failure to pass one or more of the 13 appropriations bills. Yet the hue and cry that arose in the fall of 1995 when agencies temporarily shut their doors resulted because of disputes over a relatively small portion of the federal budget. In fact, 65% of the annual $1.5 trillion budget is spent automatically every year unless Congress acts. Interest on the national debt consumes 15%, while 50% of the overall budget, a staggering $786 billion in 1995, pays for entitlement (or mandatory) spending. The remaining 35% is discretionary spending, slightly over half of which funds the nation's military. All the fuss last fall occurred over 17% of the total budget, or an amount only slightly greater than the annual interest payment for the national debt.

Out of the 17% come funds for earth scientists via the National Science Foundation, the USGS, EPA, NOAA, NASA, and other agencies and programs within the Departments of Interior, Energy, Agriculture, and Commerce. This one-sixth of the federal budget consumes a disproportionate share of Congress's attention because it allows lawmakers to deliver the goods, like dams, roads, and other parochial projects, to their constituents back home. The real power to deliver, however, is in the hands of the Representatives, referred to as the "Cardinals," and their Senate counterparts, who chair the 13 appropriations subcommittees that craft the annual spending bills.

Geoscientists face increasingly fierce fights over these scarce dollars because entitlement programs, like Medicare, Medicaid, and Social Security are currently growing at 10% per year and will squeeze the discretionary side of the ledger unless reined in. Without substantive reform of automatic spending, the Cardinals will preside over a shrinking supply of discretionary dollars, yet face constant or increasing demands from lawmakers attempting to serve their constituents. Bear in mind, also, that funding for science competes directly against health care for veterans, education, and other popular programs supported by vociferous and unified organizations.

Why is it important for earth scientists to pay attention to the appropriations process? Because the Cardinals, despite their relative autonomy, respond like other lawmakers to organized and effective lobbying from scientists, as they do from any other group. A case in point is the dramatic 6% increase in funding to the National Institutes for Health (NIH) for fiscal year 1996 compared to the previous year. This occurred despite an increase of only 1% in all federal research and development accounts for the year, and a decrease in overall discretionary spending of 2.4%. The well-organized biomedical community contacted key lawmakers and waged an effective campaign to shore up funding for their account within the Labor, Health and Human Services, and Education Appropriations Committee.

How does this process work? In early February, the President submits his budget to the Congress. Congress may or may not act on the President's plan, but at the very least will use it as a foil for the legislative budget process. The Republican-controlled 104th Congress, for example, has ignored the President's budget two years in a row, but the final spending bills differ from the President's proposal by only a few percent. The power of the veto pen, and the enormous inertia of the budget status quo, means that discretionary spending changes of more than a few percent are nearly impossible. After receiving the President's plan, the House and Senate Budget Committees construct a budget resolution, which is supposed to be adopted by April 15, that sets total spending levels to be divided among the 13 appropriations subcommittees.

Although the budget resolution is not signed into law by the President, it serves to guide Congress through the remainder of the budget cycle. From the appropriator's standpoint, the budget resolution is critical because, among other things, it defines the lump-sum amount given to the full Appropriations Committee in the House and Senate. Upon receipt of the overall spending allotment, the long knives come out and the real battle begins as the 13 Cardinals in each chamber fight for their share of the $500+ billion pie.

Representative Bob Livingston (R—LA), and Senator Mark Hatfield (R—OR), chair the Appropriations Committees in their respective houses. The two chief Cardinals carve up the lump-sum appropriation and dole it out to the 13 subcommittees. In reality, negotiations for these amounts begin early, before the budget resolution is debated and the final appropriations bills are assembled by committee staff. In contrast to typically young staff occupying Congressional personal offices, appropriations committee staff are seasoned veterans who, in many cases, have worked on Capitol Hill as long as or longer than most lawmakers. As such, they wield great power in the appropriations negotiations. They also face the task of crafting 13 bills every year that must pass if the government is to keep running; thus, they have enormous influence over the daily operations of the federal government.

Geoscientists seeking to understand and influence the appropriations process must also understand that appropriations staff answer to only a select group of lawmakers and tend to ignore the hundreds of pleas from outsiders that do not fall within the interests of this inner circle. An appropriations clerk told me: "I listen to my subcommittee chairman, the ranking minority Member, and the chairman of the full committee. That's all." Other Republican and Democrat members of the subcommittees, however, wield considerable influence because of the urgent need to pass the funding bills every year. In contrast to many of the authorizing committees, appropriations subcommittees conduct business largely in a bipartisan manner.

Bucks *continued on p. 17*

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Bucks *continued from p. 16*

Each of the 13 allocations in the budget resolution sets the tone for the 13 subcommittees for the rest of the appropriations cycle. If the amount is less than what a subcommittee expects, then the Cardinal must choose which departments or agencies will get cut. To further complicate matters, the initial allocation in a House subcommittee may not agree with the corresponding Senate allocation. This year, for example, the Energy and Water Development subcommittee in the House, chaired by Representative John Myers (R—IN), initially received nearly $1 billion less than its counterpart in the Senate, run by Pete V. Domenici (R—NM). This, in part, reflects different priorities between the two legislative bodies and generates great consternation among the affected Executive Branch agencies, whose operations may depend on which chamber prevails. The fate of earth scientists, whose programs are rarely highlighted or "earmarked" by lawmakers in the legislation or mentioned in the accompanying report, may also depend on how the House and Senate split the difference.

The rules of the House and to a lesser extent, the Senate require that agencies and programs be authorized into law before funds are appropriated for them. In practice, the program may continue even though authorizing legislation has expired. For example, the Safe Drinking Water Act was reauthorized in 1996 even though original authorization ran out in 1991. Agency funding to implement the program was provided in the interim by annual enactment of the VA, HUD, and Independent Agencies spending bill. Similarly, failure to reauthorize the Geologic Mapping Act this year will probably not sink the program because funding was included in the Interior Appropriations bill. The opposite is almost never true; a program authorized in law but denied appropriations or some funding mechanism is, in reality, no program.

This last point reemphasizes the power of the Cardinals. As an appropriations clerk remarked to me, "Congress can authorize anything, but without appropriations it goes nowhere." Moreover, lawmakers who cannot authorize a program via the authorizing committees often turn to an appropriations bill as the preferred legislative vehicle. Although the practice is generally discouraged by the Cardinals, members of Congress inevitably try to insert several authorizing provisions into appropriations bills every year. A few of the controversial environmental "riders" on last year's appropriations bills, namely the provisions denying funding to the EPA to set a radon standard in ground water, or extending the moratorium against issuing new hard-rock mining patents, are examples of authorizing on an appropriations bill. This is a time-honored practice; the original act creating the USGS in 1879 was part of an appropriations bill.

The appropriations process in Congress begins early in the year, usually lasts until September 30, the last day of the fiscal year (or even beyond, which requires Congress to pass one or more temporary spending measures, or continuing resolutions). Geoscientists who want to influence the process and be heard also need to start early, make their pitch to the right people, and follow through until Congress votes. A plea for funding the night before the appropriations committee votes on the bill usually falls on deaf ears. Because the discretionary slice of the budget pie, which includes all geoscience programs, is getting smaller, we cannot afford to ignore where the bucks start. ■

Peter F. Folger, 1995–1996 GSA Congressional Science Fellow, served on the staff of Senator Pete V. Domenici (NM). *The one-year fellowship is supported by GSA and by the U.S. Geological Survey, Department of the Interior, under Assistance Award No. 1434-95-G-2651. The views and conclusions contained in this report are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.*

ENVIRONMENT MATTERS

Institute for Environmental Education

It's Nothing Personal

Daniel Sarewitz, IEE Director

The implications of recent national elections for federal funding of science and technology are not entirely clear, but one can be reasonably confident that such funding over the next several years will decline. Many in the science community view declining federal science funds as an indication of lack of government understanding of and support for science. Thus, the commonly prescribed approach to combating this trend is to focus on communicating the value of science to our elected officials. The biomedical research community, which has a highly organized and visible lobbying effort in Washington, D.C., is often held up as the exemplar of this approach. Indeed, for fiscal 1997, in the face of flat or declining budgets for most federal discretionary programs, the National Institutes of Health received a boost of more than 6%.

The idea that declining federal support for science can be reversed simply by communicating the importance and value of science to our public servants is appealing, but it also avoids the evolving reality of budgetary politics. As explained in a column by Peter Folger, the 1995-1996 GSA Congressional Fellow (this issue, p. 16), federal funding for science comes from that 17% of the federal budget that supports all nondefense discretionary programs, such as: salaries for judges, support for air traffic control, regulation of new prescription drugs, funds for diplomatic missions, enforcement of immigration laws, protection and clean-up of the environment. As Congress and the President strive to fulfill their commitment to balance the federal budget by the year 2002, it is these programs—and these programs only—that are targeted for reduction. Today's political and economic climate dictates that the other 83% of the budget—defense expenditures, entitlement programs such as Medicare, and interest on the national debt—are off limits to budget-cutters. To make matters worse, entitlement expenditures are growing exponentially, and this growth will also have to be balanced by cuts in discretionary programs. Add to this the additional factor that tax increases are not a viable political option, and you are left with an obvious and unavoidable arithmetical conclusion: the federal budget will be balanced on the back of the discretionary programs.

Thus, the hope that federal funding for science can be maintained or increased in the current political climate is almost certainly a vain one. Effective lobbying may help to protect some science programs at the expense of others, but these victories will occur in an overall context of shrinking expenditures. Budget analysts at the American Association for the Advancement of Science have estimated that government funding for scientific research and technology development will decline by about 20% in the next five years if current deficit reduction plans are pursued. This does not reflect an antiscientific attitude on the part of our elected officials. Similar cuts will necessarily afflict most other discretionary programs. The State Department will have less money to negotiate peace agreements, the Justice Department will have less money to prosecute criminals, the Transportation Department will have less money to maintain infrastructure. Etcetera. The current desire of the electorate is to balance the budget without undertaking significant reform of entitlement programs and without raising taxes. This is what we have voted for. When the budget knife really begins to do its work, voters may adopt different priorities, but for now the trend is clear. It's nothing personal. ■

Call for Nominations

WANTED: Mentors in Applied Geology

The Geological Society of America's Institute for Environmental Education is now soliciting nominations for the Roy J. Shlemon Mentor Program in Applied Geology. Funded by an endowment from Roy J. Shlemon, the Applied Geology Mentor Program bridges the gap between the applied and academic geology communities. The mentors are experienced geologists currently practicing in various fields of applied geology. Each mentor presents a one-day workshop for graduate and senior undergraduate geology students focusing on professional opportunities and challenges in the applied geosciences. Workshops may include lectures and/or field and laboratory exercises, depending on the technical specialty of the mentor, as well as discussion of "practical problems" in applied geology such as running a business, marketing, hiring and firing, and legal and regulatory challenges.

Mentors receive an honorarium of up to $1,000 for conducting the workshop, in partial recognition of their outstanding contribution to the applied geosciences. Up to six Shlemon Mentor workshops will be held each year, in conjunction with the six GSA section meetings.

The 1996 Roy Shlemon Applied Geology Mentors were
James E. Slosson, Van Nuys, California—Rocky Mountain Section
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Michael Hart, San Diego, California—Cordilleran Section
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Criteria for Nomination

Mentors should be highly regarded practitioners in the applied geosciences. Preference will be given to nominees who emphasize one of the following specialties: Quaternary geology, geomorphology, environmental geology, engineering geology, geoarcheology, and hydrogeology. Nominees should have at least 15 years of experience outside of academia and government and should be working actively in an applied field. Nominees should also be active in the geological community, preferably with a record of presented or published papers.

Nominations should be in the form of a brief (one-half page) narrative summarizing the qualities and experiences of the nominee. This narrative may be supported by additional professional and biographical material. We request that nominators include their phone number and/or E-mail address.

Mentors will be selected by GSA section meeting committees from the pool of nominees.

Please send nominations to:
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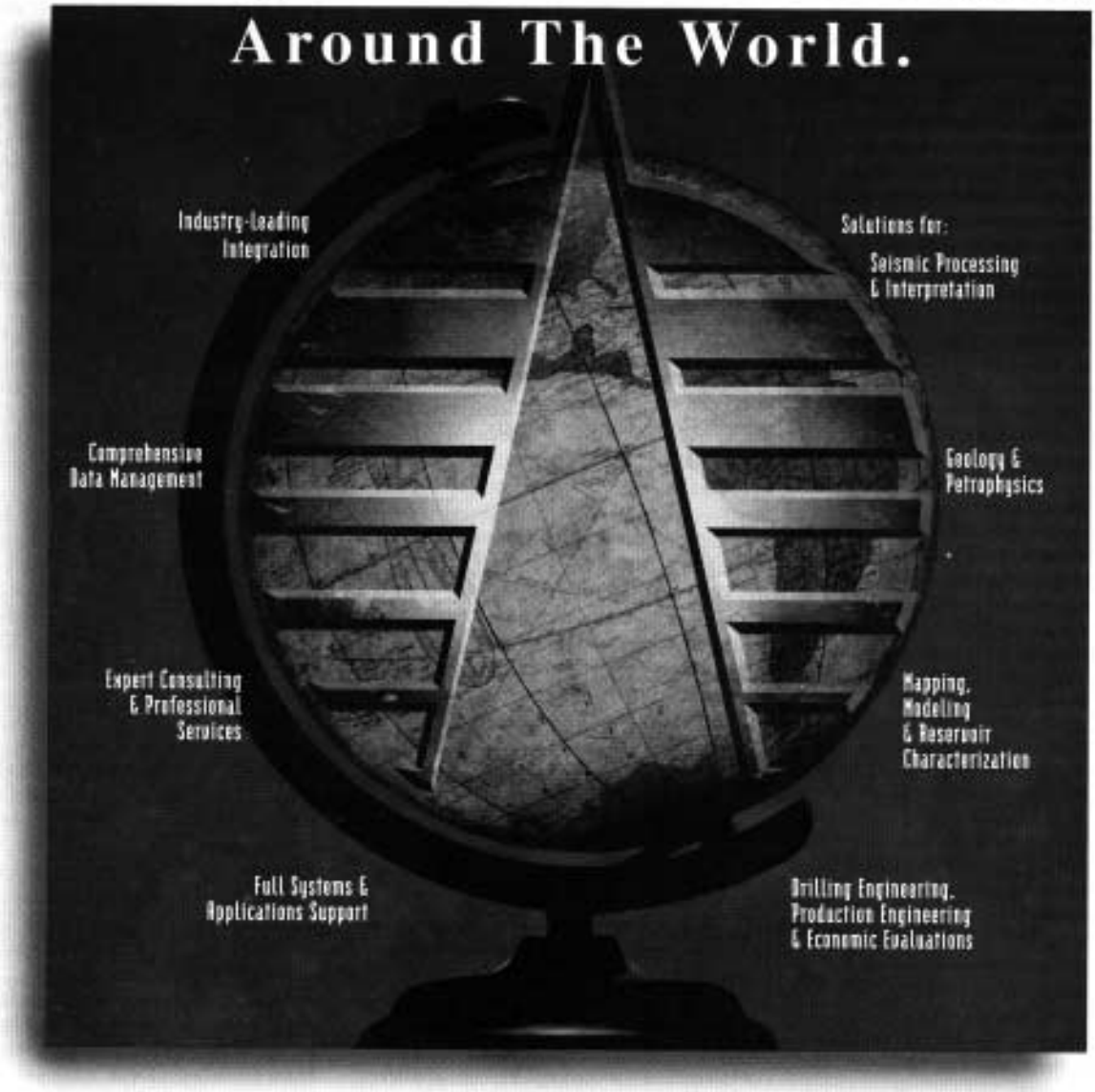

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GSA Bulletin Features Overview Article

The January *GSA Bulletin* includes a new feature: an overview article, one of several papers intended to provide *Bulletin* readers with state-of-the-field summaries in exciting areas. *Bulletin* co-editors Lynn Walter and John Geissman began planning for these feature articles in early 1996. The premier overview, by Ian Dalziel, was solicited and shepherded through the review process by Associate Editor Samuel Mukasa.

The overview article by Dalziel concerns Neoproterozoic–early Paleozoic distribution of continents and the tectonics and environments of the time. Dalziel bases the overview largely on his work and that of his students and colleagues, particularly on the southern continents that once composed Gondwanaland. However, he also cites studies by others who have worked on the same Gondwanaland fragments and other cratons of the time interval, notably Laurentia and Baltica. This makes the article a comprehensive source of information about the numerous studies that have dealt with continental drift prior to the amalgamation of Pangea, but also an important contribution about the tectonics and environments that prevailed at that critical time in biological evolution.

In the overview, Dalziel presents some relatively new ideas—for example, that some rocks bordering the Ouachita embayment and in Argentina may have a common heritage, and that through much of early Paleozoic time, the Iapetus Ocean may not have separated Laurentia from Baltica and northwest Africa, as has been traditionally accepted, but rather Laurentia from the proto-Andean margin of South America. Some of the ideas expressed are controversial and are likely to fuel additional investigations for some time to come.

Future overview articles will also likely range into provocative questions that are ripe for further research, according to *Bulletin* editors Geissman and Walter.

GSA Bulletin Update

John Geissman, Lynn Walter, *Editors,* GSA Bulletin

Greetings and Happy 1997! Our second editorial year, 1996, has been both gratifying and challenging for us. We appreciate the positive feedback we have received from so many of you about the new look of the *Bulletin* as well as its substantially broader topical base. There are many more manuscripts submitted with a decided "earth systems" approach and many more dealing with new tracers of climate change and rates of earth surface processes. We have added new Associate Editors throughout the year to adjust our AE board composition in line with these research areas.

The trend toward increased submissions has continued into 1996. Given this trend and our attempt to maintain a near-constant manuscript acceptance ratio, the obvious implication is that the time between manuscript acceptance and publication will increase. Significant increases are unacceptable, so the total number of published pages for the *Bulletin* was increased in 1996, and we hope to maintain this level in 1997 and in future years. In the spirit of maximum efficiency of science presentation, we also continue to encourage authors to place important yet nonessential supporting data, text, and figures in the GSA Data Repository. Our early goal of having the Data Repository accessible through the GSA home page on the World Wide Web is now realized.

As promised last year at this time, we have solicited, aided by our Associate Editors, overview manuscripts detailing the current research and future directions in actively developing topical areas of broad interest in the earth sciences. These comprehensive overviews, the first of which appears in the January issue of the *Bulletin,* are intended to be exceptionally timely (through improved manuscript handling practices), of appropriate length and documentation (including more complex, color illustrations available through the Web on the GSA home page, where appropriate), valuable in-depth contributions.

We continue to streamline our manuscript handling procedures with the help and feedback provided by our excellent editorial assistants, Vicki Lawrence and Cathy Ratcliff. They are the essential links in making electronic mail, phone, and postal contacts with reviewers and Associate Editors. This year, *Bulletin* activities will be incorporated into a comprehensive and flexible manuscript-tracking system initiated by David Fountain, former editor of *Geology.* This may require yet more changes in how our offices function. Please feel free to contact us with feedback, criticisms, and suggestions.

We emphasize that the *Bulletin* will continue as a forum for relatively long contributions involving fully detailed and comprehensive research. However, we are also publishing an increasing number of shorter, topical papers of broad interest. Our overall turnaround time continues to be competitive, so please consider the *Bulletin* as a widely disseminated and well-read outlet for these shorter, timely articles.

As always, the success of the editorial system and overall quality of the journal are a direct reflection of the great competence and integrity of the Associate Editors, who provide their time and expertise to the authors, the readers, and the Society. We thank the Associate Editors who completed their terms with the *GSA Bulletin* in 1996:

Daniel Bernoulli
Myron Best
Douglas Elmore
Carol Frost
Robert Hildebrand
Daniel Lux
Walt Manger
Kevin Shelton
Martha Withjack ■

GSA Science Editors

Current science editors, all unpaid volunteers, for GSA publications are:

Books: **Abhijit Basu,** Indiana University, Bloomington

Maps and Charts: **Ren A. Thompson,** U.S. Geological Survey, Denver

GSA Today science articles: **Suzanne M. Kay,** Cornell University

GSA Today Forum: **Bruce F. Molnia,** U.S. Geological Survey, Reston

GSA Bulletin: **John Geissman,** University of New Mexico, Albuquerque; **Lynn Walter,** University of Michigan, Ann Arbor

Geology: **Lee Kump,** Pennsylvania State University; **Carol Simpson,** Boston University

GSA ON THE WEB

Visit the GSA Web Site at **http://www.geosociety.org.** From our home page you can link to many information resources. Here are some highlights:

View the **Meetings** page for information on the 1997 annual and section meetings. Complete information on the 1997 GeoVentures is also online.

On our **Membership** page you'll learn about the GSA Employment Service, find out how to become a GSA Campus Representative, or learn how to get forms to join GSA as a full member or as a student. You'll also find information here on how to nominate a GSA member to Fellowship standing.

Under the **Publications** heading, you'll find many links, including one to the GSA Bookstore on the Web. Here's a fast, new way to shop! Search the descriptive copy and tables of contents on all GSA books, maps, transects, Memorials, and other products in print or in production. You can read or print product descriptions, tables of contents, pricing, and other data. You can build and place a credit-card order safely via our secure Web server. The best part is that more than 200 titles are now on sale (until March 1997). Also here is Information for Contributors to journal articles, article offprint information, how to request copyright permissions, and more.

The GSA Data Repository is a new addition on the Publications page. Here you'll find all entries since 1992, in Adobe Acrobat format for easy download via your browser. These Data Repository entries supplement some articles in GSA's journals. This is a new, faster way to obtain these data. Every month, you'll find tables of contents and abstracts of journal articles for *GSA Bulletin* and *Geology,* plus information for authors on preparation of articles for submission to GSA.

In the **Education** section, read about GSA's educational programs, including PEP (Partners for Education), and the Earth and Space Science Technological Education Project (ESSTEP). Find out about GSA's environment and public policy activities in the **Institute for Environmental Education** section, including updates on the GSA Congressional Science Fellowship program, the Roy J. Shlemon Applied Geology Mentor Program, and the U.S. Geological Survey–National Biological Service scientific opportunities workshop.

Under **Foundation** you will find information on the Foundation and the current annual giving campaign, a list of trustees and officers, and several ways to make a planned gift.

See the **Administration** section for information on GSA Medals and Awards, and other general information about GSA. You can also link to the pages for GSA Sections and Divisions for specific information on each of these.

CALL FOR NOMINATIONS REMINDERS

Penrose and Day Medals, and Honorary Fellowship

Nominations for 1997 Penrose and Day Medals and for Honorary Fellowship in the Society are due by **FEBRUARY 3, 1997.**

Young Scientist Award (Donath Medal)

The Young Scientist Award was established in 1988 to be awarded to a young scientist (35 or younger during the year in which the award is to be presented) for outstanding achievement in contributing to geologic knowledge through original research that marks a major advance in the earth sciences. The award, consisting of a gold medal called the Donath Medal and a cash prize of $15,000, was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1997, only those candidates born on or after January 1, 1962, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1997 award must include

- biographical information,
- a summary of the candidate's scientific contributions to geology (200 words or less),
- a selected bibliography (no more than 10 titles),
- supporting letters from five scientists in addition to the person making the nomination.

Deadline for nominations for 1997 is **FEBRUARY 3, 1997.**

Officers and Councilors

The GSA Committee on Nominations requests your help in compiling a list of GSA members qualified for service as officers and councilors of the Society. The committee requests that each nomination be accompanied by basic data and a description of the qualifications of the individual for the position recommended (vice-president, treasurer, councilor).

Deadline for nominations for 1998 is **FEBRUARY 18, 1997.**

Distinguished Service Award

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

John C. Frye Environmental Geology Award

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

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

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

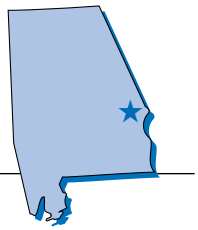
National Awards

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

Final Announcement

SOUTHEASTERN SECTION, GSA 46th Annual Meeting

Auburn, Alabama
March 27–28, 1997



The 1997 Southeastern Section Meeting of the Geological Society of America will be hosted by the Auburn University Department of Geology in Auburn, Alabama. Affiliated organizations meeting concurrently are the Southeastern Section of SEPM, the Southeastern Section of the National Association of Geoscience Teachers (NAGT), and the Southeastern Section of the Paleontological Society.

LOCATION AND SETTING

Auburn is situated along the boundary between the Piedmont and Gulf Coastal Plain provinces, a one-hour drive east of the Valley and Ridge. This quaint town is home to Auburn University, Alabama's land grant institution. Points of interest in Auburn are Chewacla State Park and three pro golf courses. Horseshoe Bend National Military Park, FDR's Warm Springs Little White House, and Callaway Gardens are 45-minute drives from Auburn. The Southeastern Section meeting will be held at the Auburn University Hotel and Conference Center (AUHCC), downtown across the street from the university and within walking distance of many shops and restaurants. Auburn is easily reached by car via interstate I-85 and by Dixie Excursions shuttle service, (334) 887-6294, from Atlanta's Hartsfield International Airport.

REGISTRATION

Preregistration Deadline:
February 21, 1997

If you preregister, you will not have to wait in long registration lines to pick up materials in Auburn because badges will be ***mailed*** within two weeks prior to the meeting. Save time and money—preregister today!

Advance registration is suggested for many of the special activities because of participation limits. Use the preregistration form provided in this announcement.

Badges must be worn for access to ALL activities, 7:00 a.m. Thursday through 5:00 p.m. Friday.

Registration discounts are given to members of both GSA and the associated societies listed on the preregistration form. Please indicate your affiliation(s) to register using the member rates.

Full payment MUST accompany preregistration form. Unpaid purchase orders are NOT accepted as valid registration. Charge cards are accepted as indicated on the preregistration form. If using a charge card, please recheck the card number given. Errors will delay your registration. The confirmation card will be your receipt. No other receipt will be sent.

Register one professional or student per form. *Copy the form* for your records.

Guest registration is required for those attending guest activities, technical sessions, or the exhibit hall. Guest registrants MUST be accompanied to the meeting by either a registered professional or student. A guest is defined as a nongeologist spouse or friend of a professional or student registrant.

Students and K–12 teachers must show a *current ID* in order to obtain these rates. Students or teachers not having a current ID when registering on site will be required to pay the professional fee.

Because badges will be mailed, ALL preregistration forms must be RECEIVED by the preregistration deadline of February 21. All registration forms received after February 21 will be held for on-site processing and charged the on-site rates.

REGISTRATION FEES

	Advance*	On-site
Professional—		
Member	$65	$75
Nonmember	$70	$80
Student—		
Member	$20	$25
Nonmember	$25	$30
K–12 Earth Science Teacher	$20	$20
Guest	$15	$15

**Deadline is February 21, 1997.*

To leave a message for an attendee at the meeting, dial (334) 844-4718.

Cancellations, Changes, and Refunds

All requests for registration additions, changes, and cancellations must be made in writing and received by February 28. GSA will refund or credit preregistration fees for cancellations received in writing by February 28. NO REFUNDS WILL BE MADE ON CANCELLATION NOTICES RECEIVED AFTER THIS DATE. Refunds will be mailed from GSA after the meeting. Refunds for fees paid by credit card will be credited according to the card number on the preregistration form. There will be NO refunds for on-site registration and ticket sales.

On-Site Registration Schedule

Auburn Hotel and Conference Center Information Desk

Wed., March 26	4:00 p.m. to 7:00 p.m.
Thurs., March 27	7:30 a.m. to 4:30 p.m.
Fri., March 28	7:30 a.m. to 11:30 a.m.

Accessibility for Registrants with Special Needs

GSA is committed to making the Southeastern Section meeting accessible to all people interested in attending. If you have special requirements, such as

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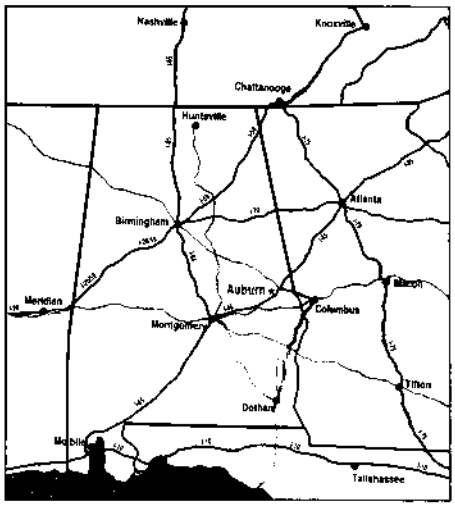

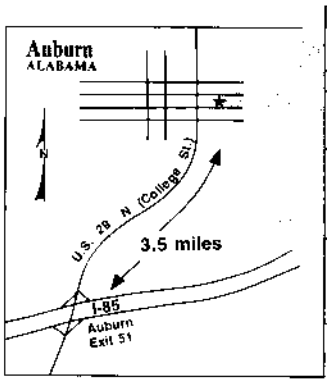

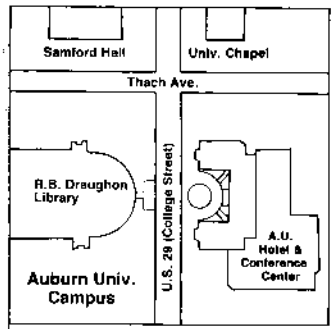

Southeastern *continued from p. 22*

an interpreter or wheelchair accessibility, please indicate this by checking the appropriate box on the registration form in the space provided. Please let us know your needs by February 21, 1997.

ACCOMMODATIONS

A block of rooms at the Auburn University Hotel and Conference Center, site of the meeting, has been reserved for attendees at a special reduced rate of $72 per night for either single or double occupancy. Attendees should make their own room reservations *before February 25,* by calling toll-free, 1-800-2AUBURN, by faxing, 334-826-8755, or by mailing the housing form provided in this announcement. *After that date, reservations will be accepted only on a space-available basis and at a higher rate*. To reserve rooms by telephone, state your GSA connection and request a reservation number.

Parking. Meeting attendees who stay at the AUHCC may park in the adjacent parking lots at no cost. Others may park in the upper-level library parking facility across the street from the AUHCC.

HOUSING FORM — *Auburn University Hotel and Conference Center*

Southeastern Section, Geological Society of America
March 27–28, 1997

Reservation must be made by February 25, 1997.

Name _____ Phone _____

Address _____

City/State/ZIP _____

Arrival Date _____ Departure Date _____

No. of Rooms _____ Bed Type: ☐ King—$72 +tax ☐ Double—$72 + tax

Sharing with: _____

Credit card Type: _____ In name of: _____

Card # _____ Expires _____

Signature _____

Send to: Auburn University Hotel and Conference Center, 241 South College St., Auburn, AL 36830-5400. Or call in your reservation at 1-800-2AUBURN. For quicker processing please fax to 334-826-8746.

WELCOMING PARTY

The welcoming party, on Wednesday evening, March 26, from 6:00 to 8:00 p.m., will be at the Auburn University Alumni Center, only a short walk from the AUHCC. Light food and beverages will be served, and a cash bar will be available. All attendees must register before the party.

TECHNICAL PROGRAM

Ten symposia, with invited papers, are planned for the meeting, along with 18 theme sessions. Please contact the conveners for more information. Additional sessions are scheduled for volunteered papers.

Symposia

1. **Phanerozoic Organic Buildups of the Southeastern United States.** *Sponsored by the Southeastern Section Paleontological Society.* Frank K. (Ken) McKinney, Dept. of Geology, Appalachian State University, Boone, NC 28608, (704) 262-2748, mckinneyfk@appstate.edu; and Carl W. Stock, Dept. of Geology, University of Alabama, Box 870338, Tuscaloosa, AL 35487-0338, (205) 348-1883, cstock@wgs.geo.ua.edu.

2. **Groundwater Geochemistry, Microbiology, and Bioremediation.** *Sponsored by the Institute for Environmental Education.* James A. Saunders, Dept. of Geology, Auburn University, Auburn, AL 36849-5303, (334) 844-4884, saundja@mail.auburn.edu; and W. Berry Lyons, Dept. of Geology, University of Alabama, Tuscaloosa, AL 35487, (205) 348-0583, Blyons@wgs.geo.ua.edu.

3. **Modern Analogs in Paleontology.** Ronald D. Lewis, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4886, lewisrd@mail.auburn.edu; and Sally Walker, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2652, swalker@uga.cc.uga.edu.

4. **Current Directions in Archaeological Geology—Late and Post-Pleistocene Environments.** Erv Garrison, Dept. of Anthropology, Baldwin Hall, University of Georgia, Athens, GA 30602-1619, (706) 542-3922, egarriso@sherlock.dac.uga.edu.

5. **Solid Earth Science: The Foundation of Ecosystem Management and Defendable Environmental Regulations.** *Cosponsored by the GSA Geology and Public Policy Committee and the Institute for Environmental Education.* Walt Schmidt, Florida Geological Survey, 903 W. Tennessee St., Tallahassee, FL 32304-7700, (904) 488-4191, schmidt_w@dep.state.fl.us.

6. **Quantitative Studies of the Pressures, Temperatures, and Durations of Metamorphic Processes.** Bill Hames, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4881, hameswe@mail.auburn.edu; and Harold Stowell, Dept. of Geology, University of Alabama, 202 Bevill Bldg., Tuscaloosa, AL 35487-0338, (205) 348-5095, hstowell@wgs.geo.ua.edu.

7. **Mechanisms of Folding and Fracturing in Appalachian Foreland-Style Structures.** *Sponsored by the SEGSA Structure and Tectonics Division.* Jon Mies, Dept. of Physics, Geology & Astronomy, University of Tennessee at Chattanooga, Chattanooga, TN 37403, (615) 755-4404, jmies@cecasun.utc.edu; and Rick Groshong, Dept. of Geology, University of Alabama, Bevill Bldg., Tuscaloosa, AL 35487-0338, (205) 348-5095, rgroshon@wgs.geo.ua.edu.

8. **Tectonics and Isotopes in the Appalachians.** Jim Hibbard, Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27695-8208, (919) 515-7242, jhibbard@ncsu.edu; and Scott Samson, Dept. of Earth Sciences, Syracuse University, Syracuse, NY 13244-1070, (315) 443-2672, sdsamson@summon.syr.edu.

9. **Characteristics of Paleogene Epoch Boundaries in the Eastern Gulf Coastal Plain: Biotic and Physical Events.** Barry Tew, Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486-9780, (205) 349-2852, nick@sand.gsa.tuscaloosa.al.us; and Ernie Mancini, Dept. of Geology, University of Alabama, Bevill Bldg., Tuscaloosa, AL 35487-0338, (205) 348-5095, emancini@wgs.geo.ua.edu.

10. **Interdisciplinary Characterization of Large, Environmentally Sensitive Sites, Southeastern USA.** *Sponsored by the Institute for Environmental Education.* Jerry Bartholomew, Earth Sciences and Resources Institute, University of South Carolina, Columbia, SC 29208, (803) 777-7693, jbarth@esri.esri.sc.edu.

Southeastern *continued on p. 24*

Southeastern *continued from p. 23*

Theme Sessions

Theme sessions provide a focus for volunteered sessions on specific topics. The following theme sessions are planned.

1. **Advances in Southeastern Cretaceous Geology.** David T. King, Jr., Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4882, kingdat@mail.auburn.edu; and William J. Frazier, Dept. of Chemistry & Geology, Columbus State University, Columbus, GA 31907-5645, (706) 568-2075, frazier_bill@colstate.edu.
2. **Rock and Fluid Chemistry of Brittle Fault Zones.** Jaffar Hadizadeh, 325 Natural Science Bldg., University of Louisville, Louisville, KY 40292, (502) 852-6821, j0hadi01@ulkyvm.louisville.edu.
3. **Piedmont Subsurface Hydrology.** John Dowd and David Wenner, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2382 or 2393, dwenner@uga.cc.uga.edu.
4. **Field Mapping in the Southern Appalachians:** A Poster Session in Memory of J. Robert Butler. Jon Mies, Dept. of Physics, Geology & Astronomy, University of Tennessee at Chattanooga, Chattanooga, TN 37403, (615) 755-4404, jmies@cecasun.utc.edu; and Mark Steltenpohl, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4893, steltmg@mail.auburn.edu.
5. **New Developments in the Geology of the Piedmont.** Alberto Patino-Douce, Dept. of Geology, University of Georgia, Athens, GA 30602, (706) 542-2652.
6. **Coastal Response to Environmental Change.** *Sponsored by the Institute for Environmental Education.* Ron Hoenstine, Florida Geological Survey, Gunter Bldg., 902 W. Tennessee St., Tallahassee, FL 32304-7700, (904) 488-9380, hoenstine_r@dep.state.fl.us; and Joseph Donoghue, Dept. of Geology, Florida State University, Tallahassee, FL 32306, (904) 644-4214, jdonoghu@garnet.acns.fsu.edu.
7. **Student Research Activities.** *Sponsored by Sigma Gamma Epsilon.* Don Neal, Dept. of Geology, East Carolina University, Greenville, NC 27858-4353, (919) 328-6360, glneal@ecuvm.cis.ecu.edu; and Douglas Haywick, Dept. of Geology & Geography, University of South Alabama, LSCB 136, Mobile, AL 36688, (334) 460-6381, dhaywick@jaguar1.usouthal.edu.
8. **Undergraduate Research Poster Session.** *Sponsored by the Council on Undergraduate Research.* Jack Beuthin, Dept. of Geology & Planetary Science, University of Pittsburgh, Johnstown, PA 15904, (814) 269-2945; and Bill Ranson, Dept. of Geology, Furman University, Greenville, SC 29613, (803) 294-2052, ranson_bill@furman.edu.
9. **K–12 and Introductory Earth Science Education.** *Sponsored by NAGT.* Tom Hanley, Dept. of Chemistry & Geology, Columbus State University, Columbus, GA 31907-5645, (706) 568-2075, hanley_tom@colstate.edu; and Jack Carrington, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4882, carrith@mail.auburn.edu.
10. **Remote Sensing in Geology.** Phil Manker, Dept. of Geology and Physics, Georgia Southwestern State University, Americus, GA 31709, (912) 931-2330, pmanker@canes.gsw.peachnet.edu.
11. **GIS Applications in Geology.** *Sponsored by the Institute for Environmental Education.* Greg Easson, University of Mississippi, Geology and Geological Engineering, 1180 Carrier Hall, University, MS 38677, (601) 232-5995, geasson@sunset.backbone.olemiss.edu.
12. **Industrial Minerals and Rocks of the Southeast.** Robert B. Cook, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4891, cookrob@mail.auburn.edu; and Robert S. Fousek, McCartney Construction Co., Inc., P.O. Box 1890, Gadsden, AL 35902-1890, (205) 547-6386, fax 205-547-6390, bfousek@paveaway.com.
13. **Geophysical Studies of the Southeastern United States.** Lorraine Wolf, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4878, lwolf@geology.auburn.edu.
14. **Biomineralization.** Roger M. Leblanc, Dept. of Chemistry, University of Miami, 1301 Memorial Dr., Room 315, P.O. Box 249118, Coral Gables, FL 33124-0431, (305) 284-2282, mmodrono@umiami.ir.miami.edu.
15. **Coastal Sedimentology.** W. F. Tanner, Dept. of Geology, Florida State University, Tallahassee, FL 32306-3026, (904) 644-3208.
16. **Animal-Substrate Relations in Modern and Ancient Environments.** Anthony J. Martin, Geosciences Program, Emory University, Atlanta, GA 30322, (404) 727-6476, paleoman@learnlink.emory.edu.
17. **Vertebrate Paleontology.** David Schwimmer, Dept. of Chemistry & Geology, Columbus State University, Columbus, GA 31907-5645, schwimmer_david@colstate.edu.
18. **Geostatistical Analysis of Subsurface Fluid Flow.** Evan Paleologos, Dept. of Geological Sciences, University of South Carolina, Columbia, SC 29208, (803) 777-8125, epal@epoch.geol.sc.edu; and Ming-Kuo Lee, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4898, leeming@mail.auburn.edu.

PROJECTION EQUIPMENT

All slides must be 2" × 2" and fit a standard 35-mm carousel tray. Please bring your own loaded carousel trays, if possible. Two 35-mm slide projectors, one overhead projector, and two screens will be available for each oral technical session. Labeled trays must be handed to the projectionist at least 20 minutes prior to the beginning of the session. A speaker ready room (AUHCC room H) for previewing slides will be provided.

POSTER SESSIONS

Four half-day poster sessions are planned. Posters will consist of one horizontally hung, 4' × 8' foam board. Poster sessions will be set up for four hours, and authors will be available for two hours to discuss their work.

WORKSHOPS

1. **Oxfordian Biostromes of the Conecuh Embayment.** David C. Kopaska-Merkel. Wednesday, March 26, 1:00 to 4:00 p.m., 200 Petrie Hall. Participants will look at cores of the Jurassic Smackover Formation, Escambia County, Alabama, that exhibit a variety of microbial and other boundstone fabrics. Held in conjunction with the Paleontological Society symposium, **Phanerozoic Organic Buildups of the Southeastern United States** (symposium 1). For more information contact David Kopaska-Merkel, Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486-9780, (205) 349-2852, dkm.alageol@genle.com. Cost: $20, including refreshments. Limit: 20.
2. **Roy Shlemon Mentors in Applied Geology Program: Workshop for Students.** Ryan D. Turner. Wednesday, March 26, 12:00 noon to 5:00 p.m., 118 Petrie Hall. The Roy Shlemon Mentors in Applied Geology Program, sponsored by the GSA Institute for Environmental Education (IEE), is a new program developed to present workshops for upper-level undergraduate and graduate-level geoscience students who will soon be entering the employment market. Ryan Turner of Turner Environmental Consultants, P.C., is the Shlemon Mentor for this meeting. The structure of the workshop includes open forum discussions of the Mentor's expertise (environmental hydrogeology), business, and experiences in making the transition from academia to the "real world," and lab-style exercises on practical problems that he has encountered, such as actual field cases, the running of his business, marketing, dealing with government regulations, contracts, lawsuits, and expert witness testimony. There is no charge to students for this short course but registration is required and space is limited. Interested students should submit a brief (half-page) statement of their interest in the program to Ryan Turner, Turner Environmental Consultants, 110 West Main St., Suite A, Carrboro, NC 27510, (919) 932-1590, RDTEC@aol.com. Cost: FREE. Limit: 25.

STUDENT RESEARCH PROGRAMS

Sigma Gamma Epsilon will sponsor an oral theme session (theme session 7) devoted to student research. The session is designed to showcase student scholarship without restrictions on subject matter, classification, or membership in Sigma Gamma Epsilon.

The Council for Undergraduate Research will sponsor a student poster session (theme session 8), to showcase senior theses and other undergraduate research projects.

EARTH SCIENCE EDUCATION PROGRAMS

Two half-day theme sessions and a one-day field trip are planned for K–12 and college-level introductory geology teachers. Theme session 8 is sponsored by the Council on Undergraduate Research and theme session 9 by the National Association of Geoscience Teachers (NAGT). In addition, field trip 7 will feature rock exposures in the Auburn vicinity and a tour of the Coca Cola Space Science Center in Columbus, Georgia.

SPECIAL EVENTS

GSA Southeastern Section Management Board Meeting, Wednesday, March 26, 4:30–6:00 p.m., AUHCC Board Room.

GSA Southeastern Section Campus Liaison Breakfast, Thursday, March 27, 6:30–8:00 a.m.; for location see program or AUHCC video monitors.

SEPM Southeastern Section Business Meeting, Thursday, March 27, 12:00 noon; for location see program or AUHCC video monitors.

GSA Southeastern Section Student Support Committee, Thursday, March 27, 12:00 noon; for location see program or AUHCC video monitors.

GSA Southeastern Section Committee on Geology and Public Policy Meeting, Thursday, March 27, 12:00 noon, AUHCC Board Room.

Paleontological Society Southeastern Section Business Meeting, Thursday, March 27, in session room immediately following Paleontological Society symposium 1, Phanerozoic Organic Buildups of the Southeastern United States.

GSA Southeastern Section Business Meeting, Thursday, March 27, 5:00–5:30 p.m., AUHCC Board Room.

GSA Southeastern Section Ph.D.-Granting Earth Science Program Chairs Breakfast Meeting, Friday, March 28, 7:00–8:00 a.m.; for location see program or AUHCC video monitors.

GSA Southeastern Section Education Division and NAGT Officers and State Representatives Combined Breakfast Meeting, Friday, March 28, 7:00–8:00 a.m.; for location see program or AUHCC video monitors.

EXHIBITS

Exhibits by business, education, and government institutions will be located conveniently across from the technical session rooms in the AUHCC. Free beverages will be provided in the exhibit area for meeting registrants, and 24-hour security will be provided in the exhibit hall. The number of booths is limited, so plan to reserve space early. Exhibits will be open Thursday, 8:00 a.m.–5:00 p.m. and Friday, 8:00 a.m.–12:00 noon. For further information and space reservations, contact Ronald D. Lewis, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4886, lewisrd@mail.auburn.edu.

FIELD TRIPS

Auburn's location, central to the Piedmont, Valley and Ridge, and Gulf Coastal Plain provinces makes it an excellent base for many interesting and inexpensive field trips. *All field trip participants must register for the meeting*. Field trip costs may include transportation, guidebook, and other items as listed in the description. All trips except for 1, 2, and 6 originate in Auburn. Registration procedures, the form, and deadlines are provided in this announcement. Registration at the meeting for postmeeting field trips may be possible if trip logistics and space permit. If trips are undersubscribed and canceled, participants will be notified no fewer than 10 days before the meeting, and all field trip fees will be refunded after the meeting. Plan travel alternatives in advance in case the trip you are registered for is canceled. There will be no refunds if participants fail to show up on time for reasons other than serious illness or emergency. Sponsoring agencies assume no liability whatsoever for failure of participants to show for a trip, for missed connections, or for injury, loss, or damage during or resulting from transportation on the field trips. *The number of participants on most trips is limited, so register early.* Additional information will be sent to trip participants at a later date. The field trip coordinator is James A. Saunders, (334) 844-4884, saundja@mail.auburn.edu.

Premeeting

1. **The Salt Mountain Limestone, Clarke County, Alabama: A Late Paleocene Coral-Algal-Sponge Reef.** March 26. *Sponsored by Southeastern Section Paleontological Society.* Jonathan R. Bryan, Earth Sciences, Okaloosa-Walton Community College, 100 College Blvd., Niceville, FL 32578, (904) 729-5246, jbryanowcc@aol.com. Cost: FREE. Departs from Jackson, Alabama, at 10:00 a.m., returns to Jackson at 1:00 p.m. Limit: 20.

2. **Contrasting Depositional Styles in the Warrior and Cahaba Coal Fields, Alabama.** March 25–26. *Sponsored by SEPM.* Jack Pashin, Alabama Geological Survey, P.O. Box O, Tuscaloosa, AL 35486-4780, (205) 349-2852; and Robert A. Gastaldo, Auburn University, (334) 844-4885, gastara@mail.auburn.edu. Comparison of Carboniferous coastal plain and offshore depositional systems of the Warrior basin with mainly alluvial plain systems of the Cahaba basin. Cost: $85, including transportation from Birmingham and return to Auburn, pretrip ice breaker, lunches, and guidebook. The trip will originate at the Colonnade Hampton Inn, 3400 Colonnade Parkway, near the intersection of routes 280 and 459, Birmingham, Alabama. Hotel reservations can be made at the Colonnade Hampton Inn (205-967-0002; double rooms cost $76). Limit: 22.

3. **Industrial Minerals and Rocks of Northeastern Alabama.** March 26. Robert S. Fousek, McCartney Construction Co., Inc., P.O. Box 1890, Gadsden, AL 35902-1890, (205) 547-6386, fax 205-547-6390; and Robert B. Cook, Auburn University, (334) 844-4891, cookrob@mail.auburn.edu. Participants will visit a clay pit and brick processing plant, sand and gravel operation, and marble, limestone, and quartzite quarries. Cost: $75, including transportation departing from and returning to Auburn, refreshments, lunch, and guidebook. Limit: 20.

4. **Wetumpka Impact Crater.** March 26. Tony Neathery, 1212-H 15th St. E., Tuscaloosa, AL 23505, (205) 553-5466; David T. King, Jr., Auburn University, (334) 844-4882, kingdat@mail.auburn.edu; and Lorraine Wolf, Auburn University, (334) 844-4878, lwolf@geology.auburn.edu. Participants will examine outcrops in the area of the Wetumpka impact crater as leaders describe structural, stratigraphic, and geophysical findings on this potential(?) K-T boundary-related feature. A pre-trip, open discussion of cratering processes will be held Tuesday, March 25, 7:00–9:00 p.m., in 118 Petrie Hall. Cost: $55, including transportation departing from and returning to Auburn, refreshments, lunch, and guidebook. Limit: 40.

5. **Comparison of the Pine Mountain Block Basement-Cover Sequence with the Lower Cambrian Clastic-Carbonate Sequence of the Talladega Slate Belt, Alabama.** March 25–26. Denny Bearce, Dept. of Geology, University of Alabama at Birmingham, Birmingham, AL 35294, (205) 934-2439, geof005@uabdpo.dpo.uab.edu; James Tull, Florida State University, (904) 644-4214, tull@geomag.gly.fsu.edu; and Mark Steltenpohl, Auburn University, (334) 844-4893, steltmg@mail.auburn.edu. Comparison of Late Proterozoic(?)–early Paleozoic Lauren-

Southeastern *continued on p. 26*

Southeastern *continued from p. 25*

tian margin stratigraphic evolution in the low-grade (chlorite zone) slate belt with that inferred from the high-grade (kyanite-sillimanite zone) Pine Mountain block. Cost: $50, including transportation departing from and returning to Auburn, refreshments, lunch, and guidebook. Limit: 25.

6. **Quaternary Stratigraphy of the Fall Zone, Chattahoochee Alluvial Valley.** March 26. Don Thieme, Dept. of Geology, University of Georgia, Athens, GA 30601, (706) 542-2430, dthieme@uga.cc.uga.edu. Visit outcrops of fluvial deposits up to 100 feet above river grade and terrace sequences showing active lateral migration and 40 feet of incision from late Pleistocene to early Holocene. Discussion of prehistoric and historic land use in the vicinity of Lower Creek Kasihta and Uchee towns will be of interest to those attending symposium 4, Current Directions in Archaeological Geology—Late and Post-Pleistocene Environments. Cost: $30, including transportation departing from Columbus, Georgia, and returning to Auburn, refreshments, lunch, and guidebook. Limit: 25.

Postmeeting

7. **Teachers' Field Trip to Selected Exposures in the Piedmont and Coastal Plain Provinces near Auburn, Alabama.** March 29. *Sponsored by NAGT.* Jack Carrington, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4282, carrith@mail.auburn.edu. Visit field exposures in the Auburn vicinity and enjoy a short tour of the Coca Cola Space Science Center in Columbus, Georgia. Cost: $16, including transportation departing from and returning to Auburn, and guidebook. Limit: 28.

8. **Mylonites and Other Fault-related Rocks of the Pine Mountain and Uchee Belts of Eastern Alabama and Western Georgia.** March 29. Thomas Hanley, Dept. of Chemistry & Geology, Columbus State University, Columbus, GA 31907-5645, (706) 568-2075, hanley_tom@colstate.edu; and Mark Steltenpohl, Auburn University, (334) 844-4893, steltmg@mail.auburn.edu. Visit spectacular exposures of mylonites from the Towaliga, Bartletts Ferry, and Goat Rock fault zones as well as shear zones within the Pine Mountain Grenville basement massif. Cost: $30, including transportation departing from and returning to Auburn, refreshments, lunch, and guidebook. Limit: 25.

During Meeting

9. **Self-guided tour of the Geology of Chewacla State Park: Grenville Basement and Pine Mountain Group Cover Sequence, Pine Mountain Window, Alabama.** Brandon Coates, Auburn University Geology Club, Auburn University, Auburn, AL 36849-5305, (334) 844-4282, coatebh@mail.auburn.edu; and Charlie Waltman, Auburn University Sigma Gamma Epsilon, Auburn University, (334) 844-4282, waltmck@mail.auburn.edu. Scenic Chewacla State Park is only a 4-mile drive from the Hotel and Conference Center, and this self-guided tour leads you along foot paths through spectacular fall-line exposures of the Pine Mountain Grenville basement massif and its attached miogeoclinal cover. Cost: $5 for the field guide, which can be purchased at the registration desk; $1 per person charge to enter the park.

GUEST ACTIVITIES

Guest trips are planned to beautiful Callaway Gardens on Thursday and/or historic Horseshoe Bend National Military Park on Friday. *Guests are strongly encouraged to preregister for these activities, as they will be canceled if there is not sufficient interest.* Fees for canceled trips will be refunded after the meeting. In addition to the two organized trips, points of interest in the Auburn area are Chewacla State Park, three pro golf courses, historic downtown Opelika, and the Auburn University Athletic Museum and Hall of Honor. Downtown Auburn has quaint shops, restaurants, and bars, all within a few blocks of the convention center. A 45-minute drive away is Franklin Delano Roosevelt's Little White House in Warm Springs, Georgia. Guests also are encouraged to visit scenic Chewacla State Park, is only 4 miles from the Hotel and Conference Center. A $1 charge per person at the entrance allows you to walk scenic trails through the woods, around Chewacla Lake, and along cascades that mark the fall line.

1. **Callaway Gardens.** Thursday, March 27, 10:00 a.m.–4:00 p.m. Dogwoods and azaleas should be in bloom at beautiful Callaway Gardens, site of the Buick Open PGA golf tour. Guests will tour the Sibley Horticultural and Day Butterfly Centers. Cost: $17, includes transportation and entrance fee only.

2. **Horseshoe Bend National Military Park.** Friday, March 28, 9:00 a.m.–1:00 p.m. Participants will tour the visitor center and walk and ride (by van) through this famous battlefield, where Major General Andrew Jackson defeated the Red Stick Creek Indians and attained national prominence. Cost: $10, including transportation.

PUBLICATIONS

A limited number of *Abstracts with Programs* for the meeting will be available at the registration desk. Advance-copy purchases made through GSA Membership or Publication Sales require prepayment and will be mailed approximately three weeks prior to the meeting. Refunds for duplicate orders will not be made.

STUDENT TRAVEL GRANTS

Limited funds for support of travel expenses for students presenting papers at the meeting are available from the GSA Southeastern Section. For information, contact Harold Stowell, Dept. of Geology, University of Alabama, Birmingham, AL 35294, (205) 934-5102, hstowell@wgs.geo.ua.edu. Travel grant requests must be postmarked no later than *February 21, 1997.*

OTHER INFORMATION

For detailed information concerning the technical program, contact Charles E. Savrda, Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4887, savrdce@mail.auburn.edu. For other questions and suggestions, contact local program co-chairs Mark Steltenpohl (steltmg@mail.auburn.edu) and Robert A. Gastaldo (gastara@mail.auburn.edu), Dept. of Geology, Auburn University, Auburn, AL 36849-5305, (334) 844-4282. ■

PREREGISTRATION FORM

GSA Southeastern Section **Auburn, Alabama, March 27–28, 1997**

Please print clearly • THIS AREA IS FOR YOUR BADGE

Name as it should appear on your badge (last name first)

Employer/University Affiliation

City State or Country

Mailing Address (use two lines if necessary)

City State

ZIP Code Country (if other than USA)

Circle member affiliation (to qualify for member registration discount):

(A) GSA (B) NAGT (C) PS (D) SEPM

GUEST INFORMATION • Please print clearly • This area is for badge

Name as it should appear on your guest's badge

City State or Country

Please inform us by February 21 of any special considerations that you or your guest require.

☐ I will need special considerations.

( ) - **Business Phone**

( ) - **fax**

( ) - Home Phone

Preregistration Deadline: February 21

Copy for your records. Deadline for changes or cancellations is February 28

MAIL TO:
GSA SOUTHEASTERN SECTION MEETING, P.O. BOX 9140, BOULDER, CO 80301

Remit in U.S. funds payable to:
1997 GSA Southeastern Section Meeting
(All preregistrations must be prepaid. Purchase Orders not accepted.)

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PREREGISTRATION FEES

	Full Meeting	Qty.	Amount
Professional Member*	(01) $65 ☐	__	$ _____
Professional Nonmember	(03) $70 ☐	__	$ _____
Student Member*	(05) $20 ☐	__	$ _____
Student Nonmember	(07) $25 ☐	__	$ _____
K–12 Professional	(42) $20 ☐	__	$ _____
Guest	(09) $15 ☐	__	$ _____

*Member fee applies to any current Professional OR Student Member of GSA or Associated Societies listed at left. Discount does not apply to guest registrants.

GUEST EVENTS

1. Callaway Gardens	March 27	(20)	$17	__	$ _____
2. Horseshoe Bend National Military Park	March 28	(21)	$10	__	$ _____

SPECIAL EVENTS

1. GSA SE Section Campus Liaison Breakfast	March 27	(60)	FREE	__	$ _____
2. GSA SE Section Student Support Committee Lunch	March 27	(61)	FREE	__	$ _____

WORKSHOP

1. Oxfordian Biostromes	March 26	(150)	$20	__	$ _____
2. Shlemon Mentors Program for Students	March 26	(151)	FREE	__	$ _____

FIELD TRIPS

1. Salt Mountain Limestone	March 26	(101)	FREE	1	$ _____
2. Contrasting Depositional Styles	March 25-26	(102)	$85	1	$ _____
3. Industrial Minerals and Rocks	March 26	(103)	$75	1	$ _____
4. Wetumpka Impact Center	March 26	(104)	$55	1	$ _____
5. Comparison of the Pine Mountain Block	March 25-26	(105)	$50	1	$ _____
6. Quaternary Stratigraphy of the Fall Zone	March 26	(106)	$30	1	$ _____
7. Teachers' Field Trip	March 29	(107)	$16	1	$ _____
8. Mylonites and Other Fault-related Rocks	March 29	(108)	$30	1	$ _____

TOTAL FEES $_____

January *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 109, Number 1, January 1997

CONTENTS

MOVING? Don't risk missing a single issue of *GSA Today*! If you're planning on changing your address, simply write in your new address and mail this coupon along with your subscription mailing label (use label from this newsletter) to: GSA, Membership Services, P.O. Box 9140, Boulder, CO 80301-9140. Or you may call with your change of address information—(303) 447-2020 or 1-800-472-1988 or E-mail us at member@geosociety.org.

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GEOLOGY
VOLUME 25
NO. 1
P. 1–96
JANUARY 1997

The Geological Society of America

Congressional Science Fellowship 1997–1998

The Geological Society of America is accepting applications for the 1997–1998 Congressional Science Fellowship. The Fellow selected will spend a year (September 1997–August 1998) in the office of an individual member of Congress or a congressional committee for the purpose of contributing scientific and technical expertise to public policy issues and gaining firsthand experience with the legislative process. The American Association for the Advancement of Science conducts an orientation program to assist the Fellow seeking a congressional staff position in which he or she can work on major legislative issues.

Criteria

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

Award

The GSA Congressional Science Fellowship carries with it a $42,000 stipend, and limited health insurance, relocation, and travel allowances. The fellowship is funded by GSA and by a grant from the U.S. Geological Survey. (Employees of the USGS are ineligible to apply for this fellowship. For information about other programs, contact AAAS or the Geological Society of America.)

To Apply

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

DEADLINE FOR RECEIPT OF ALL APPLICATION MATERIALS IS FEBRUARY 3, 1997

In Memoriam

Robert E. Bergstrom
Champaign, Illinois
September 28, 1996

Orlo Childs
Tucson, Arizona

James R. Butler
Chapel Hill, North Carolina
September 27, 1996

Helen L. Cannon
Santa Fe, New Mexico
October 20, 1996

George H. Dury
Suffolk, England
October 4, 1996

Gus H. Goudarzi
Brocksville, Florida
May 29, 1996

Galen C. Knutsen
Littleton, Colorado

Francis McKeown
Lakewood, Colorado

Charles W. Prewett
Kingwood, Texas
June 6, 1996

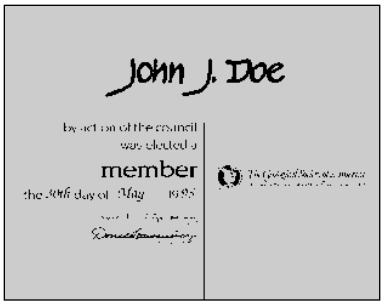
Alfred Rittman
Catania, Italy

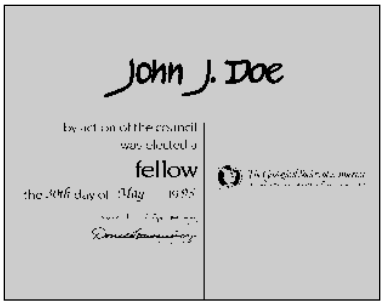
William J. Sando
Washington, D.C.
October 9, 1996

Bernard B. Scheps
Haifa, Israel
January 21, 1996

Laurence L. Sloss
Evanston, Illinois
November 2, 1996

Robert C. Spivey
Carbondale, Kansas
October 22, 1996





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1/97

CALENDAR

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

1997 Penrose Conferences

April

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

September

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

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

1997 Meetings

February

February 9–12, **International Containment Technology Conference**, St. Petersburg, Florida. Information: Conference Coordinator, Florida State University, 2035 East Paul Dirac Dr., 226 HMB, Tallahassee, FL 32310-3700, (904) 644-5524, fax 904-574-6704, E-mail: ICTCE@mailer.fsu.edu, http://em-50.em.doe.gov/BEST/FA/landfills/containment.html.

March

March 23–26, **Symposium on the Application of Geophysics to Environmental and Engineering Problems**, Reno, Nevada. Information: Jayne Sturges, SAGEEP, 7632 Costilla Ave., Englewood, CO 80112, (303) 771-2000, fax 303-843-6232, E-mail: 103443.720@compuserve.com.

April

Early April, **World Mining & Industrial Expo 97**, Shenzhen, China. Information: U-Link Marketing, 1780-401 W. Georgia St., Vancouver, BC V6B 5A1, Canada, (604) 669-8169, fax 604-669-6812, http://www.worldmineexpo.com.

May

May 8–10, **48th Highway Geology Symposium**, Knoxville, Tennessee. Information: Harry Moore, Tennessee Department of Transportation, Geotechnical Section, P.O. Box 58, Knoxville, TN 37901, (423) 594-9436, fax 423-594-9310. *(Abstract deadline: January 15, 1997.)*

June

June 10–12, **International Symposium on Physics, Chemistry, and Ecology of Seasonally Frozen Soils**, Fairbanks, Alaska. Information: Conferences and Special Events, 104 Eielson Bldg., P.O. Box 757800, Fairbanks, AK 99775-7800, (907) 474-7800, fax 907-474-5592, E-mail: fyci@aurora.alaska.edu, http://www.nstl.gov/frozen.

June 17–22, **Chapman/CSEDI/JOI/USSSP Conference on the History and Dynamics of Global Plate Motions**, Point Reyes National Seashore, Marshall, California. Information: AGU Meetings Department, Plate Motions Conference, 2000 Florida Ave., NW, Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: meetinginfo@kosmos.agu.org.

June 18–20, 1997, **3rd International Symposium on Fractals and Dynamic Systems in Geoscience**, High Tatras, Stara Lesna, Slovakia. Information: M. Kupkova, Institute of Materials Research SAS, Watsonova 47, 04353 Kosice, Slovakia, phone: 42-95-6338116, fax: 42-95-6337108, E-mail: kupkova@linux1.saske.sk, http://www.saske.sk/FRACTAL/fr.html.

July

July 14–15, **Rocky Mountain Symposium on Environmental Issues in Oil and Gas Operations**, Golden, Colorado. Information: Special Programs and Continuing Education, Colorado School of Mines, 1-800-446-9488, ext. 3321 (8-5 MST), fax 303-273-3314, E-mail: space@mines.edu, http://www.mines.edu/Outreach/Cont_Ed.

September

September 14–18, **Evolution of the Marine Phytoplankton,** American Association of Stratigraphic Palynologists special symposium, Woods Hole, Massachusetts. Information: Paul K. Strother, Weston Observatory of Boston College, Dept. of Geology & Geophysics, Weston, MA 02193, (617) 552-8395, fax: 617-552-8388; E-mail: strother@hermes.bc.edu, http://www2.bc.edu/~strother/1997_AASP/1997.html.

September 27–30, **American Association of Petroleum Geologists Eastern Section and Society for Organic Petrology Joint Annual Meeting**, Lexington, Kentucky. Information: James Drahovzal, Kentucky Geological Survey, University of Kentucky, Lexington, KY 40506-0107, (606) 257-5500, fax 606-257-1147, E-mail: drahovzal@kgs.mm.uky.edu, http://www.uky.edu/ArtsSciences/Geology/eaapg/welcome.html. *(Abstract deadline: April 1, 1997.)*

September 28–October 2, **Brazilian Geophysical Society Fifth International Congress**, Saõ Paulo, Brazil. Information: Technical Program Committee, Icaro Vitorello or Antonio L. Padilha, phone 55-123-25-6784 or 6807, fax 55-123-25-6810, E-mail: icaro@dge.inpe.br, padilha@das.inpe.br, cisbgf@iag.usp.br. (*Abstracts deadline: May 30, 1997.*)

October

October 28–November 1, **Mining and Geology Forum—Mineral Raw Resources of the CIS**, St. Petersburg, Russia. Information: Tatiana Perepetch, RESTEC, St. Petersburg, http://www.spb.su/restec.

November

November 17–19, **Applied Geologic Remote Sensing Twelfth International Conference**, Denver, Colorado. Information: Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123, E-mail: raeder@erim.org. *(Summary deadline: March 21, 1997.)*

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.

GSA ANNUAL MEETINGS

1997

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

General Chair: ***M. Lee Allison,*** *Utah Geological Survey*

Technical Program Chairs:
John Bartley, Erich Petersen, *University of Utah*

Theme Session Proposal Deadline is January 2, 1997.
See November *GSA Today* for the theme invitation *or* the World Wide Web for invitation and proposal form: ***http://www.geosociety.org.*** Proposals are sent directly to John Bartley.

Field Trip Chairs: ***Bart Kowallis,*** *Brigham Young University*
Paul Link, *Idaho State University*
No more field trips will be accepted.

1998

Toronto, Ontario, Canada, October 26–29
Metro Toronto Convention Centre
Sheraton Toronto Centre Hotel and Towers
General Chair: ***Jeffrey J. Fawcett,*** *University of Toronto*

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

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

Pierre Robin
University of Toronto
Dept. of Geology
22 Russell Street
Toronto, ON M5S 3B1, Canada
(416) 978-3022
fax 416-978-3938

Henry Halls
Erindale College
Mississauga, ON L5L 1C6, Canada
(905) 828-5363
fax 905-828-3717
hhalls@credit.erin.utoronto.ca

FUTURE MEETINGS

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

GSA SECTION MEETINGS—1997

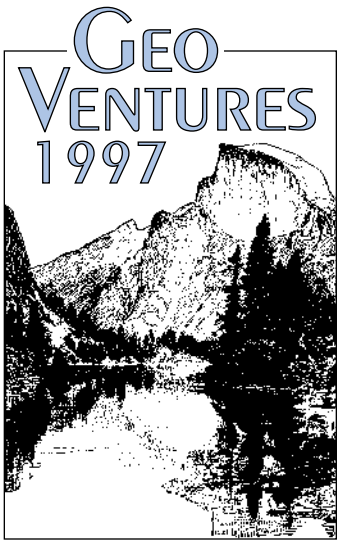
NORTHEASTERN SECTION, March 17–19, Sheraton Valley Forge Hotel, King of Prussia, Pennsylvania. Information: William A. Crawford, Department of Geology, Bryn Mawr College, Bryn Mawr, PA 19010-2899, (610) 526-5112, fax 610-526-5086, wcrawfor@brynmawr.edu. *Preregistration Deadline: February 14, 1997.*

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

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

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

CORDILLERAN SECTION, May 21–23, Kona Surf Resort and Convention Center, Kailua-Kona, Hawaii. Submit completed abstracts to: Fred MacKenzie, Department of Oceanography, University of Hawaii–SOEST, 1000 Pope Road, Honolulu, HI 96822, (808) 956-6344, fredm@soest.hawaii.edu. *Abstract Deadline: January 24, 1997.*



Field Trips with a Difference for GSA Members and Friends

CALL TODAY! HOLD A SPOT FOR YOURSELF AND FRIENDS.

We encourage you to make your decision as soon as possible. There is great interest in these trips; many people have registered already.

General Fee Information: If you have been with us previously on a GeoTrip, the nonmember surcharge will be waived. Please remind us of this when you register. Sorry, there is no nonmember surcharge waiver for GeoHostels, however, if you attend more than one 1997 GeoHostel, we will waive the sucharge.

Single or Shared Accommodation: Some trip fees are based on double occupancy. However, if you wish single accommodations, a limited number of rooms are available at extra cost on a first-come, first-served basis. In the case of double occupancies, we will do our best to help find a suitable roommate, but if none is found, the single rate will apply. Please read the lodging information for each trip.

Age Requirement: Participants must be at least 21 years old.

Health Recommendations and Special Needs: You must be in good physical and mental health. Any physical condition requiring special attention, diet, or treatment, must be reported *in writing* when the reservation is made. We will do our best to accommodate special needs, including dietary requirements and physical disabilities. Please feel free to discuss your situation with us; however, we reserve the right to decline any person as a member of a trip. We also reserve the right to require a person to withdraw from the trip at any time when such action is determined to be in the best interests of the health, safety, and general welfare of the group.

Air Travel: We strongly urge you to make air travel arrangements via Travel King, GSA's official travel agency. We have discussed the trips in detail with the helpful agents at Travel King. They are ready to help you find the least expensive routing to your destination. Please call Travel King for a no-obligation price quote at 1-800-458-6398 toll free, or (303) 776-2270 collect from outside the U.S. The fax number is 303-776-5170.

Cancellation Processing Fee: Deposits and payments are refundable, less processing fee, up to the cut-off date. Termination by an individual during a trip in progress for any reason whatsoever will not result in a refund, and no refund will be made for unused portions of the trip.

Full Itineraries: Detailed itineraries for each GeoVenture and helpful travel information are available from GSA. Please feel free to contact Edna Collis, GSA Meetings Department, at 1-800-472-1988, ext. 134 or (303) 447-2020, fax 303-447-0648, ecollis@geosociety.org.

1997 GeoVentures Fee Schedule

	Italy	Canyonlands	Mt. St. Helens	Yellowstone-Beartooth	Sky Islands SE Arizona
Dates	May 9–21	May 30–June 7	June 21–26	July 19–24	August 2–7
No. of Days	14	10	6	6	6
Member Fee	$2375	$1445	$650	$690	$540
Nonmember Fee	$2475	$1545	$700	$740	$590
Deposit	$250	$200	$100	$100	$100
Balance Due	February 28	March 28	April 28	May 28	June 28
100% Deposit refund date (less processing fee)	February 28 ($50)	March 28 ($50)	April 28 ($20)	May 28 ($20)	June 28 ($20)

Register Today!

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

Name

Institution/Employer

Mailing Address

City/State/Country/ZIP

Phone (business/home)

Guest Name

GSA Member #

CALL TODAY FOR MORE INFORMATION:
1-800-472-1988, x134, or (303) 447-2020, E-mail: ecollis@geosociety.org.
Check for updates: http://www.geosociety.org

	Deposit Per Person	No. of Persons	Total Paid Deposit
GT971—Italy	$250	____	$_____
GT972—Canyonlands	$200	____	$_____
GH971—Mount St. Helens	$100	____	$_____
GH972—Yellowstone	$100	____	$_____
GH973—Sky Islands	$100	____	$_____
		TOTAL DEPOSIT	$_____

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

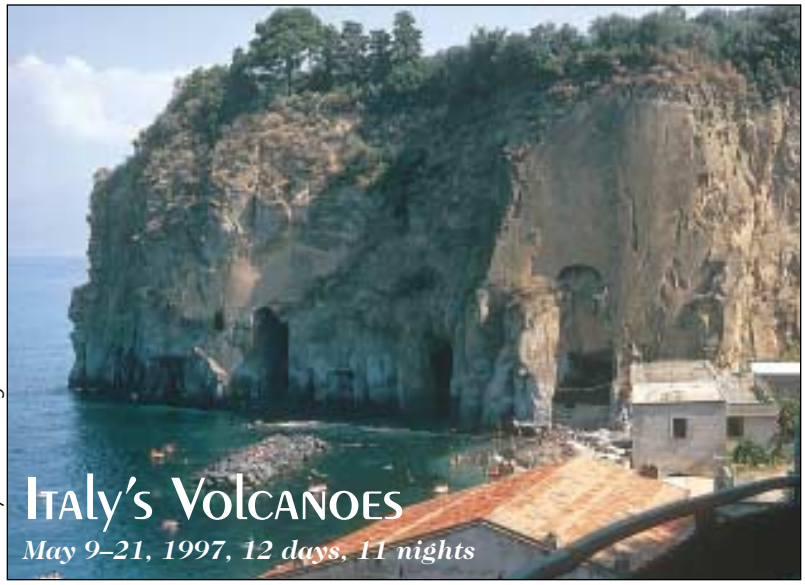
☐ VISA ☐ MasterCard ☐ American Express

Credit Card # Exp. Date

Signature

YOU CAN REGISTER ON THE WEB OR MAIL OR FAX REGISTRATION FORM AND CHECK OR CREDIT CARD INFORMATION TO:
1997 GSA GeoVentures, GSA Meetings Department,
P.O. Box 9140, Boulder, CO 80301.
fax 303-447-0648

MAKE CHECKS PAYABLE TO: GSA 1997 GeoVentures



Photos by Haraldur Sigurdsson

Italy's Volcanoes

May 9–21, 1997, 12 days, 11 nights

GeoTrip

Scientific Leaders

Haraldur Sigurdsson, Graduate School of Oceanography, University of Rhode Island
Mauro Rosi, Department of Geology, University of Pisa, Pisa, Italy

Description

This unique trip has been requested dozens of times. At last it's here, with extraordinary leaders! It begins on May 9 with air travel to Rome, connecting to Naples, and a tour of Vesuvius volcano. The trip continues with visits to the archaeological sites of Pompeii and Herculaneum, destroyed by the famous A.D. 79 eruption. The group takes a ferry to the island volcano of Stromboli, which has been continuously active for more than 2,500 years. Additional ferry trips go to the adjacent volcanic islands of Lipari and Vulcano. The group continues to Sicily and ascends Mount Etna, Europe's largest active volcano before returning home on May 21.

There are no special physical requirements, although we will ask that everyone provide verification of health care coverage.

Travel

Group reservations on Alitalia Airlines are offered at $876 plus tax between Newark and Naples-Catania-Newark. An add-on fare using Continental airlines from selected United States gateways to Newark to connect with Alitalia is available. Of course, air miles on other airlines can be used. We strongly encourage you to talk with TR Consultants about your air reservations at 1-800-923-7422.

All arrangements for the ground parts of this trip have been made by TR Consultants, Inc. and its partner company, Volcano Tours—both in Providence, Rhode Island.

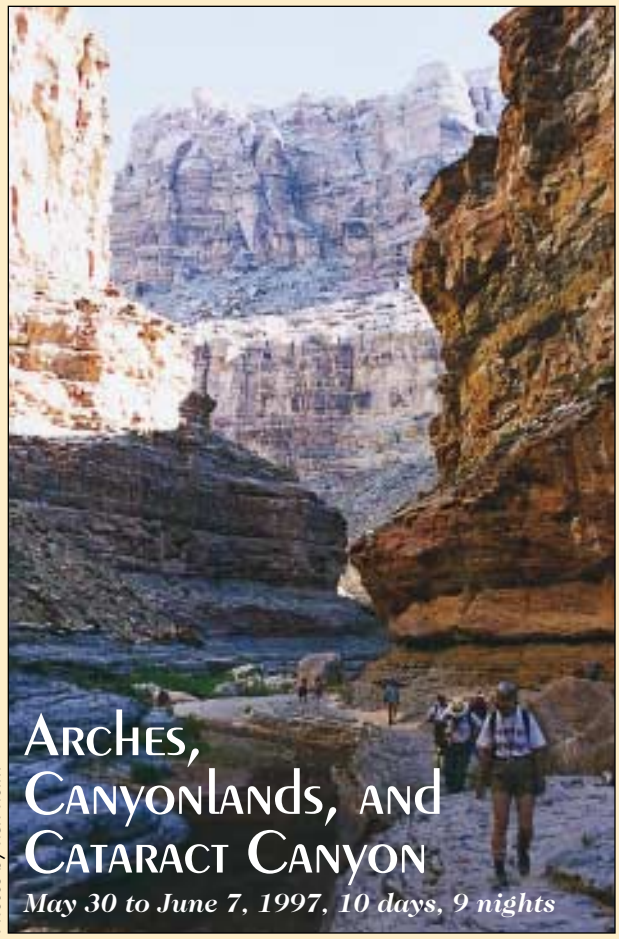
Fee, Payment, and Cancellation

GSA Member: $2375 *Nonmember: $2475*

The single supplement is $350, based on availability of rooms—many of the places we are visiting have very limited lodging.

GSA is handling trip reservations: A deposit of $250 is due with your reservation. The deposit is refundable (less a $50 processing fee) through February 28. The total balance is due February 28. (Because of the limited access to some of the sites, we have to

Italy *continued on p. 34*



Photos by Ken Kolm

Arches, Canyonlands, and Cataract Canyon

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

GeoTrip

Scientific Leader

Jack Campbell,
Department of Geology, Ft. Lewis College, Durango, Colorado

Description

This trip is an exceptional educational opportunity for the physically active person. We will be hiking the rim area of the Canyonlands, inlcuding trips to the LaSal Mountains and Arches National Park (Fiery Furnace). We'll hike from the rim at the Upheaval Dome site to the river to meet the rafts. Each day after that we'll hike from our campsite to a remarkable new area. At last the boatmen guide our rafts through the wet and wild Cataract Canyon, which is a major whitewater experience. Our last day, we'll hike out Dark Canyon back to the rim where we will be picked up for the return flight to Moab. This sunset overflight is ***unforgettable.***

For post-trip adventure, Moab is within driving distance of Bryce, Zion, and Grand Canyon and an array of other features such as Capitol Reef and the newly designated Grand Staircase–Escalante National Monument.

Lodging, Meals, and Transportation

Lodging in Moab will be in a comfortable motel. Camping near the river for several nights will be in tents and sleeping bags provided by the rafting outfitter. Meals are provided except for the departure morning. Travel will be by vans, motorized rafts (J-rigs) or on foot. During the days on the rim, transportation will be by van. A spectacular overflight by charter air returns groups from Hite—across Canyonlands—back to Moab.

Physical Requirements

Especially because of the heat in southeastern Utah at this time of year (~90–100 °F), individuals must be in excellent health. The trip includes several substantial hikes for which each person will carry a day pack with camera, water, and snacks. The longest hike will be 5 miles with a 2000-ft.

Arches *continued on p. 34*

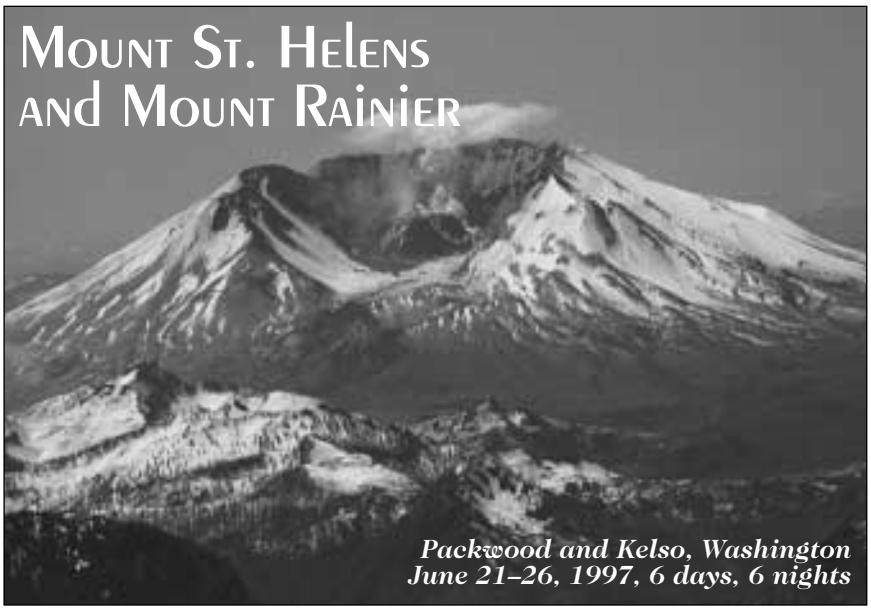


Photo by Richard Waitt

Packwood and Kelso, Washington
June 21–26, 1997, 6 days, 6 nights

GeoHostel

Scientific Leaders

Richard Waitt, U.S. Geological Survey, Cascades Volcano Observatory, Vancouver, Washington

Patrick Pringle, Washington Department of Natural Resources, Olympia, Washington

Description

This GeoHostel will focus on field trips to Mount St. Helens, especially to explore processes and effects of the cataclysmic eruption of May 18, 1980. Among them are: decapitation of former summit; world's largest historic landslide; tsunami wave as high as 800 feet on Spirit Lake; gigantic pyroclastic surge (so-called "lateral blast") that in four minutes mowed down 235 square miles of mature forest; great muddy floods (lahars). The ever-changing processes of revegetation, reforestation, and reentry of fauna to the devastated area are part of the scientifically unique experience, one of the reasons Congress set aside the heart of the affected area as Mount St. Helens National Volcanic Monument. Two days will be devoted to the east and southeast sides of Mount St. Helens, and two days to the south and west sides, including two stunning new visitor facilities in the heart of the devastated area, and one day will be at spectacular Mount Rainier (northeast, east, and south flanks) in Mount Rainier National Park. While at Mount St. Helens, we will hike through a remaining stand of old-growth coniferous trees, many as tall as 230 feet. Each day involves a hike through a unique landscape; none of the hikes is longer than about three miles nor with an altitude change of more than about 900 feet. Because snow will still be visible on the higher mountain peaks, June will be stunning for photography.

Lodging, Meals, and Ground Transportation

The group will stay on Saturday, Sunday, and Monday at the Inn of Packwood, Packwood, Washington, and on Tuesday, Wednesday, and Thursday nights at the Red Lion Inn in Kelso, Washington. All lodging is based on double occupancy. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts, sack lunches, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Fee and Payment

$650 for GSA Members *$700 for Nonmembers*

$100 deposit is due with your reservation and is refundable through April 28, less $20 processing fee. Total balance is due: April 28.

Included: Classroom programs and materials; field trip transportation; lodging for six nights (double occupancy); meals outlined above; welcoming and farewell events.

Not included: Transportation to and from Portland, Oregon; transportation during hours outside class and field trips; and other expenses not specifically included.

Italy *continued from p. 33*

make payments to the Italian providers 60 days in advance of departure.) The fee is nonrefundable after February 28.

Included: The trip fee includes all lodging, meals, ground transportation (including ferries), and fees. Accommodations are based on double occupancy in "Superior Tourist" class hotels, and one night aboard a ferry on May 13. Every day includes full breakfasts, box lunches, and full dinners. Meals are included for the arrival night on May 10 and continue through the departure breakfast on May 21. Transport is by deluxe air-conditioned motorcoach for eight days (Naples, Lipari, and Sicily); none is required in Vulcano and Stromboli. Ferry transportation is included for island travel. Also included are field guides and maps, wine with dinner, gratuities, taxes, and all fees. Just pack your bags!

Not Included: Airfare, airport departure taxes, travel insurance, lodging in Newark, personal expenses such as soda pop and alcoholic beverages, laundry, excess baggage fees, transfers for passengers arriving and departing independently, and other expenses not specifically included.

Arches *continued from p. 33*

elevation gain. Although taken at a reasonable pace with many points to rest and to explore the geology, these hikes should be undertaken only by persons who are in good health and physically active. Verification of health care coverage will be required. No rafting experience is necessary; however, Cataract Canyon offers some of the biggest and most challenging whitewater in the United States.

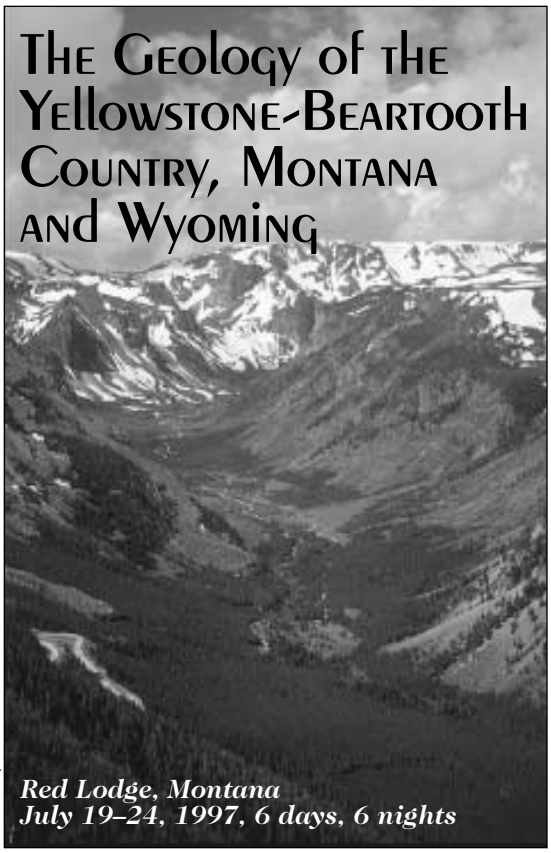
Fee and Payment

GSA Member: $1445 *Nonmember: $1545*

A $200 deposit is due with your reservation. The single supplement is $160. It is refundable through March 28, less $50 processing fee. Total balance due: March 28. Minimum age: 21.

Included: ***All*** meals starting with dinner on arrival night but excluding breakfast on the departure day; comfortable four-wheel-drive van transportation; four nights double-occupancy lodging at the Moab Valley Inn; tents, sleeping bags, and pads when camping (refund if you bring your own); geological reading materials and guidebook; overflight of Canyonlands; and of course, the companionship of expert scientific leaders.

Not included: Gratuities for raft guides. Airfare from Grand Junction, Colorado, or transfer to Moab. We will arrange for an optional group shuttle.



Photos by Rob Thomas

GeoHostel

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

Description

The geology of the Yellowstone-Beartooth country is some of the most spectacular in North America, from Archean metamorphic rocks to Quaternary glacial deposits. The GeoHostel will include field trips to look at Archean through Quaternary geology of the Beartooth plateau via the famous Beartooth Highway, layered mafic intrusions at the Stillwater Mine, Absaroka volcanics in the upper Clarks Fork drainage, the Heart Mountain detachment and Phanerozoic stratigraphy of the Sunlight Basin and Dead Indian Hill region, and volcanics of the northeastern edge of the Yellowstone plateau. The trips are full days. Enjoy the spectacular scenery of the Yellowstone-Beartooth country.

Lodging, Meals, and Ground Transportation

The group will be lodged at the Best Western Lu Pine Inn in double occupancy motel-type rooms. GSA will do its best to help find a suitable roommate for single travelers. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts and sack lunches, dinner on Monday evening at the Grizzly Bar, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Fee and Payment

$690 for GSA Members *$740 for Nonmembers*

$100 deposit is due with your reservation and is refundable through May 28, less $20 processing fee. Total balance is due: May 28.

Included: Classroom programs and materials; field trip transportation; lodging for 6 nights; double occupancy, meals outlined above; welcoming and farewell events.

Not included: Transportation to and from Red Lodge, Montana; transportation during hours outside class and field trips; and other expenses not specifically included.

GeoHostel

Scientific Leaders: *Tim Lawton and Nancy McMillan, New Mexico State University, Las Cruces, New Mexico*

Description

Above the grasslands of southeastern Arizona, isolated ranges, the "sky islands," rise to heights of 8,000–9,000 feet. The geology and natural history of these mountains have stronger affinities with the Sierra Madre of Mexico than with the Rocky Mountain cordillera, making the region unique in the United States. The monsoons of late July and August bring cooling—and sometimes drenching—afternoon rains and an array of Sierra Madre wildflowers to the higher elevations. The geology of the Chiricahua, Mule, and Huachuca mountains records Paleozoic marine deposition, Jurassic-Cretaceous crustal extension and basin formation, latest Cretaceous mountain building and basin inversion of the Laramide orogeny, and catastrophic volcanism in the Tertiary. Within and among these ranges are the mining camps—Tombstone, Bisbee, and Gleeson, among others—that generated the early wealth of Arizona and sowed the seeds of conflict recorded by U.S. Army forts Huachuca and Bowie.

This GeoHostel, which includes a program of ambitious hikes, will explore this geology and the natural and human history of the area by means of a series of field trips and half-day hikes to several ranges and mining centers. Located within 50 miles of the Mexican border, the area is a world-renowned mecca for birdwatchers. Daily field trips will allow plenty of time for birding.

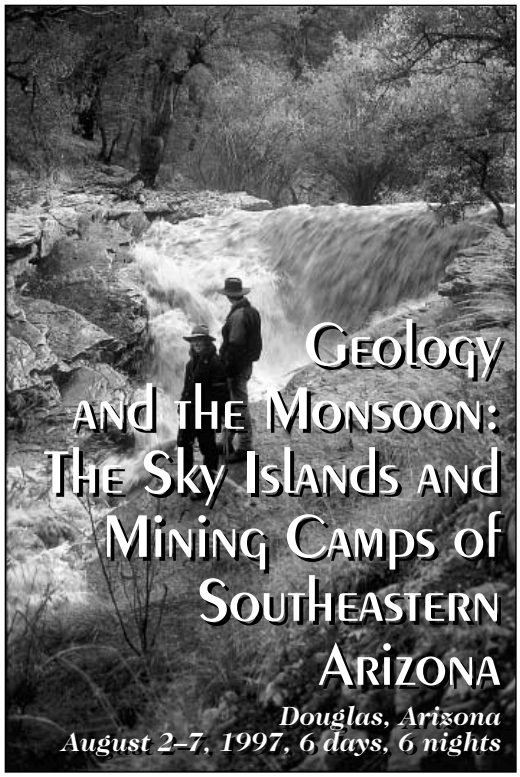


Photo by Tim Lawton

Lodging, Meals, and Ground Transportation

The group will be lodged at Cochise College in dormitory style, single occupancy (doubles for couples) type rooms. Meals will include plenty of hors d'oeuvres at the Welcoming Reception and Orientation on Saturday evening, daily breakfasts and sack lunches, and a hearty farewell dinner on Thursday evening. Field trip transportation will be provided in air-conditioned, 15-passenger vans.

Fee and Payment: *$540 for GSA Members* *$590 for Nonmembers*

$100 deposit is due with your reservation and is refundable through June 28, less $20 processing fee. Total balance is due: June 28.

Included: Classroom programs and materials; field trip transportation; lodging for six nights; single occupancy (double for couples), meals outlined above; welcoming and farewell events.

Not included: Transportation to and from Douglas, Arizona; transportation during hours outside class and field trips; and other expenses not specifically included.

1996 GSA Annual Meeting

EARTH SYSTEM SUMMIT Denver

Statistics

Technical Program

Abstracts submitted	2870
Abstracts presented	2756
Abstracts rejected or withdrawn	114
Percentage of abstracts accepted	96%
Poster presentations *(including theme posters)*	745
Oral presentations	2011
Oral presentations, discipline sessions	824
Oral presentations, theme sessions	882
Oral presentations, symposia	305
Highest number of concurrent oral sessions	18
Total number of sessions *(including posters)*	203
Theme sessions in poster format	13
Theme sessions in oral format	64

Registration

Professional	3915
Student	1600
Exhibitor	762
Guest	224
Total attendance	6501

Short Courses

Number of GSA–sponsored courses	6
Participants	207

Field Trips

Number of trips	26
Participants	821
Number of participants in half-day trips	345

Exhibits

Number of booths	259
Number of exhibiting companies	194

Employment Service

Applicants	217
Employers	32
Interviews	524
Positions available	42


GSA
Registration


GSA
EMPLOYMEN
SERVICE

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-1133, or E-mail:acrawfor@geosociety.org. Please include complete address, phone number, and E-mail address with all correspondence.

Classification	Per Line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
Positions Open	$6.50	$5.50
Consultants	$6.50	$5.50
Services & Supplies	$6.50	$5.50
Opportunities for Students		
first 25 lines	$0.00	$2.35
additional lines	$1.35	$2.35
Code number: $2.75 extra		

Positions Open

IDAHO STATE UNIVERSITY

We seek a field-based earth scientist to fill a tenure-track position, beginning academic year 1997–1998 at a rank commensurate with qualifications, in one of the following fields: (1) Applied Geophysics, or (2) Sedimentary Geology/Paleontology. A Ph.D. or A.B.D. is necessary. Teaching duties include 3 undergraduate/graduate classes per semester or equivalent work plus participation in our Geology Field Camp. Supervision of M.S. students and pursuit of a funded research program is required, while expertise in the geology of the North American Cordillera is desirable. The successful candidate will have broad geologic interests, be comfortable in a small department where cooperation and shared teaching and research are standard, and assist the department's expansion into quantitative methods and GIS applications. Send resume, transcripts, statement of academic philosophy and interests, and names of 3 referees to Search Committee, Department of Geology, Idaho State University, Pocatello, ID 83209-8072. Position is contingent on funding, and applications will be reviewed beginning February 15, 1997. ISU is an EO/AA Employer.

WATERSHED HYDROLOGIST
UNIVERSITY OF CALIFORNIA, DAVIS

The Hydrology Program of the Department of Land, Air, and Water Resources seeks applicants for a nine-month tenure-track position; eleven-month term employment to be offered and continued based upon academic personnel review, at the Assistant Professor level. The appointee will develop a quantitative field-experimental research program in Watershed Hydrology emphasizing processes that may include land-atmosphere interactions, precipitation and runoff, surface water and groundwater interaction, surface water detention, wetland hydrology, snow hydrology, and chemical cycling in watersheds. The appointee should be able to synthesize the acquired data, using appropriate mathematical modeling tools. Possible research topics include impacts of range management, forestry, or urban development on watershed function, water yield and surface water quality, remote sensing of rainfields by radar, evaporation, infiltration, surface runoff and erosion, stream flow, groundwater recharge and contaminant transport. The appointee is expected to teach an undergraduate field course in hydrology, an undergraduate course in watershed hydrology and a graduate level course in experimental watershed hydrology. A quantitative background in mathematical modeling and teaching experience are desirable. The position is available July 1, 1997. Applicants should submit resume, transcripts, research and teaching statements with background in each, copies of relevant publications and manuscripts and the names and addresses of at least four references to: Professor Jan W. Hopmans, Watershed Hydrology Search Committee Chair, Hydrology Program, Land, Air and Water Resrouces, University of California, Davis, CA 95616, telephone (916) 752-3060/1130, email jwhopmans@ucdavis.edu. Open until filled. To ensure consideration applications should be postmarked by 3/14/97. A more detailed job description can be obtained from the above address. Information on the Department, Hydrology Program, and its faculty, can be found on http://hydrosci.ucdavis.edu.

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

FACULTY POSITION / PALEONTOLOGY

The Department of Geological Sciences, Mackay School of Mines, University of Nevada, Reno invites outstanding science teachers to apply for a position as Assistant Professor of Geology (tenure-track) in paleontology. Areas of expertise may include, but are not limited to, invertebrate/vertebrate paleontology (micro or macropaleontology), or paleobiology. We are particularly interested in applicants who work in the areas of biostratigraphy, paleobiostratigraphy, paleoecology, or paleoclimatology. A Ph.D. in Geological Sciences or equivalent field of study is required.

Mackay School of Mines has an established tradition of field-oriented teaching that takes advantage of the superb geology of the Great Basin. Paleontology is an essential part of our geoscience curriculum. We seek Ph.D.-level applicants who will enthusiastically participate in teaching introductory lecture and laboratory courses in earth sciences. Undergraduate teaching responsibilities also will include an invertebrate paleontology/biostratigraphy course that is a major requirement for our undergraduate program. We offer B.S., M.S., and Ph.D. degrees in geological engineering. We expect the new faculty member to teach and develop graduate-level seminars and direct graduate student research in area of specialty.

The successful applicant will have the opportunity to integrate teaching and research into our varied programs of geologic studies that include tectonics, structural geology, stratigraphy, sedimentology, seismology, geophysics, neotectonics, geological engineering, economic geology, geochemistry, and Quaternary climate studies. Preference will be given to candidates with experience in field applications and quantitative methods. Applicants should demonstrate the potential for developing sponsored research and have publication records appropriate to their experience.

A curriculum vita, a list of publications, a description of teaching and research interests, and a list of three references (including phone, FAX numbers, and e-mail addresses) should be sent to: Search Committee Chair, Department of Geological Sciences / 172, University of Nevada, Reno, NV 89557. For full consideration, application materials should be received by March 1, 1997. The University of Nevada is an equal opportunity/affirmative action employer. Women and minorities are especially encouraged to apply.

BRYN MAWR COLLEGE

The Department of Geology seeks a 1997-1998 leave replacement in environmental geology and sedimentology to teach two courses per semester and to participate in a concentration in Environmental Science with anthropology and biology. Courses include environmental geology or earth systems science, selected undergraduate offerings in sedimentology, oceanography, geophysics, or geohydrology, possibly a graduate course in some aspect of sedimentary geology, and the directing of undergraduate research projects. The candidate must have a Ph.D.

Bryn Mawr College is a selective liberal arts college located west of Philadelphia. The department is well-equipped for teaching, research and computing. http://www.brynmawr.edu/Adm/academic/geology.html.

Applications, including three references and complete vita, should be sent to Wm. A. Crawford, Chairman, Department of Geology, Bryn Mawr College, 101 N. Merion Avenue, Bryn Mawr, PA 19010. Bryn Mawr College is an Equal Opportunity Affirmative Action Employer. The College particularly wishes to encourage applications from individuals interested in joining a multicultural and international academic community. Minority candidates and women are especially encouraged to apply. Deadline for applications: January 20, 1997.

SEDIMENTARY GEOLOGY, GEOLOGY DEPARTMENT
CENTRAL MICHIGAN UNIVERSITY

The Department of Geology invites applications for an entry-level tenure-track position beginning in mid-August 1997 dependent upon funding. Position specifications: Ph.D. required; effective communication skills required; teaching experience required; graduate course work in sedimentary geology required; teaching experience in sedimentary geology preferred; preferred research areas are carbonate sedimentology/stratigraphy or basin analysis or glacial stratigraphy; willingness to develop collaborative research programs with departmental colleagues preferred; willingness to involve undergraduates in research program required, experience in directing undergraduate research preferred. The applicant will be expected to teach introductory courses as well as upper level courses in her/his discipline. Interested persons should send a résumé and arrange to have three letters of reference sent to Dr. Stephen D. Stahl, Chairman, Geology Department, Central Michigan University, Mt. Pleasant, MI 48859. All applications and supporting materials must be received by January 15, 1997. CMU (AA/EO institution) encourages diversity, and resolves to provide equal opportunity regardless of race, sex, disability, sexual orientation, or other irrelevant criteria.

ASSISTANT PROFESSOR OF GEOLOGY
UNIVERSITY OF SOUTHERN INDIANA

The University of Southern Indiana invites applications for a tenure-track position beginning Fall 1997. Candidates should be broadly trained field-oriented geologists with expertise in one or more of the following areas: groundwater geology, geophysical methods, remote sensing, and geologic/environmental hazards and pollution control. Additional expertise in active tectonics, basin analysis, geochemistry, structural geology and/or computer modeling is also desired. Ph.D. in geology preferred, but exceptional ABD's may be considered. The University is committed to excellence in teaching, scholarship and professional activity, and service to the University and the community. Application deadline is February 28, 1997, but will be accepted until position is filled. Submit letter of application including statements of teaching philosophy and research interests, curriculum vitae, and names and addresses of three professional references to: Mr. Eric Sprouls, Geology Search Committee Chair, Department of Geology, University of Southern Indiana, 8600 University Blvd., Evansville, IN 47712. AA/EOE

ASSISTANT PROFESSOR, GEOLOGY
BALL STATE UNIVERSITY, MUNCIE, INDIANA

Tenure-track position available August 22, 1997, in area of mineralogy or structural geology, field methods, and petrology. Responsibilities include: teaching two or three of the above courses along with a course in general education, such as physical or environmental geology; and a senior/graduate level course related to the candidate's specialty; developing a program of research; advising student research at graduate and undergraduate levels. Area of research is open but should enhance the department's offerings and research in the above areas or combined with engineering/environmental geology or geoscience education. *Minimum qualifications:* doctoral degree; ABD's will be considered if all requirements met by August 22, 1997; some college teaching and/or professional experience. *Preferred qualifications:* doctorate in geology; demonstrated teaching abilities and effective interaction with other faculty and students on individual projects and research; interest in teaching and eventually directing the summer five-week field mapping course currently taught in South Dakota and Wyoming; experience and knowledge in geoscience education methods. Send statement of teaching and research interests, including how research might be developed to include students, especially undergraduates; vita; names of at least three references; and transcript of highest degree earned to: Chairperson of Search Committee, Department of Geology, Ball State University, Muncie, IN 47306. Review of applications will begin February 3, 1997, and continue until the position is filled.

Ball State University is an equal opportunity, affirmative action employer and is strongly and actively committed to diversity within its community.

STRATIGRAPHY / SEDIMENTOLOGY
PALEONTOLOGY

The Department of Geology and Geography at Ohio Wesleyan University invites applications for a tenure-track faculty position at the Assistant Professor level, to teach courses in Stratigraphy/Sedimentology and Paleontology, to contribute to introductory-level teaching, and to offer independent study opportunities for students. We seek a candidate who also has the background to offer a course in Hydrogeology and/or Environmental Geology. The position will begin August 18, 1997, and requires a person with Ph.D. in hand or near completion. The applicant should have a strong interest in teaching as well as continuing research interests.

Ohio Wesleyan University is a residential liberal arts college with an enrollment of about 1800 students, located in Delaware, Ohio, 20 miles north of Columbus. Teaching and research equipment include: Scanning Electron Microscope with EDS System, Automated Thin Section Preparation System, petrographic and stereozoom microscopes, photographic darkroom, departmental computer laboratory, and office and classroom connections to the University computer system. The faculty includes three full-time geologists and two full-time geographers.

Applicants should send letter of application detailing teaching and research interests, curriculum vitae, official academic transcripts, and three letters of recommendation to: Dr. Karen H. Fryer, Department of Geology and Geography, Ohio Wesleyan University, Delaware, OH 43015 by January 15, 1997. Application materials received after this date may be considered until the position is filled. Ohio Wesleyan University is an Affirmative Action/Equal Opportunity Employer. Women and minority candidates are encouraged to apply.

GEOLOGICAL MAPPING

The Utah Geological Survey is seeking applications for a Project Geologist to work as a field geological mapper. Duties include: conducts multifaceted geological mapping projects; plans and implements research needed to support mapping projects; compiles field mapping using digital photogrammetric methods; constructs and drafts structural cross sections and other supporting materials; analyzes and interprets complex geologic data, integrates data from several geologic disciplines; writes interpretive supporting manuscripts; prepares materials for publication; edits and reviews geologic reports; monitors geologic contracts; serves as program specialist in one or more disciplines of geology; serves as expert on the geology of one or more

parts of Utah; assists in planning and developing proposals for new mapping projects. Requirements: Bachelor's degree in geology or a closely related field. Preference may be given to applicants with experience in mapping geologic quadrangles at scales of 1:24,000 or 1:100,000 and writing for publication.

The position will be located in either Salt Lake City or Cedar City, Utah. For more information, please visit the UGS home page at http://utstdpwww.state.ut.us/~ugs/

The state of Utah's Department of Human Resource Management (DHRM) has implemented an automated recruitment and selection system called Utah Skill Match. Resumes are scanned into a database and then matched against all available job openings within state government for a one-year period. Resumes must be submitted to DHRM to be considered for employment at the UGS. Instructions for submitting resumes are available on the UGS home page.

Resumes will be accepted until position is filled. Salary range: $29,931–$44,949.

Utah Geological Survey, Box 146100, Salt Lake City, Utah 84114-6100, (801) 537-3305.

The state of Utah is an equal opportunity employer.

TECTONICS / NEOTECTONICS

Applications are invited for a tenure-track faculty position in tectonics and/or neotectonics in the Department of Geology and Geophysics at the University of California, Berkeley. Specialists in all areas of regional and global tectonics, and in neotectonics/paleoseismology are encouraged to apply. The successful applicant will be expected to carry out a field-based research and teaching program.

The closing date for receipt of applications is January 31, 1997. This position (ID #141) is offered at the Assistant Professor level and will begin July 1, 1997.

Interested candidates should send a cover letter, stating research and teaching interests, a resume, a selection of recent publications, and names of three references to: Walter Alvarez, Chair, Tectonics Search Committee, Department of Geology and Geophysics, 301 McCone Hall, University of California, Berkeley, CA 94720-4767.

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

HYDROGEOLOGY AND TECTONICS

The Department of Geology, University of Florida, is accepting applications for two tenure-track assistant professors for August 1997 or January 1998 in the broad fields of hydrogeology and tectonics. Preference will be given to quantitative, process-oriented scientists who will develop strong and innovative research programs, and exhibit a strong commitment to teaching. We are particularly interested in scientists whose research involves fundamental earth processes and the rates at which these processes occur, e.g.: physical and chemical analysis of hydrodynamic systems, including wetlands; basin analysis and evolution; numerical geodynamics; and thermochronology. The Department will relocate, and research space will double in 1998 as a result of an NSF/ARI grant. More information can be found at: http://www.clas.ufl.edu/CLAS/Departments/Geology/.

Qualified candidates should send a letter of interests, including a statement of research and teaching goals, a curriculum vitae, and the names and addresses of three references by February 1, 1997 to: Dr. Michael Perfit, Dept. of Geology, PO Box 117340, University of Florida, Gainesville, FL 32611-7340; (352) 392-2231 (perfit@geology.ufl.edu). The University of Florida is an equal opportunity/affirmative action employer; qualified women and minorities are especially encouraged to apply.

GEOLOGY AND REMOTE SENSING

The Faculty of Geosciences of the Ludwig-Maximilians-University, Munich, Germany invites applications for the chair of a Full Professor position C4 in Geology and Remote Sensing. The chair will be at the Institute of General and Applied Geology to ensure the roots in the geological research. Together with the chair of Geography and Remote Sensing the two positions will head a new founded Institute for Geoscientific Remote Sensing. The main research activities in the field of Remote Sensing are hyperspectral remote sensing, methodological development, data processing techniques, GIS, sensor development and sensor adaption (e.g. MOMS-2P, Modular Optoelectronic Multispectral Stereo Scanner on the Russian MIR station) for geoscientific applications. The institute has a modern image processing lab, a spectrometric lab and photogrammetric laboratory and is involved in most of the national and European Earth Observation Satellite Programs.

Applications, accompanied by a resume, scientific expertise and complete bibliography references should be sent until 1/31/97 to: Fakultät für Geowissenschaften der Ludwig-Maximilians-Universität München, Luisenstr.37, D-80333, MUENCHEN, phone: +49 89 5203243, fax: +49 89 5203319.

GEOMORPHOLOGIST / ENVIRONMENTAL GEOLOGIST
SOUTHERN CONNECTICUT STATE UNIVERSITY

The Department of Earth Sciences at Southern Connecticut State University expects to have available on September 1, 1997, a tenure-track position to be filled at the Assistant/Associate Professor level. Courses to be taught include Geomorphology, Historical Geology, and Field Geology for majors, as well as introductory Earth Science courses for non-majors. Quality of teaching is especially important. The candidate will also work with other faculty members to strengthen our Environmental Earth Science Program. Applicants should have the Ph.D. degree or be in the final stages of completion of the degree. A letter of application, a complete resume, and three letters of recommendation should be submitted to John Drobnyk, Chairman, Earth Science Department, Southern Connecticut State University, New Haven, Connecticut 06515. Applications will be reviewed beginning February 1, 1997, and interviews will take place in March or April 1997.

SCSU is an equal opportunity, affirmative action employer and strongly encourages minorities and women to apply.

BAHAMIAN FIELD STATION

Executive Director for the Bahamian Field Station, a not-for-profit educational and research institution on the remote island of San Salvador, Bahamas. Ph.D. in the Natural Sciences, with good communication, mechanical and business skills required. As head administrator, responsibilities would include overall organization and management of the Field Station to include the physical plant, designing of programs, grantsmanship, coordinating of research, planning and management of supply and travel logistics, and overall supervision of the Bahamian staff. Send request for detailed information by January 20, 1997, to Dr. Donald T. Gerace, The Bahamian Field Station, 3616 Peace River Dr., Punta Gorda, FL 33983, or e-mail to: peace@flnet.com.

KECK GEOLOGY CONSORTIUM
Summer Undergraduate Student/Faculty Research Projects

We seek two geoscientists to join with faculty from the 12 schools in the Keck Geology Consortium to lead research groups for exceptional undergraduate students. The first opening is for a person with expertise in carbonate dissolution, cave/karst studies, or paleomagnetic or U-series dating to participate in a study of the Cenozoic Appalachian erosional history near Lexington, VA. The second opening is for a mineralogist, petrologist or geochemist of minority heritage to participate in a study of ferric iron partitioning between mineral pairs in the Adirondack Mountains, Northern New York. We seek candidates employed in academic, industry or government who have a strong interest in undergraduate science education or undergraduate research. A stipend of $4500 and all expenses are paid for participation in a 4 to 5 week summer project. Interested persons should contact Dr. Cathryn A. Manduca, Keck Geology Consortium Coordinator at (507) 646-4424 or e-mail: cmanduca@carleton.edu. Positions are contingent on NSF funding.

COASTAL GEOLOGY AT DUKE UNIVERSITY

The Earth Science Division of the Nicholas School of Environment at Duke University seeks applications for a tenure-track position in coastal geology to be filled at the assistant or untenured associate professor level at the Durham Campus. The starting date is open, but we hope to fill the position by fall 1997. The successful candidate will hold a Ph.D. degree and will be expected to develop an outstanding research program in his or her specialty and be committed to both undergraduate and graduate teaching (including B.S. M.S. and Ph.D. level geology degree candidates and professional students from the Coastal Environmental Management Program). The position is broadly defined in terms of specialty and could include nearshore oceanography, coastal processes, Quaternary sedimentology/stratigraphy, geomorphology, nearshore morphodynamics, esturine sedimentology, geologic hazard analysis, and aeolian processes.

Send vitae and names of 3 references to: Chair of the Search Committee, Division of Earth Sciences, Nicholas School of the Environment, Box 90230, Duke University, Durham, NC 27708-0230. All applications received by March 1, 1997, will be guaranteed consideration. Duke University is an Equal Opportunity/Affirmative Action Employer.

Services & Supplies

FOR SALE: CUBAN GEOLOGY BOOK. The IGCP proj.-364 contribution "Cuban Ophiolites and Volcanic Arcs" (254 pp, Miami, 1996) is now available ($20 + $3.50 S&H). It has three chapters: General geology and geophysics, Geology of the ophiolites, Geology of the volcanic arcs. To order a copy send a check or money order payable to Wanda Iturralde, 1300 W 47 Place 216A, Hialeah, FL 33012.

Opportunities for Students

Graduate Opportunities in Geochemistry at the University of New Orleans. The Department of Geology and Geophysics invites applicants for graduate research assistantships in petrology and geochemistry. Research projects include: volcanologic, petrologic, and geochemical studies in the Central American Arc; geochemistry and metamorphism of ultramafics; and crustal evolution. For further information regarding this program please contact Dr. Kathleen Johnson at (504) 280-6792 or e-mail: kjohnson@geology.uno.edu. For general information on other graduate programs contact the Graduate Coordinator, Department of Geology and Geophysics, University of New Orleans, New Orleans, LA 70148. Completed applications must be received by March 1, 1997.

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

NASA Planetary Biology Internships. The Marine Biological Laboratory, Woods Hole, Massachusetts, invites applications from graduate students and seniors accepted to graduate programs for awards of $2200 plus travel to participate in research at NASA centers and collaborating institutions for approximately 8 weeks. Typical intern programs include: global ecology, remote sensing, microbial ecology, biomineralization, and origin and early evolution of life. Application deadline: 1 March 1997. For information/applications, contact: Michael Dolan, Planetary Biology Internship, Department of Biology, Box 3-5810, University of Massachusetts, Amherst, MA 01003-5810. Email: pbi@bio.umass.edu. Tel (413) 545-3223. An Equal Opportunity/Affirmative Action Employer.

The Keck Geology Consortium Undergraduate Research Opportunities is seeking undergraduate geoscience students to participate in its summer research program. Junior level students who have declared a geology major are invited to apply for any of six projects involving four weeks of summer research followed by a term or year of independent study at the student's home institution. Students receive a stipend of $1200 and expenses. All students must have a faculty sponsor who agrees to supervise the student's work at the home institution. Information and application materials are available at www.carleton.edu/curricular/GEOL/resource/keck/keck.html, or from Dr. Cathryn A. Manduca, Keck Geology Consortium Coordinator at (507) 646-4425, or e-mail: cmanduca@carleton.edu. Student selection will begin Feb. 9. Positions contingent on NSF funding. **Undergraduate Research Opportunities for Students of Color.** The Keck Geology Consortium is seeking undergraduate African American, Native American, Hispanic, or Native Pacific Islander geoscience students to participate in its summer research program. Sophomore students who have completed at least one geology course are invited to apply for five weeks of research in Virginia or Massachusetts. Junior students who have declared a geology major are invited to apply for any of six projects involving four weeks of summer research followed by term or year of independent study at the student's home institution. Students receive a stipend of $1200 and expenses. All students must have a faculty sponsor who agrees to supervise the student's work at the home institution. Information and application materials are available at www.carleton.edu/curricular/GEOL/resource/keck/keck.html or from Dr. Cathryn A. Manduca, Keck Geology Consortium Coordinator at (507) 646-4425, or e-mail: cmanduca@carleton.edu. Student selection will begin Feb. 9.

Petroleum System Modeling Research Assistant. The Department of Geology at the University of Alabama seeks applicants for a graduate research assistantship at the Ph.D. level in petroleum system modeling. Previous experience in subsurface 3-D geologic modeling is preferred. The Department is housed in a state-of-the-art research complex equipped with the required analytical and computer capabilities to perform innovative basin analysis studies. Twelve-month stipend is $15,000 and tuition is paid by the University.

A letter of interest should be sent to the Graduate Research Committee, Box 870338, Department of Geology, University of Alabama, Tuscaloosa, Alabama 35487 by January 15, 1997. The University of Alabama is an equal opportunity/affirmative action employer.

Geology Has New Co-Editor

Carol Simpson, Boston University, is the newest co-editor of *Geology,* appointed to a three-year term. She succeeds David Fountain, University of Wyoming, whose second term as co-editor ended at the end of 1996. Simpson is working with Editor Lee Kump, Pennsylvania State University.

Simpson, professor and chair of the Boston University Department of Earth Sciences, received undergraduate degrees in chemistry at the Swansea College of Technology in Wales and in geology at the University of Wales; her master's, in geology, at the University of Witwatersrand, South Africa; and her Ph.D., in structural geology, at the Swiss Federal Institute of Technology (ETH), Zurich. She has been a visiting assistant professor at Brown University and Oklahoma State University, assistant and then associate professor at Virginia Polytechnic Institute and State University, associate professor at Johns Hopkins University, and program director for the National Science Foundation Earth Sciences Division Tectonics Program.

As a co-editor of *Geology,* Simpson will handle about 375 manuscripts a year—making decisions about whether newly submitted papers are appropriate for the journal, who would be good reviewers for papers, how to weigh reviews when reviewers disagree on a paper, and other matters related to the scientific content of the submitted papers. Her goals for the three-year term are to strengthen *Geology's* position as the leading journal for rapid publication of short, innovative, earth science articles, and to maintain the high academic standard of published *Geology* articles.

As do the other GSA journal editors, Simpson has a part-time assistant for the editorial office at Boston University. (Note: Authors must submit manuscripts for *Geology* to GSA headquarters, not directly to the co-editors. See the January issue of *Geology* or the GSA Web page, http://www.geosociety.org, for instructions for submitting manuscripts.) ■