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Tectonic Facies in an Archipelago Model of Intra-Plate Orogenesis

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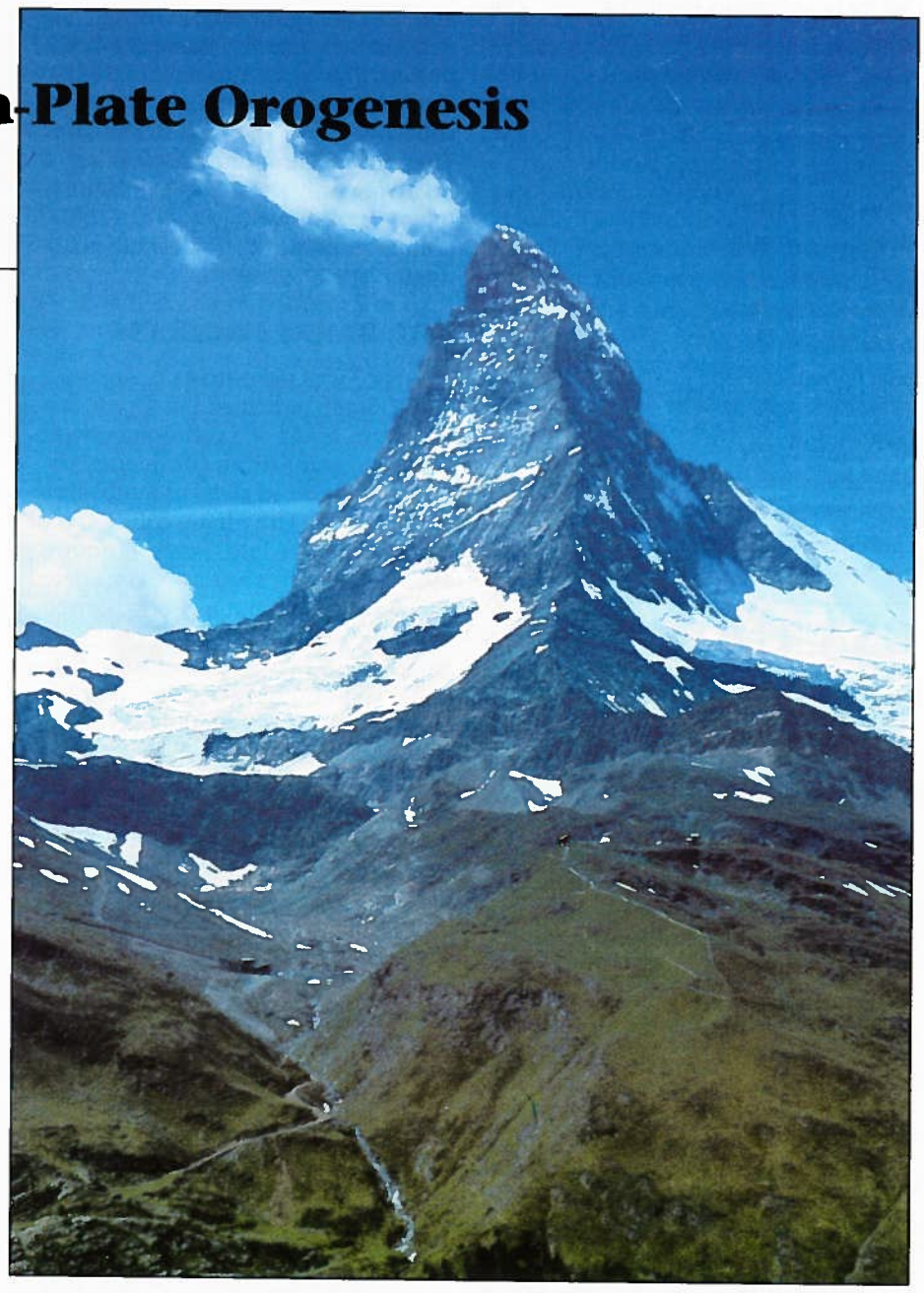

The Matterhorn. The Austroalpine Dent Blanche nappe (upper part) is a fragment of the Apulian plate thrust northward over the Penninic rocks (lower part), which are from the ocean basin that separated the European continent from the Apulian continent in Mesozoic time. Photo by Ueli Briegel, ETH, Zurich.

ABSTRACT

The Alpine units Austides, Pennides, and Helvetides are applicable to designate the basement and cover thrusts of the overriding and underthrust plates in mountains formed by plate collision. These units are not useful in mapping orogenic systems formed by intraplate deformation in back-arc regions. The three tectonic facies of the archipelago model of orogenesis are characterized by their styles of (1) rigid-basement thrusts, (2) mobilized basement-and-cover deformation, and (3) thin-skinned-cover deformation.

INTRODUCTION

The revolutionary new idea of the plate tectonics theory is the postulate of large horizontal displacement of continents and oceans, and a new geological interpretation is the concept of melange, which has been held up as the field evidence of ocean subduction. The theory has retained, however, the classic notion that the precursors of mountains are mobile belts; they were called *geosynclines,* but are now called *active margins*. Terranes outside the mobile belts were once called *cratons*; they are now called *plates*. Mountains were thought to have been formed when cratons were pressed together, by compression or by continental drift, and we now postulate plate displacement and plate collisions. What was a miogeosyncline is now known as a passive margin, and a eugeosyncline is an ophiolite melange. We still think in terms of orogenic phases; flysch continues to be synorogenic and molasse, postorogenic, whereas igneous activities can be pre-, syn-, or postorogenic.

In my efforts during the past 15 years to apply the two-plate model to the geology of China, I have run into difficulties. There are too many melange belts, too many suture zones, and too many plates. The puzzles were resolved after I adopted an actualistic analogue of intraplate deformation in the back-arc region of the southwest Pacific. This experience led me to reexamine the Alpine, and this article is a narrative of my awakening.

TEMPORAL EVOLUTION OF MOUNTAINS

The genesis of mountains, like that of living organisms, has been studied on the basis of comparative anatomy. The approach is to identify the few basic elements in the *Bauplan* (blueprint) for all different individuals. There are the two major kinds of mountains on the surface of Earth: the Tethyan and the circum-Pacific. They seem to be distinctly different, but the geology of Switzerland shows that the Cretaceous Alps underwent the circum-Pacific stage of orogenesis before the postcollisional deformation during the Tertiary Tethyan stage (Hsü and Briegel, 1991). Mountains made by ocean-continent interactions are the precursors of collisional mountains after the intervening ocean is consumed.

The continuous growth of mountains suggests a comparison of their anatomy to living organisms. "Higher" animals are born essentially as they will be. Plants differ from animals in that they undergo fundamental changes during their growth. The seed of a redwood is not only greatly different in size from a fully grown tree, the process of seed germination is quite different from that of a photosynthetic plant. Comparison of the anatomy of mountains to that of animals may have served to perpetuate the classical prejudice that the structures in a mountain chain were formed mainly during its "birthday" (i.e., the paroxysmal phase of an orogeny). Mountains were, however, not made in an orogenic phase. Mountains evolving steadily from the circum-Pacific stage to the Tethyan stage is a process comparable to the growth of a plant, with all its gradual changes from seed germination to full blossom (Hsü, 1989).

THE ALPINE *BAUPLAN* AND TECTONIC UNITS OF STRUCTURAL SUPERPOSITION

The *Bauplan* concept of comparative anatomy is derived from an analysis of architectures. If we overlook the decorative superficiality, the essential elements are the same: buildings have a foundation, floor, walls, ceiling, and roof. There should be windows and doors for most, and chimneys for some. Buildings do not sprout spontaneously from the ground; there is an orderly process of construction. Knowing the indispensability of the vital parts, we could conclude, on the basis of broken tiles in a ruin, where a house once stood. Likewise for a plant, traces of a crown imply the presence of a tree with its stem and root.

The two vital organs in the *Bauplan* of geosynclinal theories were oldland and geosyncline. Mountains were formed when an oldland was thrust on top of a geosyncline (Grabau, 1924; Bucher, 1933). The process is now called *intraplate collision,* or post-collisional deformation. Oldlands such as Appalachia may or may not have survived the earth science revolution, whereas geosynclines are disguised under pseudonyms such as unstable platforms, intracratonic basins, and quasigeosynclines.

The three vital organs in the *Bauplan* of the plate tectonic theories are (1) the motor *(erzeugende Scholle),* (2) the overridden *(überfahrene Zone),* and (3) the escaped *(unbelastete Zone).* Phrased in terms of a two-continents–one-ocean model, the motor is the overriding plate in a continental collision, the overridden are the underthrust and subducted elements, whereas the escaped did escape because

Tectonic *continued on p. 290*

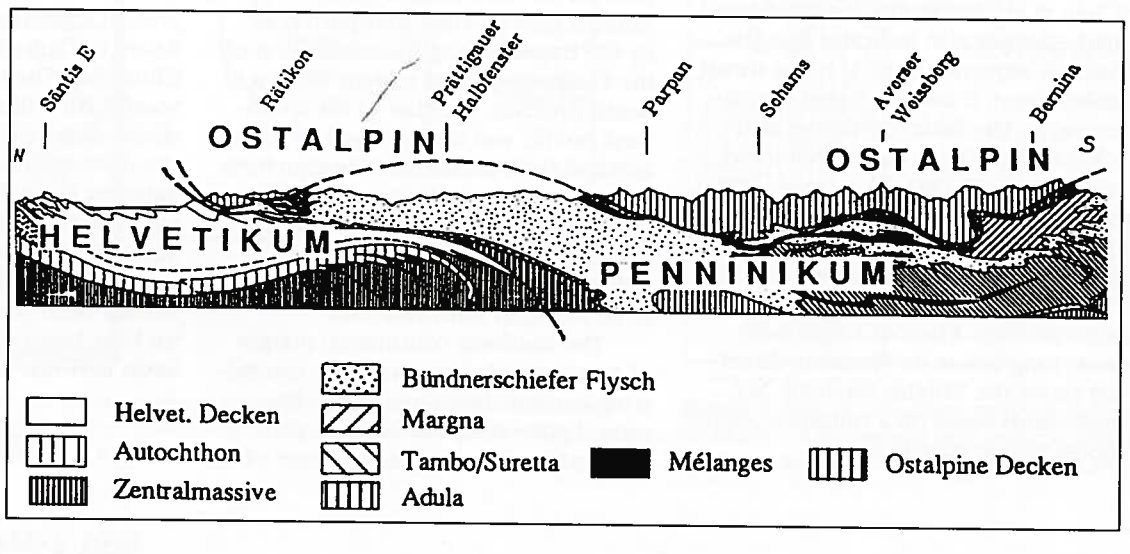

Figure 1. Tectonic units of the Alps; a schematic north-south cross section across eastern Switzerland (after Hsü and Briegel, 1991).

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Tectonic *continued from p. 289*

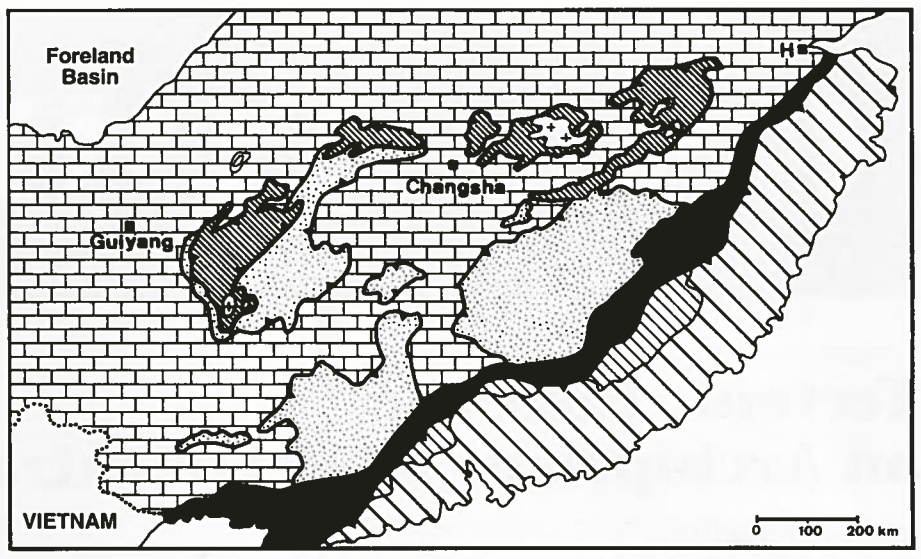
it had been pushed to the foreland by the motor (Suess, 1937; Trümpy, 1960; Şengör and Okurogullari, 1991). This trinity was first recognized in the Alps (Fig. 1). The Austrides (Ostalpin) of rigid-basement nappes are the motor. The Pennides (Penninikum), including ophiolite mélanges, mobilized-basement nappes, *Bündnerschiefer*, and *schistes lustrés* are the overrun elements, and they are characterized by ductile deformation under metamorphic conditions. The escaped elements are the Helvetic, Prealpine, and Flysch nappes, collectively known as the Helvetikum. The style of thin-skinned tectonics, involving only the folding and thrusting of the sedimentary cover, is the dominant mode of the Helvetic deformation (Hsü, 1994).

THE BANXI PROBLEM

The Swiss tectonicists E. Argand and R. Staub described the Alpine orogenesis in terms of a collision between European and African continents; we now use the word *plates* as a substitute for *continents*. The Alpine collision took place during the late Eocene (Trümpy, 1973). The Tethys was once considered a narrow trough, but it is now viewed as a wide expanse of ocean. The paradigm of two-continent (now two-plate) collision has served for more than a century as the ruling theory of the Alpine tectonics. The trinity of Austrides-Pennides-Helvetides (Ostalpin-Penninikum-Helvetikum) was the foundation of the classic theory, and the trinity is held up as verification of plate tectonics.

Armed with this simplistic trinity, I went to work in China. Six tectonic units are recognized, from north to south, in the deformed terranes in south China (Fig. 2): (1) the Yangtze deformed belt, folded Sinian to Mesozoic strata; (2) Proterozoic granite and Banxi melange; (3) the Huanan deformed belt, folded Sinian to Mesozoic strata; (4) Huanan flysch, mainly lower Paleozoic; (5) Huanan metamorphics, Paleozoic and/or Mesozoic metamorphism; and (6) Huanan Precambrian basement and Phanerozoic intrusives.

Applying the Alpine model of two-plate collision, I suggested that the Yangtze and Huanan (units 1 and 3) are the Helvetides; the Banxi melange, the Huanan flysch, and the Huanan metamorphics (unit 2 melange, units 4 and 5) are the Pennides; and the Precambrian rocks (unit 2 granite and unit 6) are the Austrides of the Huanan Alps (Hsü et al., 1990). They should constitute the trinity of the escaped, overrun, and motor elements of the collisional type of mountains. The two-plate interpretation requires that the Banxi be klippes overthrust on top of the Helvetides (Fig. 2) and that they be metamorphosed and deformed during the Mesozoic. Field work and subsurface and seismic data have indicated that the Banxi melange is indeed overthrust above the Yangtze carbonate terrane (Chen et al., 1993). On the other hand, field evidence also indicates that the Huanan sequence (unit 3) is not thrust under Banxi; it overlies Banxi unconformably. The Banxi ophiolites and eclogites have been dated radiometrically at 850–950 Ma (Zhou et al., 1992), suggesting that the Banxi melange was an accretionary wedge formed by subduction prior to the Mesozoic collision. This melange is at least in part Precambrian and was a part of a rigid basement long before its Mesozoic thrusting above the Yangtze foreland. My predictions based on a simplistic Alpine model were contradicted.



Helvetides of S. China
- Foreland basin
- Sinian - Triassic

Pennides of S. China
- Banxi klippes
- Flysch klippes
- Metamorphic belt

Austrides of S. China
- Cover
- Basement
- Proterozoic granite klippes

Figure 2. A two-plate model for the tectonics of south China. The hypothesis that the Banxi rocks are klippes of Mesozoic mélanges has been falsified by observations that the Banxi is the Precambrian basement of an island arc overlain by a Paleozoic sedimentary cover.

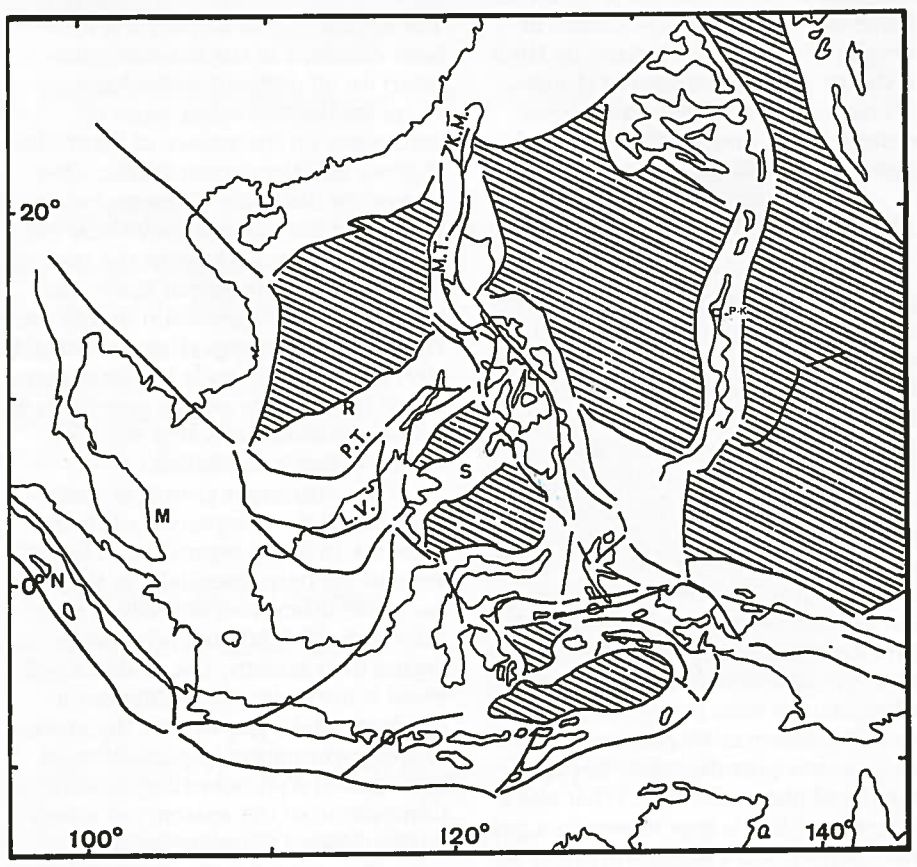


Figure 3. Back-arc basins and sutures in Southeast Asia. M.T.—Manila Trench, K.M.—Kenting melange, L.V.—Lupar Valley melange, P.T.—Palawan Trough, S—Sulu Ridge, R—Reed Bark, M—Malay Peninsula.

WEST PACIFIC MODEL OF OROGENESIS AND DEFINITION OF TECTONIC FACIES

While serving on the JOIDES Tectonics Panel in the late 1980s, Ian Dalziel introduced me to the concept of the back-arc basin collapse. He pointed out that there is more to Andean geology than that portrayed by the hypothesis of the subduction of the Pacific plate. The eastern margin of South America, like that of the southwest Pacific, was once fringed by island arcs and back-arc basins. The structures of the southern Andes are demonstrably formed by the elimination of the basins by arc-arc collisions (Dalziel, 1981), and the actualistic analogue is to be found in southeast Asia.

The southern continental margin of Asia is not the plate margin. Considering back-arc basin intra-plate features, I place the plate boundary of Asia south of the Banda-Sunda arc of Indonesia and east of the Mariana arc of the west Pacific (Fig. 3). Between the frontal arcs and the mainland are numerous remnant arcs and basins. Some of the basins are still active centers of seafloor spreading, such as the Mariana Basin behind the Mariana arc. Some are no longer active, such as the West Philippine Basin and the Malaysian Basin. Some are actively being pressed together, such as the Celebes Basin, the Sulu Basin, and the South China Sea. The lithosphere of the South China Basin, for example, is thrust under the Manila Trench, and the northern tip of the basin is eliminated by the collision of mainland Asia with the Philippine arc along the Kenting melange zone of the Taiwan Central Range. Some back-arc basins have already been completely eliminated by back-arc basin collapse. The back-arc basin between what was once an active

Tectonic *continued on p. 292*

FORUM

Bruce F. Molnia

Forum is a regular feature of *GSA Today* in which many sides of an issue or question of interest to the geological community are explored. Each Forum presentation consists of an informative, neutral introduction to the month's topic followed by two or more opposing views concerning the Forum topic. Selection of future Forum topics and participants is the responsibility of the Forum Editor. Suggestions for future Forum topics are welcome and should be sent to: Bruce F. Molnia, Forum Editor, U.S. Geological Survey, 917 National Center, Reston, VA 22092, (703) 648-4120, fax 703-648-4227.

Effects of Potential Geothermal Development on the Thermal Features of Yellowstone National Park—Part 1

PERSPECTIVE 1: Introduction

Bruce F. Molnia, Forum Editor

Stewardship of the U.S. public lands is a primary responsibility of the Department of Interior. The impact of the multiple use of some of these DOI lands frequently becomes an issue, especially when environmental protection or preservation of unique resources may be jeopardized by a planned use. Federal decision-makers have increasingly relied on the scientific community to provide them with input that will result in educated and defendable decisions. This forum focuses on a multiple-use issue where qualified scientists used the available technical information and reached different answers about the merits of a proposed geothermal activity near Yellowstone National Park (Yellowstone). This perspective and the four perspectives that follow summarize the background, scientific data and findings, interpretations of these data, and use of these data in the decision-making process.

The completion in 1986 of a 140-m-deep well that produced water at temperatures near 60 °C on private land north of Yellowstone reactivated a controversy over the potential effects of geothermal development on the thermal features of Yellowstone (Fig. 1). The well was drilled by the Church Universal and Triumphant within the Corwin Springs Known Geothermal Resources Area (Corwin Springs area), a region designated by the Bureau of Land Management as having potential for geothermal development on the basis of active hot springs, travertine deposits, and the prevalence of extensional faulting. The church's geothermal well is located immediately across the Yellowstone River from La Duke Hot Spring, which, along with numerous unnamed springs and seeps, flows into the Yellowstone River ~3 km north of the national park boundary. Thermal water also issues from Bear Creek Springs near the southeastern end of the Corwin Springs area. The nearest known thermal springs inside Yellowstone occur in the vicinity of Mammoth Hot Springs, a major tourist attraction, ~12–15 km southeast of the Church well. Concerns expressed by the U.S. National Park Service and other groups and individuals over possible effects of the sustained use of the well on the thermal features of Yellowstone led in 1988 to a temporary moratorium on geothermal development in the region and a congressionally mandated study of geothermal systems in this region by the U.S. Geological Survey.

Concerns had been expressed in the early 1980s over potential geothermal development in the vicinity of the Island Park caldera, located outside the southwestern boundary of Yellowstone (Fig. 2). In 1984, a similar, but permanent moratorium was placed on geothermal leasing on federal lands within the Island Park Geothermal Area. This area, which includes the Island Park caldera, extends to distances as great as 48 km from the national park boundary, conforming to existing national forest and Bureau of Land Management land boundaries. To date, no geothermal wells have been drilled in the Island Park Geothermal Area, and the only evidence for geothermal resources within it is the existence of the Pleistocene-age Island Park caldera.

U.S. Geological Survey investigations of geothermal systems in the Corwin Springs area and adjacent lands are described in the eight chapters of the Survey's Water Resources Investigations Report 91-4052, "Effects of potential geothermal development in the Corwin Springs Known Geothermal Resource Area, Montana, on the thermal features of Yellowstone National Park," edited by M. L. Sorey (referred to throughout this Forum as WRIR 91-4052).

WRIR 91-4052 concluded that limited geothermal development in the vicinity of La Duke Hot Spring posed no discernible risk of adverse effects to Yellowstone's thermal springs. The basis for this conclusion is explained in Perspective 2 by Sorey, Kharaka, and Evans. Former Secretary of Interior Manuel Lujan used the results of this study to formulate recommendations to Congress regarding limited use of wells in this part of the Corwin Springs area. Perspective 3 by Friedman challenges the validity of these interpretations. Rebuttals and closing comments about both sides of the scientific argument are presented in Perspectives 4 and 5 in next month's *GSA Today*.

Congressional hearings were held in 1991 to review WRIR 91-4052, Secretary Lujan's recommendations, an unpublished impact analysis prepared by the National Park Service, and testimony from numerous groups and individuals. The Park Service analysis concluded that geothermal wells should be banned from the Corwin Springs area and that only surface diversion of water from La Duke Hot Spring be allowed. This conclusion was based on an opinion that there was sufficient probability of a connection between geothermal systems in Yellowstone and those in the Corwin Springs area to warrant extreme caution and a desire to avoid setting a precedent of allowing any geothermal wells to be used near Yellowstone's boundaries. The outcome of the 1991 Congressional hearings was the first of several versions of legislation referred to as the Old Faithful Protection Act.

In the just-completed 103rd Congress, the latest version again failed. HR 1137 was passed by the House of Representatives in 1993, but no action was taken by the Senate. HR 1137 defined a geothermal well as one that produces water at temperatures greater than 15 °C and restricted the use of such wells on public and private lands within a 24–48 km buffer zone around Yellowstone. This buffer, referred to as the Yellowstone Protection Area, is shown in Figure 2. HR 1137 would have banned the use of geothermal wells within the Yellowstone Protection Area (including the Island Park Geothermal area) unless they have been permitted through state legislation that has been approved by the secretary of the Department of Interior. Only Montana has adopted approved legislation in the form of a Reserved Water Rights Compact. Correspondingly, the boundary of the Yellowstone Protection Area in Montana matches that of the Controlled Groundwater Area defined in the Montana legislation.

Forum *continued on p. 296*

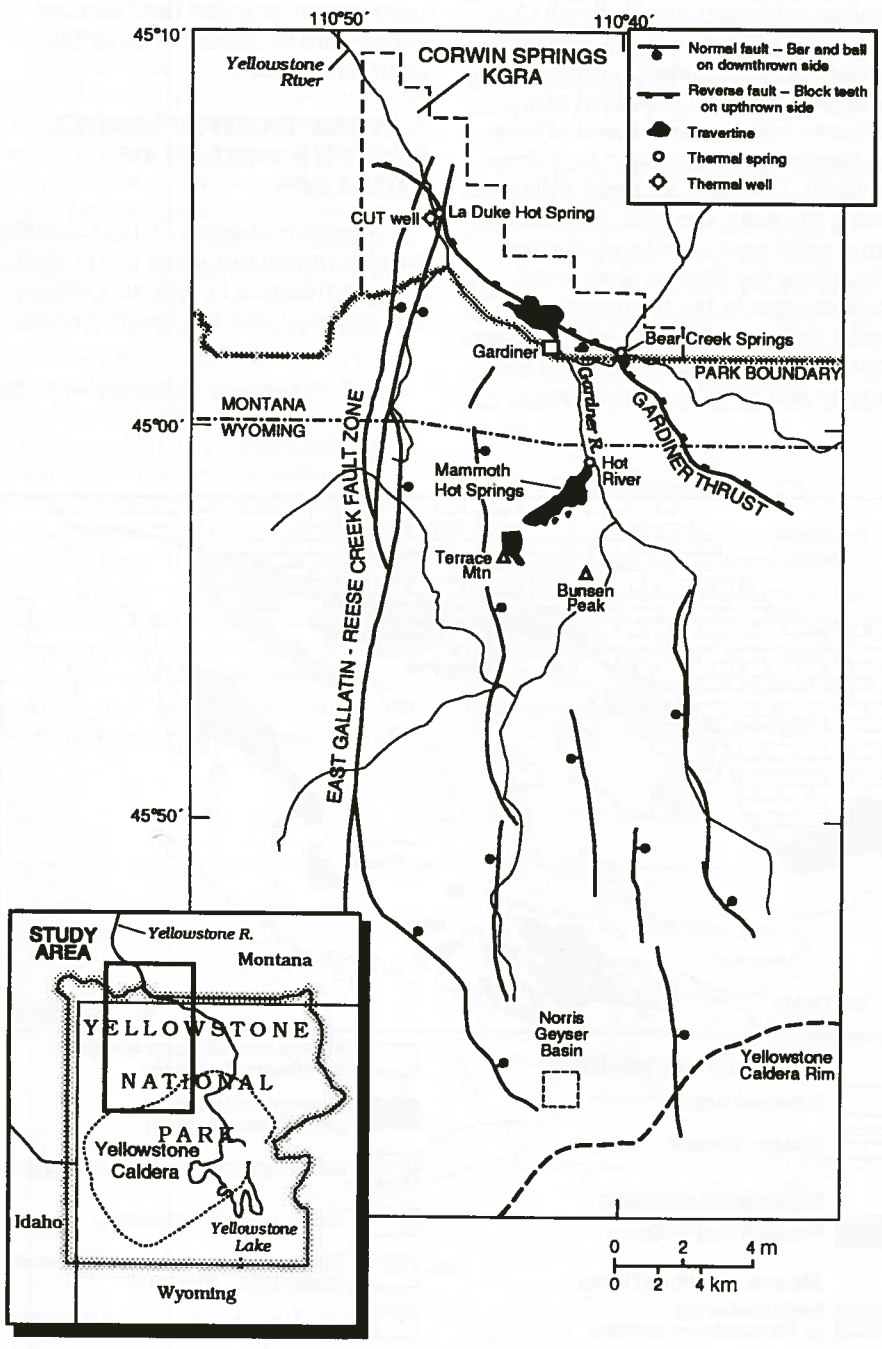


Figure 1. Map of U.S. Geological Survey study area in and adjacent to Yellowstone National Park showing locations of Mammoth Hot Springs, Corwin Springs Known Geothermal Resources Area, and other features referred to in forum articles.

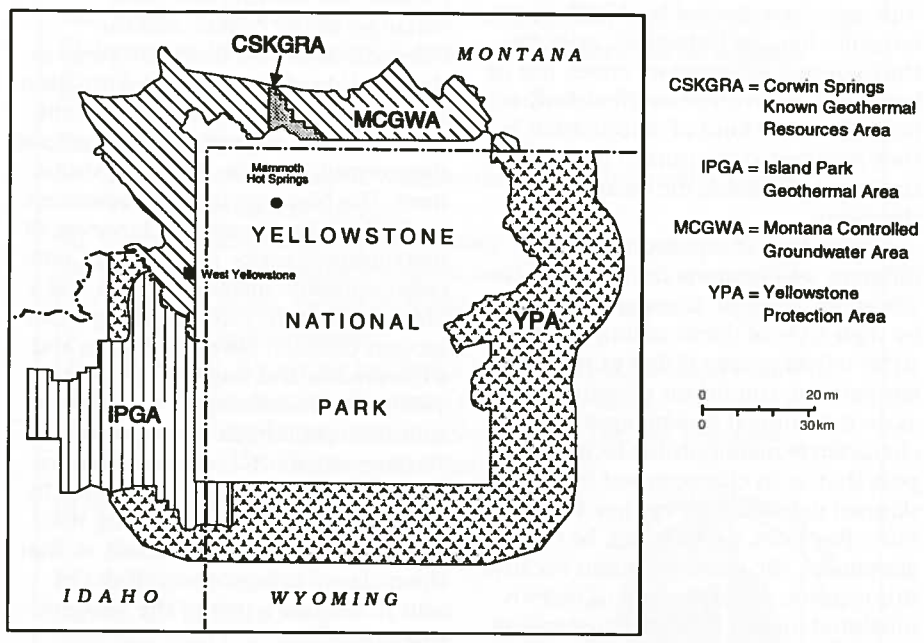


Figure 2. Map of Yellowstone National Park and surrounding areas designated for restriction or prohibition of geothermal wells under existing state legislation in Montana and proposed federal legislation known as the Old Faithful Protection Act of 1994.

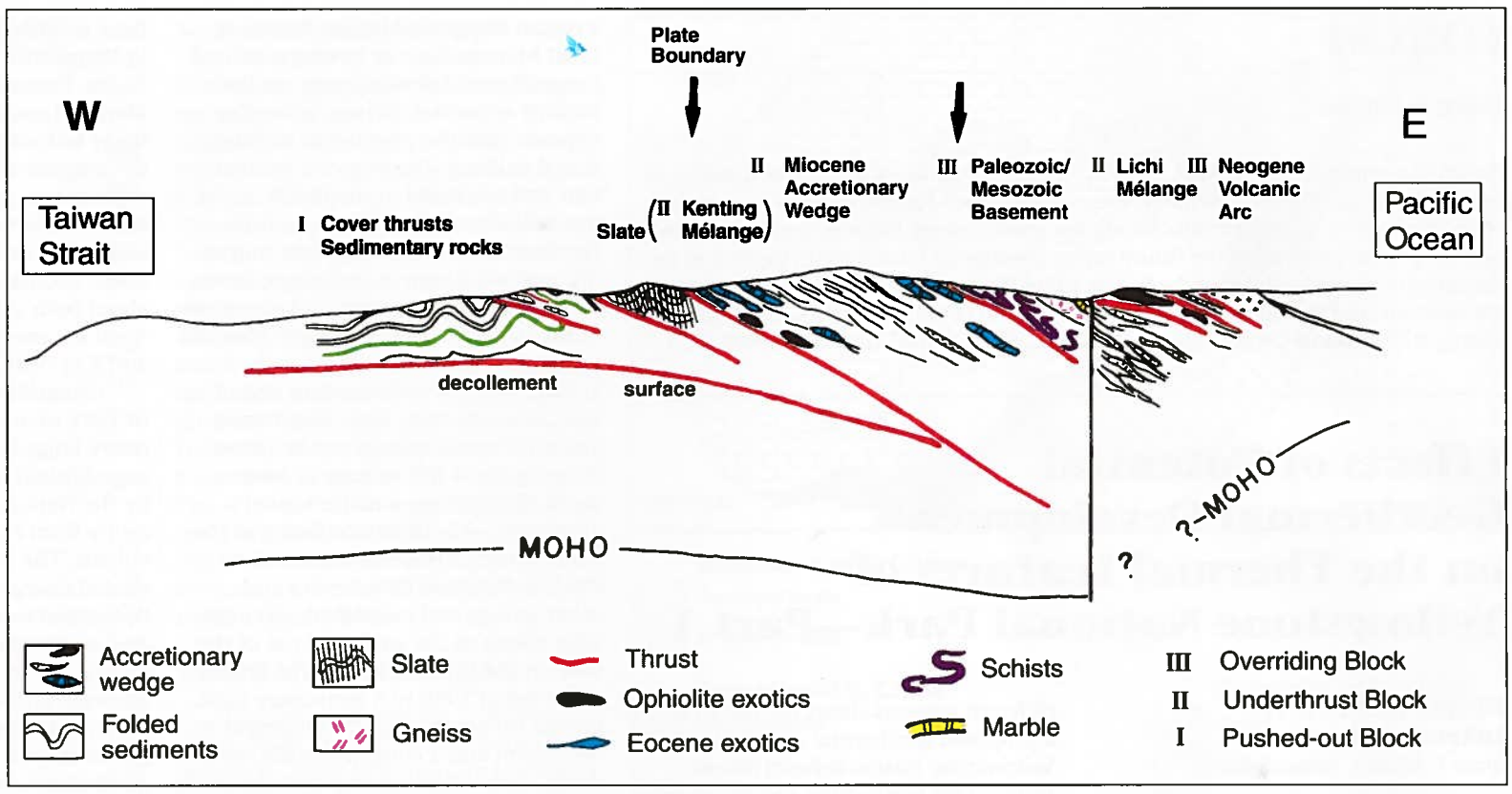


Figure 4. Tectonic units of Taiwan; a west-east schematic cross section across the island.

Tectonic *continued from p. 290*

volcanic arc in southern Borneo and a remnant nonvolcanic arc in Sarawak was, for example, a Cretaceous and Paleogene basin, and the basin was consumed by an arc-arc collision in the late Eocene marked by the suture of the Lupar Valley melange. The Palawan Trough is another collapsed back-arc basin.

Between back-arc basins are the remnant arcs, such as the Palau-Kyushu Ridge between the West Philippine and Parece Vela Basins, the Sulu Ridge between the Sulu and Celebes basins, and the Reed Bank between the South China Basin and the Palawan Trough. The sedimentary sequences on top of subsiding remnant arcs are similar to those on passive margins.

The terms Austrides, Pennides, and Helvetides are useful indicators of structural superposition within the framework of a two-plate model. The trinity of terms is almost useless where there has been more than one collision; the Austride sedimentary cover of an overriding element of one arc-arc collision may be the Helvetide or the escaped of the next. Another flaw of the nomenclature lies in the supposition that the style of deformation of each unit has a one-to-one correspondence to its tectonic superposition. The Helvetides in the foreland deformed belt of the Alps are the escaped structures, and the Austrides are the overriding structures. However, Austrides, such as the nappes of the North Limestone Alps, are characterized by décollement tectonics like the Helvetides; only the thin-skinned sedimentary cover, not its basement, is involved in the deformation. The same kind of deformation is thus manifested by units in different structural positions, the escaped and the motor.

I was thus compelled to select a different set of criteria for tectonic classification. Tectonic facies are definable by their style of deformation, and the styles reflect grossly different pressure-temperature conditions of deformation, as do the mineral assemblages that characterize metamorphic facies. I propose that units characterized by thin-skinned deformation, be they Helvetides, Pennides, or Austrides, be called *alemanides*; the name is chosen because this tectonic style is typical of regions inhabited mainly by German-speaking Swiss, or descendents of the Alemann people. Units characterized by ductile deformation under various metamorphic conditions, such as *schistes lustrés* and ophiolite melanges, are called *celtides*; the name is chosen because this deformation style is typical of the Pennine Alps of western Switzerland, where the French-speaking Swiss had a Celtic heritage. The Pennides are not the only celtides in the Alps; those Austrides that have been underthrust (i.e., overrun) and metamorphosed are also celtides. Units characterized by rigid-basement thrusting are called *rhaetides*; the name is chosen because these nappes are present mainly in southeastern Switzerland, where the inhabitants claim a Rhaetic ancestry. The rhaetides are commonly motor structures or Austrides, but autochthonous or parautochthonous massifs are also rhaetides. The tectonic facies alemanide, celtide, and rhaetide are thus units descriptive of a style of deformation, and they can be used to describe tectonic units that are formed by any combination of continent-continent, arc-continent, or arc-arc collisions, regardless of their tectonic superposition. In areas of repeated deformation, rocks formed by an earlier ductile deformation (celtides) may have later been deformed by rigid-basement thrusting; they are the rhaetides of the second generation of deformation.

WEST PACIFIC MODEL FOR THE GEOLOGY OF CHINA

In analyzing the Tertiary geology of Taiwan, the western foreland fold belt is easily recognized as the alemanide, the Kenting and Lichi melanges as the celtide, and the Paleozoic-Mesozoic basement rocks as the rhaetide of a Neogene deformation (Lu and Hsü, 1992); the three tectonic facies are also, respectively, the escaped, the overrun, and the motoring structures. The Neogene rhaetide basement (unit III of Fig. 4) consists, however, of metamorphic rocks, including a Cretaceous ophiolite melange, which was a Mesozoic celtide, formed during a Cretaceous collision between Eurasia and a Gondwanaland fragment (Hsü et al., 1990). This metamorphic terrane was split off from Eurasia during the early Tertiary, when it was the basement of an island arc. It was then deformed by rigid-basement thrusting during the collision of the arc and Eurasia, so that the melange (a Mesozoic celtide) in unit III became a part of the Neogene rhaetide.

The Taiwan example illustrates that the functional unity of the same object may have changed with time. Our failure to recognize that an earlier celtide has become the rhaetide of a later deformation was the stumbling block in our interpretation of the geology of South China. We had to abandon our assumption of a Mesozoic age for the Banxi deformation; the ocean lithosphere that was subducted to form the Banxi accretionary wedge is Precambrian.

The Banxi is not a group of formations; the melange consists of rocks of different origins separated by shear surfaces. The three main components of the Banxi are (1) ophiolites and high-pressure metamorphic rocks, (2) calc-alkaline volcanics, and (3) flysch (Xu et al., 1993). The Banxi was a celtide during the Precambrian, but those rocks were the rigid basement of a Paleozoic remnant arc separated from the Yangtze passive margin by a deep-sea basin. This back-arc basin collapsed during the early Mesozoic when the Banxi rocks were overthrust as rhaetides above the Yangtze alemanides. The melanges in the Nanpanjiang region include sediments on the ocean crust of a back-arc basin between the Yangtze and Banxi arcs, and they became a celtide when the two arcs collided (Fig. 5).

A trinity of Paleozoic alemanides, celtides, and rhaetides is recognizable south of the Banxi belt. They include (1) the thin-skinned deformation of the lower Paleozoic sedimentary cover of the Banxi arc, (2) the accretionary wedge of the lower Paleozoic flysch and metamorphics under the Huanan arc, and (3) the Precambrian basement of the Huanan arc and its lower Paleozoic sedimentary cover. The three units of alemanide, celtide, and rhaetide were formed prior to and during the mid-Paleozoic suturing of the Banxi and Huanan arcs, and they are now buried under a neo-autochthonous sedimentary cover.

A WEST PACIFIC MODEL FOR THE ORIGIN OF THE ALPS

Argand postulated in 1911 that the Tethyan mountains owed their origin to the collision of Europe and Africa and supposed that the Mediterranean

Tectonic *continued on p. 293*

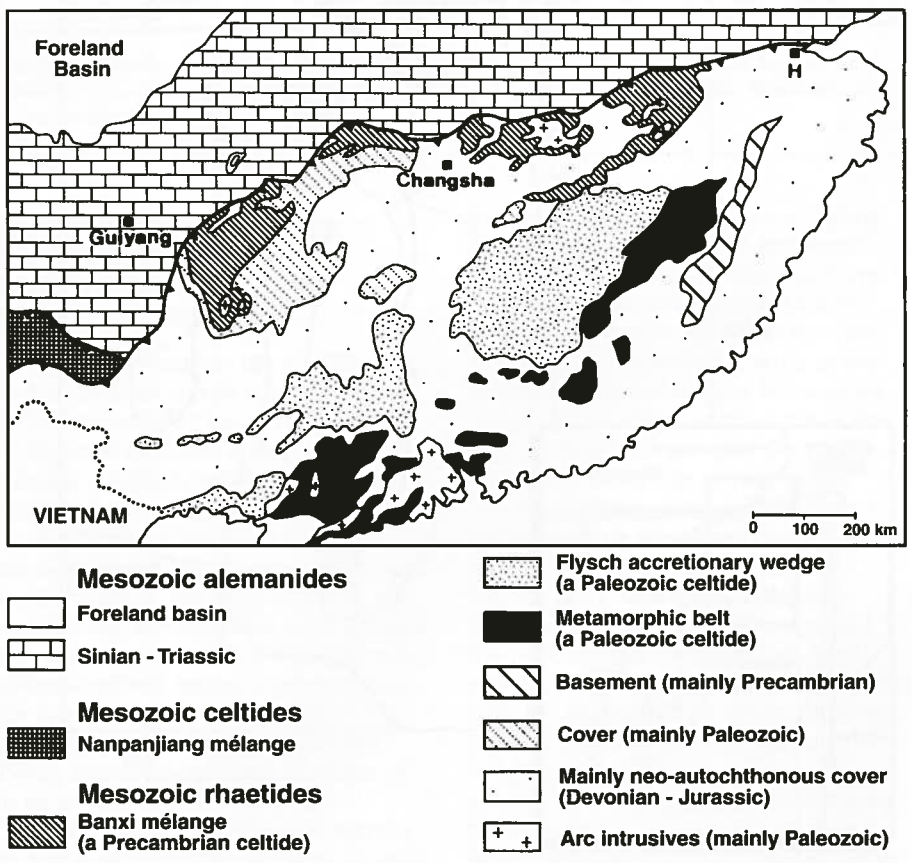


Figure 5. An archipelago model as the working hypothesis to interpret the tectonics of South China.

Tectonic *continued*

basins did not come into existence until after the Eocene Alpine collision. Placing the north boundary of the African plate along the Tethyan suture, Italy and the Balkans are now considered a North African promontory and the Mediterranean basins, holes in the African plate. The relative position of Europe and Africa has been determined on the basis of interpreting the magnetic lineations under the Atlantic seafloor. The displacement was largely left-lateral from 180 to 90 Ma, and there has been a counterclockwise rotation since then (Dewey et al., 1973; see also Fig. 6). A two-plate scheme has not been an adequate model to interpret European geology, and the existence of numerous microcontinents between Europe and Africa has been assumed.

The key to understanding the geology of the Alps is perhaps a belated recognition that the southeastern European margin was an Andean type of magmatic arc in Permian time. This northern margin of the Paleotethys ocean was changed during the Mesozoic into an island-arc type of active margin. There should thus have been an outer volcanic arc between the European continent and the open ocean near the western terminus of the Panthalassa.

The existence of a pre–middle Miocene arc-trench system, buried under the Mediterranean Ridge, is suggested by geophysical evidence (Hsü, 1994). Apparently the southern active margin of Europe extended westward, and the plate boundary between Europe and Africa was a transform margin. This transform fault is now buried under the shelf sediments of the western Mediterranean or under the Numidian flysch of North Africa.

The orogenesis of Southeast Asia, except that of Timor, was not caused by the collision of Asia and Australia; the two continents have not collided yet except in Timor. Likewise, the origin of the Tethyan mountains cannot have been related to a collision of the European and African continents, because the collision has not yet taken place. The active margin of eastern Europe (south of Crete) is still separated from the passive margin of Africa by the Levantine Sea, and the passive margin of continental Europe (north of the Balearic and Tyrrhenian back-arc basins) is still separated from the transform margin of Africa by the western Mediterranean. Buried under the Tertiary sediments of the Mediterranean Ridge is the outer magmatic arc of the European plate, equivalent to the Mariana-Sunda-Banda arcs of Asia. The Mesozoic and Tertiary Paleotethys and Neotethys were marginal seas, and the Tethyan deformation can only have resulted from arc-continent or arc-arc collisions within the European plate, north of its island-arc margin. The Alpine deformation is a manifestation of the collapse of the Piedmont back-arc basin. Other Tethyan mountains, such as the Pyrenees, Austrian Alps, Apennines, Carpathians, Dinarides, Hellenides, Taurides, and Troodos, have likewise been formed by back-arc basin collapse. Small areas underlain by ocean crust in southern Europe, such as the Caspian Sea, Black Sea, Antalya Basin, Rhodos Basin, and Ionian Basin, are relict-back-arc basins; they owed their origin to back-arc seafloor spreading during the Mesozoic, and they have not yet been completely eliminated by arc-arc collisions.

SUMMARY

Structural geologists have always known that lithospheric plates are not rigid. The geology of the west Pacific is an excellent demonstration that the zone of orogenic strain is not limited to a plate margin. Intraplate deformation causes the orogenesis that eliminates back-arc basins, thereby causing arc-continent or arc-arc collisions. Whereas I recognize the many accretionary complexes in the geological record of Asia, I cannot subscribe to the hypothesis of Şengör and Okurogullari (1991), that continents have grown mainly by forearc accretions. Şengör and I visited eastern Tibet recently to examine the Paleotethyan suture zone between Eurasia and Gondwanaland. We encountered evidence of numerous Precambrian or Paleozoic terranes in the great pile of the Triassic accretionary complex on the southwest fringe of Eurasia. The existence of several remnant arcs with Precambrian-Paleozoic basement was sufficient to convince Şengör of the role of back-arc accretion in the Phanerozoic growth of Asia.

I express my wonder that the precursors of mountains are not mobile *belts*. Mountain chains are linear features, but tectonically active back-arc regions, such as the southwest Pacific today, may originally have been wider than they are long. The collapse of numerous back-arc basins explains the fact that ophiolite sutures rarely occur singly.

ACKNOWLEDGMENTS

This paper is an outgrowth of a Sino-Swiss project on the tectonic facies of China. I am indebted to many Chinese colleagues, especially Sun Shu, Wang Qincheng, and Chen Haihong of the Chinese Academy of Sciences, for their cooperation.

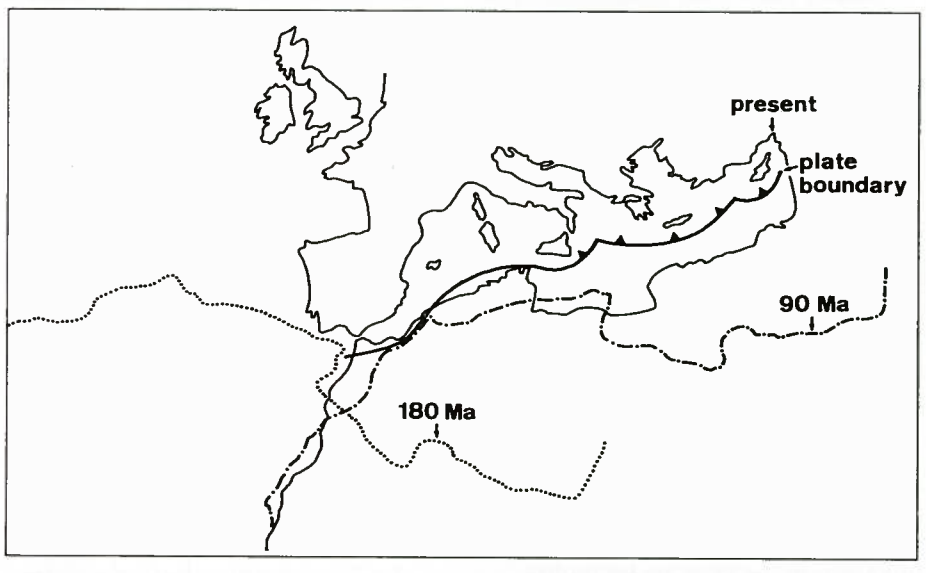


Figure 6. Displacement of the African plate relative to Europe during the past 180 Ma.

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APPLICATION OF GEOSCIENCES TO DECISION MAKING

1995 U.S. Geological Survey McKelvey Forum
Washington, D.C., February 13–16, 1995

ISSUES:

- What are the energy resources of the future based on scientific, technologic, economic, environmental, and sociopolitical factors?
- How does the natural occurrence of oil, gas, and coal impact the atmosphere, water quality, and climate changes?
- What are the environmental effects of energy resource development?
- How is geological information used in formulating regulatory policy?

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Panel Members:
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Mr. Daniel Becker, Chief, Global Warming and Energy Program, Sierra Club
Mr. Michael German, Senior Vice President, American Gas Association
Gen. Richard Lawson, President, National Coal Association
Dr. Jeremy Leggett, Greenpeace
Dr. Dale Nesbitt, Economist and Senior Vice President, Decision Focus, Inc.
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Fables for Our Times: How Firma Is Terra?

Chuck Drake, Dartmouth College, Hanover, New Hampshire

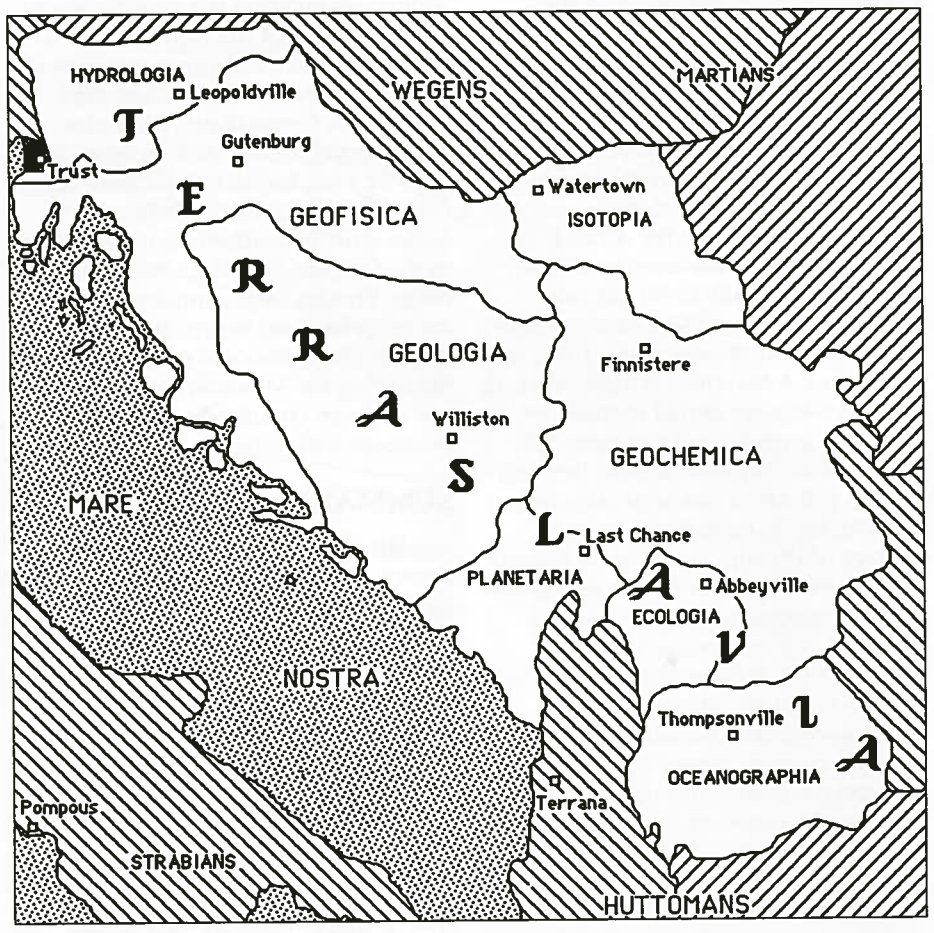
Once upon a time, on the shores of the Mare Nostra, the inhabitants dwelt in small bands, sustaining themselves by hunting and gathering and clothing themselves in the skins of animals they had slain. They worshipped pagan gods, most of which were personifications of natural phenomena. As time passed and they became more numerous, they began to practice agriculture and to maintain order, to protect their land from invaders, and to provide services for which a need was perceived, and they organized themselves into a single country, Terraslavia.

There were the natural tensions to be expected among diverse groups with different myths, rituals, and cultures, but in general the peoples remained surly, but not mutinous. Gradually, through the influence of their sometimes friendly, sometimes hostile neighbors, they were converted from their original animistic religions to a new one which had a single, all-powerful God who had created the Earth and all living things in the time of their earliest ancestors. Curious objects in the rocks of the area, which bore some resemblance to living creatures, were taken as either examples of failed experiments by the Great Creator or possibly creatures produced in a moment of capriciousness and then discarded when God created humanity, the ultimate product of inventive skills.

Then they were invaded. The neighboring Huttoman people, followers of a new prophet, rose to power and invaded the area, sweeping aside old cultures and religions and imposing new ones. Some local inhabitants, particularly those now inhabiting Geologia, adopted the new religion with ease and grace; others resisted and were put to the sword or driven to outlying provinces. The new God was eternal—no sign of a beginning, no prospect of an end—and the curious objects in the rocks were recognized as the remains of organisms no longer living and useful for measuring relative time in the distant past.

The people of Geologia were strong and spirited and, with the help of the Huttomans, put down their primitive neighbors in Geofisica and Geochemica as well as in the satellite provinces associated with them. The Geochemicans were too weak at that time to offer much resistance, but the Geofisicans offered battle on several fronts, arguing that the Geologican estimates of time were ridiculously long and that the comforting permanence of the continents as God had created them was questionable. They maintained these fundamental beliefs and reached a stalemate with the Huttomans.

Then there was another invasion, this time by barbarians from the north. The Wegens, as they were called, had developed a technologically advanced civilization and were naturally drawn to the numerically literate Geofisicans, one of whose prophets had advanced the creed, "When you can measure what you are speaking about and express it in numbers, you know something about it. But when you cannot—your knowledge is of meagre and unsatisfactory kind." Terraslavian disciples of this creed developed revolutionary ideas about the effect of variations in the Earth's orbit on climate and about the separation of the outer crust of the Earth and the underlying mantle. The leader of the invaders even had the temerity to suggest that the Earth was not as God had made it and that the continents had moved about through time. This heretical idea was ruthlessly purged by the Geologians, and those who persisted in promulgating it were summarily burned at the stake. It is curious that the Ph.D. thesis of the Wegen leader who came up with this model was a recalculation of the Alphonsine Tables—tables that described the motions of the planets in an Earth-centered solar system. This concept had been rejected even by the Geofisicans centuries earlier, although



it remained part of the catechism of some sects.

After being rebuffed, the Geofisicans secretly joined forces with the inhabitants of Oceanografia, and the two groups applied their joint efforts to exploring Mare Librum, the great oceans of the world. Here they would not be harassed by the Geologians and could work in peace. Their efforts bore fruit, and with the ammunition gathered during these explorations they launched a campaign which would bring the Geologians to their knees and force them to embrace the new faith of moving continents. The Geologians fought bravely but were soundly defeated in the Battle of the Subduction Zone, and most accepted the new gospel rather than face the rack or the sword.

But with victory, the Geofisicans then had to govern. As is often the case with those who excel at revolutionary warfare, they had only modest talent and little stomach for governing. Thus they hung out in the coffee shops of Gutenburg, their capital, told war stories, and debated about the nature of the Earth's interior. The Oceanografians were in even worse turmoil and, lacking leadership, prowled the saloons of their first city, Thompsonville, searching for truth at the bottom of a bottle.

Into the vacuum rode the Geochemicans, who saw in this indecision an opportunity to impose their creed on the others and to seize the high ground by force. Waiting until the Geologians declared themselves

Fable *continued on p. 295*

Penrose Conference Scheduled

Tectonic Development of the Canada Basin, Arctic Ocean

September 28–October 3, 1995

A Geological Society of America Penrose Conference concerning the tectonic development of the Canada Basin and surrounding regions will be held September 28–October 3, 1995, in Banff, Alberta, in the Canadian Rockies. We hope that this international conference will receive partial financial support from the National Science Foundation. We have some support committed from the Mobil Oil Foundation and hope to obtain additional corporate sponsorship.

This conference will focus on the available data from the Arctic Ocean and surrounding regions that pertain to the paleogeography and tectonic history of this region from Devonian to Eocene time. 1995 is a critical time to hold such a meeting and to bring together the three groups of researchers on arctic geology and geophysics: those studying terrestrial geology and geophysics around the margin of the Arctic Ocean; those working with marine geological and geophysical data; and those compiling and collecting aeromagnetic, aerogravity, and satellite altimeter data. A collective evaluation of these data is essential for deciphering the tectonic development of this remote and difficult-to-access region.

Serious efforts have been made by U.S., Canadian, Russian, German, and Norwegian scientists and oil industry personnel to collect geological and geophysical data in the Arctic Ocean and surrounding regions since the late 1960s, yet we do not fully understand the paleogeographic distribution of the land masses, or the tectonic development of this vast region. This is partly due to lack of data and partly due to lack of easy access to existing data. Efforts are being made to rectify these situations, but a gathering is necessary to discuss the progress we have made and to identify the regions where concentrated collective efforts can be made to analyze existing data and to identify existing data gaps.

The large size of the Arctic Ocean and its environmental conditions make the cost of data collection very high and require that as much remote-sensing data be utilized as possible. Compilations of all available data such as the aeromagnetic data from the Arctic and surrounding regions compiled by the Geological Survey of Canada and the coverage provided by ERS-1 satellite altimeter data are important steps in that direction. The new generation of satellites coming online will also be of great value for both potential field and onshore geologic studies. Finally, with the opening of the Russian scientific community to greater interchange with the Western world, geological and geophysical data that were previously unknown in the West are becoming available. For the first time, land-based and marine data are being linked across the Bering Strait and the Arctic Ocean through international cooperative projects and are focusing on tectonically significant regions of the arctic margin.

While the rotational opening of the Canada Basin about a pivot point near the Mackenzie Delta may currently be favored, there is no agreement at this time as to exactly how this opening operated, how simple or complex it was, what geologic entities rotated, or what the age and duration of the opening might have been. We feel that even if we are unable to come to agreement on the age and detailed tectonic history of the Canada Basin, we will at least be able to determine the extent of the available data, compare its impact on the tectonic models, and perhaps, most importantly, help reach a consensus about what critical problems remain to be solved and how best to solve them.

Participation in the conference will be limited to about 70 people. All interested scientists are encouraged to apply. Attendance for graduate students and

Penrose *continued on p. 295*

Fable *continued from p. 294*

independent of a crumbling Terraslavia, they used the issue of lebensraum for the Geochemicans in Geologia to seize territory and to loot and pillage. This action took the Geofisicans by surprise and, although sworn enemies of the Geochemicans, they also took arms against the Geologians to protect their own interests. Subsequently they had reservations and equivocated, sometimes helping one side, sometimes the other.

Once in control of a territory, the Geochemicans followed the example of earlier conquerers and practiced scientific cleansing, removing the populations that would not accept their whole Earth values for distribution of the elements, who still subscribed to the tenets of the false prophet Darwin on the survival of the fittest rather than more advanced ideas about survival of the luckiest, and who questioned the significance of parts per trillion of some element in the environment. In their capital, Finnistere, they spoke of a Greater Geochemica encompassing most of the former Terraslavia and cleansed of heretical thoughts and false doctrines.

The Geologians sought succor in world opinion and pleaded for assistance from outside, but other countries lacked resolve and would send only a few observers whose mission was to wring their hands and provide information on atrocities to the media. A ban on flying overhead and dropping technical papers on the local population was put into effect, but this did not curb the distribution of such materials by means of artillery and mortar. The Geologians begged to be armed with new ideas, but this plea was denied by the Alliance of Governmental Institutions, perhaps because there were few ideas to offer.

In some of the smaller provinces there was also turmoil. Isotopia joined forces with Geochemica—indeed, they had a common heritage. Oceanografia had an identity crisis and decided to break away from the Geofisicans and to establish themselves as an independent country. It remains to be seen whether this nation is viable. The Planetarians made a nervous peace with Geochemica in the hope that they would be left alone. The Ecologians cowered in fear, waiting until the preoccupation of the Geochemicans with Geologia weakened and attention was turned to their tiny, but economically strong, province. The population held many beliefs that were quite different from those of the Geochemicans and they looked with apprehension at the possibility that these beliefs would be submerged or eliminated if they were incorporated into a Greater Geochemica. The Hydrologians, located far to the north and at least temporarily out of reach of the Geochemicans, seemed safe, although they remained wary.

It is not easy to see what the future will bring. The Geofisicans and Oceanographians are suffering from lack of opportunities, although they appear to be there for those with innovative ideas and flexible agendas. Warfare has sapped the strength of the Geologians, and cultural changes have weakened their will. The economy is poor in Geochemica, due in part to the cost of armaments, while it is strong in Ecologia and Hydrologia, which suggests that the inhabitants of these two provinces should be vigilant lest they be consumed or subsumed.

The nations of the world, remembering the effect of past religious and cultural strife in this area and recognizing the destabilizing influence this strife generates in the world community, developed a number of plans to end the hostilities and bring peace once again to Terraslavia. But none of these plans has proved acceptable to all parties; none of them want to give up their identities or their perceived freedoms to be part of an integrated whole. Thus it seems likely that the small, isolated enclaves will sink into obscurity. Perhaps if they sufficiently decimate each other's populations through internecine warfare they can find peace by reverting to hunting/gathering. Perhaps they will be taken over by neighboring countries with scientifically related populations, and Terraslavia will be but a memory. ■

The trouble with our times is that the future isn't what it used to be.

—Paul Valery

New Bureau of Mines Director Sworn In

Rhea L. Graham, a geologist with a background in environmental consulting and engineering geology, has been sworn in as the 19th director of the U.S. Bureau of Mines. Graham, who has extensive experience in the minerals industry, served as the administrator of the Mining and Minerals Division of the State of New Mexico Energy, Minerals and Natural Resources Department. She also worked as manager of environmental sciences for an Albuquerque-based environmental consulting firm. She is a member of GSA.

Smithsonian Offers Research Fellowships

The Smithsonian Institution research fellowship program for 1995 includes the fields of history of science and technology and earth sciences.

Smithsonian Fellowships are awarded to support independent research in residence at the Smithsonian in association with the research staff and using the institution's resources. Under this program, senior fellowships of three to twelve months, predoctoral and postdoctoral fellowships of three to twelve months, and graduate student fellowships of ten weeks are awarded.

History of science and technology includes engineering, industrial archaeology, mathematics, natural history, physical sciences, and social dimensions of science and technology. The earth sciences subjects include meteoritics, mineralogy, paleobiology, petrology, planetary geology, sedimentology, and volcanology.

The deadline for proposals is *January 15, 1995*. For more information and application forms, write to Smithsonian Institution, Office of Fellowships and Grants, 955 L'Enfant Plaza, Suite 7000, Washington, DC 20560, E-Mail: siofg@sivm.si.edu. Indicate the particular area in which you propose to conduct research and give the dates of degrees received or expected.

Minority Internship Program

Internships, offered through the Office of Fellowships and Grants, are available for students to participate in research and museum-related activities for periods of nine to twelve weeks during the summer, fall, and spring. U.S. minority undergraduate and graduate students are invited to apply. The appointment carries a stipend of $250 per week for undergraduate and $300 per week for graduate students, and may provide a travel allowance.

Deadlines:
For summer (to begin after June 1): *February 15*
For fall (to begin after September 1): *June 15*
For spring (to begin after January 1): *October 15*

For applications and/or information, write to the address above.

Penrose *continued from p. 294*

postdoctoral researchers will be subsidized, and these individuals are especially encouraged to apply. The registration fee will be approximately (U.S.) $500, and we hope this can be sponsored or waived for many of the participants. The registration fee will include all meals, double occupancy lodging, a half-day field trip, bus transportation from and to the Calgary International Airport, and other conference expenses except alcoholic beverages. The field trip to the Canadian Rockies will be led by members of the Geological Survey of Canada.

Co-conveners of the conference are ***Lawrence A. Lawver,*** Institute for Geophysics, University of Texas at Austin, 8701 N. MoPac Expressway, Austin, TX 78759-8397, (512) 471-0433, fax 512-471-8844, E-mail: larry@utig.ig.utexas.edu; ***Shiri Srivastava,*** Atlantic Geoscience Centre, Geological Survey of Canada, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2, (902) 426-3148, fax 902-426-6152, E-mail: srivasta@agcrr.bio.ns.ca; ***Ashton Embry,*** Geological Survey of Canada, Institute of Sedimentary and Petroleum Geology, 3303-33rd St. N.W., Calgary, Alberta T2L 2A7, Canada, (403) 292-7125, fax 403-292-4961; ***Kaz Fujita,*** Michigan State University, Department of Geological Sciences, East Lansing, MI 48824-1115, (517) 355-0142, fax 517-353-8787, E-mail: kaz@siberia.glg.msu.edu; and ***David Stone,*** University of Alaska, Geophysical Institute, Fairbanks, AK 99775-0800, (907) 474-7622, fax 907-474-7290, E-mail: ffdbs@aurora.alaska.edu.

Application deadline is March 1, 1995. To apply for the conference, please provide the following information: (1) name and position; (2) organization and mailing address; (3) phone number, fax number, and E-mail address if available; (4) a brief statement of your interest and experience with regard to the Arctic; and (5) a brief statement on the subject you wish to present at the meeting. Formal invitations will be mailed in May 1995. Send applications to Lawrence Lawver at the address above. ■

Dibblee Foundation Nominations Invited

The Thomas Wilson Dibblee, Jr., Geological Foundation (Dibblee Geological Foundation) has established the Dibblee Medal in recognition of the unique contributions of Tom Dibblee to the science of geologic mapping. The medal is to be awarded at least biennially to a geologist whose published geologic mapping is exceptionally noteworthy.

The award consists of a sterling silver medal bearing the likeness of Tom Dibblee; and on the obverse side, a sketch map of California, the geology of which has been Tom's domain for 60 years. A plaque suitable for wall hanging will accompany the medal.

Nominations of candidates to be considered for award of the Dibblee Medal are now being solicited. Nominations should include the name of the candidate, biographical data, a description of the geologic mapping, and the names of at least two geologists who support the nomination. Mail each nomination and supporting data by March 1, 1995, to:

Dibblee Geological Foundation
Post Office Box 60560
Santa Barbara, California 93160

The second Dibblee Medal will be awarded at the meeting of the Pacific Section of AAPG in May 1995, at San Francisco, California.

The Dibblee Foundation is a nonprofit corporation chartered in California in 1983 for the purpose of publishing Tom Dibblee's geologic mapping. To date, the Foundation has published 47 maps covering sixty-five 7½-minute quadrangles; several hundred more await publication.

Forum *continued from p. 291*

Interestingly, the Montana legislation requires a technical oversight committee to review permit applications for new geothermal wells but accepts the existing permit for the Church's geothermal well for flow rates <2.2 L/s. As HR 1137 would have required the Church to reapply for a permit under the regulations of the Montana Reserved Water Rights Compact, use of this well could have been banned at any flow rate. HR 1137 would also have banned future geothermal wells drilled on all private and state lands within the Island Park Geothermal Area.

Park protection legislation such as HR 1137 raises numerous issues worthy of debate, including (1) the reliability of existing scientific information to assess hydrologic risks, (2) the degree of acceptable risk, and (3) the jurisdiction of the federal government to restrict water resource use on private and state lands outside national parks. The first two issues are discussed in Perspectives 2 and 3. The third issue, outside the scope of this discussion, involves potential conflicts with state water law and concerns over the federal government taking private property rights and has been the principal reason that the Old Faithful Protection Act has failed to become law.

PERSPECTIVE 2: The U.S. Geological Survey Study

Michael L. Sorey, Yousif K. Kharaka, and W. C. Evans, U.S. Geological Survey, Menlo Park, California

A two-year study by the U.S. Geological Survey (referred to as "the study" throughout this Forum) of geothermal systems in the Corwin Springs area and adjacent parts of Yellowstone was done in collaboration with the National Park Service, Argonne National Laboratory, and Los Alamos National Laboratory. The results of the study, published in 1991 by the Survey as WRIR 91-4052, include input from 16 different investigators. In this forum, we have used results from various parts of this report without specific citation. The opinions expressed in this Perspective are those of its three authors and, although based on findings of the study in its entirety, are not necessarily those of every investigator involved in the study.

WRIR 91-4052 addressed three principal issues: (1) the sources of thermal water in the hot springs at Mammoth, La Duke, and Bear Creek; (2) the degree of subsurface hydrologic connection between these areas; and (3) the effects of geothermal development in the Corwin Springs area on thermal springs in Yellowstone. The investigations included geologic mapping; geophysical surveys; chemical sampling and analyses of waters, gases, and rocks; determinations of rates of discharge of various thermal springs; and hydrologic tracer tests. Related investigations of mercury concentrations in shallow soils and of streambed temperatures in the Yellowstone and Gardner Rivers were conducted by the National Park Service. The study area extended from the Norris Geyser Basin at the south to the northern end of the Corwin Springs area at the north (Fig. 1). There are only a few geothermal wells in the study area, including well Y-10 at Mammoth and the church well near La Duke Hot Spring. Additional useful information could have come from drilling and testing of new wells, but such work was beyond the scope and authorization of the study.

The general approach of the study was to use geologic mapping and geophysical surveys to assess the likelihood that permeable pathways exist between hot springs in the Corwin Springs area and those in the Mammoth Hot Springs area. Evidence of actual flow of thermal water between areas was sought from comparisons of chemical and isotopic characteristics of thermal waters and from age determinations and isotopic compositions of travertine deposits. Distances and possible travel times for flow between thermal areas were too great to be detected by more direct methods involving injection of tracers, except within the Mammoth area, where the existence of hydraulic connections between springs on the travertine terraces at Mammoth Hot Springs and springs located along the Gardner River was established (Fig. 1).

Geothermal System Characteristics

Chemical and isotopic characteristics of thermal waters in the Norris–Mammoth–La Duke region reflect a volcanic reservoir-rock influence (with Na, Cl, and SiO_2 as the principal dissolved constituents) at Norris, but change to reflect more of a sedimentary reservoir-rock influence (with Ca, HCO_3, and SO_4 as the principal dissolved constituents) moving northward to Mammoth and the Corwin Springs area. A common feature of thermal waters at Mammoth, La Duke, and Bear Creek is flow through pre-Cretaceous sedimentary rocks in the Gardiner syncline, where reservoirs for thermal fluids and sources of most of the dissolved species are provided by Paleozoic carbonate rocks. Stratigraphic and hydrologic relations favor an overall south-to-north direction for ground-water flow in the syncline from Mammoth toward the Gardiner thrust fault. Reservoir temperature estimates based on chemical geothermometers are close to 100 °C for Mammoth, 80 °C for La Duke, and 70 °C for Bear Creek thermal waters. Minimum depths of fluid circulation required to reach these temperatures range from 2-3 km, which are depths at which the Paleozoic carbonates occur west of Mammoth and under the Yellowstone River Valley.

Normal faults associated with the East Gallatin–Reese Creek fault zone may also provide flow paths for geothermal systems in the Mammoth area and in the Corwin Springs area. La Duke Hot Spring and adjacent thermal springs in the Yellowstone River are aligned along segments of the Reese Creek fault zone. Electrical resistivity data indicate intense hydrothermal alteration along this fault zone near the northern boundary of Yellowstone.

Uranium-series age determinations on travertine and associated carbonate veins in the northern part of the study area provide a chronology of episodic discharge of carbonate-rich thermal waters at sites inside and outside Yellowstone that is interrelated with the glacial chronology in this region over the past 140 000 yr. Strontium isotopic values ($^{87}Sr/^{86}Sr$) for travertine from the Gardiner bench north of the town of Gardiner in the Corwin Springs area, where thermal springs were active as recently as 19 000 yr B.P., are identical to those for travertine and present-day hot water from the Mammoth area. This indicates that hydrologic connections existed in the past and may still exist between the geothermal system associated with Mammoth Hot Springs and geothermal system(s) within the eastern half of the Corwin Springs area. In contrast, strontium isotopic values for water at La Duke Hot Spring (reported in WRIR 91-4052) and travertine from the La Duke area (determined after WRIR 91-4052 was published) are distinctly different from the values at Mammoth.

Thermal water at La Duke Hot Spring is generally similar to Mammoth thermal water in terms of salinity and concentrations of major cations and anions, but contains more sulfate (1250 vs. 600 mg/L) and less chloride (40 vs. 170 mg/L). Significant differences exist between these two water types in terms of concentrations and ratios of the more conservative constituents, pressures of dissolved CO_2, and isotopes of water, helium, boron, and lithium. These differences, as expressed in mass-balance relations, are consistent with the existence of separate geothermal systems associated with thermal waters at Mammoth and La Duke involving reactions with different reservoir rocks under different thermodynamic conditions. The same geochemical indicators suggest that there may be a small component of Mammoth-type water in Bear Creek Springs.

In summary, there is geologic and mineralogic evidence for flow paths that extend from the Mammoth area to parts of the Corwin Springs area, but the geochemical evidence indicates that thermal waters similar to those discharging at Mammoth currently do not flow to La Duke Hot Spring. We believe that this indicates that Mammoth Hot Springs and La Duke Hot Spring are associated with separate geothermal systems, even though both systems may include deep reservoirs within the Paleozoic carbonates. We also recognized in WRIR 91-4052 that thermal water discharging at La Duke Hot Spring could originate inside Yellowstone but not be in hydrologic connection with the Mammoth geothermal system.

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Reminders

CALL FOR NOMINATIONS

Materials and supporting information for any of the following nominations may be sent to GSA Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301. For more detailed information about the nomination procedures, refer to the October 1994 issue of *GSA Today,* or call headquarters at (303) 447-2020, extension 136.

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).

Nominations for 1996 officers and councilors must be received at GSA headquarters no later than **FEBRUARY 15, 1995.**

Penrose and Day Medals, and Honorary Fellowship

Nominations for GSA's Penrose and Day Medals and for Honorary Fellowship in the Society are due at headquarters by **FEBRUARY 1, 1995.**

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 1995, only those candidates born on or after January 1, 1960, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1995 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.

Nominations for the 1995 Young Scientist Award must be received at GSA headquarters by **FEBRUARY 1, 1995.**

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, Student 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 1995 is **MARCH 1, 1995.**

National Awards

The deadline is **April 30, 1995,** for submitting nominations for these four awards: William T. Pecora Award, National Medal of Science, Vannevar Bush Award, Alan T. Waterman Award

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Effects of Geothermal Development

In the U.S. Geological Survey analysis of the effects of potential geothermal development on Yellowstone, presented in WRIR 91-4052, a conservative approach was taken by assuming that a hydrologic connection could be established between Mammoth and La Duke by geothermal developments that resulted in large changes in hydraulic head. Under this condition, there are two principal factors to consider in evaluating the effects of geothermal production wells on the national park. The first factor is what constitutes a thermal feature in Yellowstone. The entire park was listed as a significant thermal feature in a *Federal Register* notice on August 3, 1987, which some take to include "all aquifers, seeps, heated soils, underwater springs, and surface features." By this definition, any use of geothermal or ground-water wells near the park boundary would probably cause some level of change in Yellowstone's thermal features. Such changes may be of no consequence to the park's thermal springs but could be construed as a negative effect to be avoided. Instead, the authors of WRIR 91-4052 based their evaluation of the effects of development on the possibility of observable changes to thermal springs in the vicinity of Mammoth Hot Springs.

The second factor in this regard is that wells drilled in the vicinity of La Duke Hot Spring and Bear Creek Springs could obtain most of their production from the diversion or capture of naturally discharging thermal water. The church well, for example, was shown to divert thermal water from La Duke Hot Spring when producing at its capacity of 25 L/s during a 13-hr flow test in 1986. Such a process tends to minimize and localize drawdown in the aquifer tapped by the well. Drawdown in this well, which totaled <5 m by the end of test, was sufficient to cause La Duke Hot Spring to cease flowing. La Duke Hot Spring flows 5–9 L/s. As discussed below, the total rate of discharge of thermal water in the La Duke area is on the order of 60 L/s. Theoretical calculations indicate that sustained use of this well at rates of 25 L/s or less would cause little or no head change in the geothermal reservoir beneath the Mammoth area, some 15 km distant. In contrast, future wells drilled to capture natural thermal-water discharge in the vicinity of Bear Creek Springs would have a more direct effect on Yellowstone, because much of this natural discharge occurs in the Yellowstone River where it flows inside the park boundary.

The total rate of thermal-water discharge in the La Duke area was determined during the study from four sets of measurements of sulfate flux in the Yellowstone River at sites upstream and downstream from the region of spring inflow. This seepage-gain technique requires integrated samples at each site, a streamflow measurement at one or both sites, and accurate laboratory determinations of sulfate concentration on each sample. Sulfate was chosen in this application because of its relative abundance in the La Duke thermal water (1250 mg/L). Values of thermal-water discharge are obtained by dividing the differences in sulfate flux between sampling sites by the sulfate concentration in the thermal water. The accuracy of this technique is improved if measurements are made during periods of relatively low streamflow. The range, average value, and standard deviation of four sets of measurements made over the 1989–1990 period were 49–67, 61, and 8.5 L/s, respectively. Additional sets of measurements were obtained during autumn in 1991 and 1992, yielding discharge values of 62 and 59 L/s, respectively.

The consistency of results between the six sets of sulfate flux measurements provides some assurance that the total rate of thermal-water discharge into the Yellowstone River has been determined with reasonable accuracy. Sources of variation in these results include errors in determinations of dissolved sulfate and river flow, nonuniform sulfate concentrations within the river sections sampled, and possible variations with time in the total thermal-water discharge in this area.

WRIR 91-4052 concluded that use of the Church geothermal well at rates of up to 25 L/s would not pose a threat to Yellowstone's thermal springs. This conclusion was based on the presumption that most of this production would be obtained from capture of part of the natural thermal-water discharge in the La Duke area and hence that changes in hydraulic head in subsurface aquifers would be relatively small and localized. These considerations were extended to the use of additional wells that might be drilled in the La Duke area that also captured natural thermal-water discharge as long as the combined production was less than 60 L/s. WRIR 91-4052 pointed out, however, that it would be more difficult to determine the degree of thermal-water capture from future wells if the rate of thermal-water flow to the Yellowstone River had already been reduced by the existing church well.

WRIR 91-4052 recognized that development options involving combinations of production wells, injection wells, and monitoring wells, which are commonly used to minimize effects on surficial thermal features, would probably not provide the level of protection deemed appropriate for Yellowstone. The language used in the report probably should have made such reservations more forceful and clear. In addition, if the goal of park protection is extended to include the prevention of any changes in hydraulic head beneath the park boundary, then fluid production from thermal and nonthermal wells within some distance of the park boundary should be banned. The Old Faithful Protection Act of 1994 would have applied a ban on fluid production from wells with temperatures above 15 °C to distances of 24–48 km from the park boundary. Geothermal wells that are not pumped but use downhole heat exchangers for energy recovery were also included in the ban.

The proposed federal legislation attempted to provide, in the words of its author, Rep. Pat Williams (R—MT), "an iron-clad, rock-ribbed, copper-riveted guarantee of protection for Yellowstone." Other legislators referred to HR 1137 as a matter of killing a gnat with an atom bomb, and instead suggested resolving the issue by legislative taking (with financial compensation) of the church's water right and geothermal well. Beyond this approach lie matters of private property, constitutional law, and buffer zones around other national parks. As things stand today, there is no moratorium in effect on geothermal wells around the park, and the Church Universal and Triumphant has a water right from the State of Montana to produce up to 2.2 L/s (10 acre-ft/yr) from its existing well. To produce this well at greater rates, the Church would have to obtain a permit under the regulations set forth in the Montana Water Rights Compact. The church also has the option of obtaining an access easement under the Yellowstone River to divert water from La Duke Hot Spring, for which the church holds water rights in excess of the natural flow of the spring.

The scientific study of geothermal systems in the northern part of Yellowstone and the Corwin Springs area has provided useful information about the nature and magnitude of geothermal resources in this region and an assessment of effects of limited development of these resources in the vicinity of La Duke Hot Spring on the thermal features of Yellowstone. A conservative approach was employed in evaluating effects of potential geothermal development by considering that hydrologic connections could exist between Mammoth Hot Spring and the thermal springs in the Corwin Springs area. Furthermore, we believe that the measurements of the total rate of thermal water discharge in the La Duke area are sufficiently accurate to conclude that use of the existing church geothermal well at rates near 25 L/s would capture only part of this natural discharge and thereby cause no discernible changes at hot-springs areas inside Yellowstone.

Others may conclude that all geothermal well production should be banned outside Yellowstone, as stipulated in HR 1137, to prevent any hydrologic change beneath the park boundary or to avoid setting a precedent by allowing one such well to be used. Such an approach, however, carries with it other legal and legislative questions that may be difficult to resolve.

PERSPECTIVE 3: Possible Effect of Nearby Geothermal Development on Yellowstone National Park

Irving Friedman, U.S. Geological Survey, Denver, Colorado

Background

WRIR 91-4052 was used by proponents of geothermal development adjacent to Yellowstone in their opposition to legislation intended to protect the thermal features of the park. Having been involved for several decades with efforts to monitor the thermal features of the park, and having expertise in isotope geochemistry, I examined WRIR 91-4052 in detail. The following comments regarding this report state my concerns.

WRIR 91-4052 concluded that there was no present hydrologic connection between the La Duke Hot Spring area (including the Church well) and Mammoth Hot Springs, a major thermal feature in the park located ~16 km southeast of La Duke. It also concluded that pumping the Church well at rates of 25 L/s would not impact Mammoth Hot Springs or other thermal features in the park, and that additional pumping at a rate of about 60 L/s would also cause no harm to Yellowstone, provided that the pumping was determined to be from the same reservoir. Because the total surface

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The Geological Society of America

Research Grants Program 1995

The primary role of the Research Grants Program is to provide partial support for research by graduate students at universities in the United States, Canada, Mexico, and Central America. GSA strongly encourages women, minorities, and persons with disabilities to participate fully in this grants program. Eligibility is not restricted to GSA members. New application forms are available each fall in the geology departments of colleges and universities offering graduate degrees in earth sciences. Forms are mailed in September to GSA Campus Representatives and department secretaries and chairpersons in the United States, Canada, and Mexico. They are also available upon request from the Research Grants Administrator, Geological Society of America, P.O. Box 9140, Boulder, Colorado 80301. *Please use only the 1995 application and appraisal forms.*

Confidential evaluations from two faculty members are required from candidates for the M.S. or Ph.D. degree and must accompany applications submitted. PLEASE USE THE "APPRAISAL OF APPLICANT" FORMS, WHICH ACCOMPANY THE 1995 APPLICATION FORMS. Application forms will not be accepted by facsimile.

The Geological Society of America awarded over $300,000 in grants in 1994. The grants went to 238 students doing research for advanced degrees. The average amount awarded was $1275. The largest grant was $2000, but there is no predetermined maximum amount.

The Committee on Research Grants will meet in March to evaluate applications and award grants. In April, all applicants for grants will be informed of the committee's actions by the Executive Director of the Geological Society of America.

ALL APPLICATIONS MUST BE SUBMITTED ON THE 1995 FORMS AND POSTMARKED BY FEBRUARY 15, 1995

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discharge from the Mammoth Hot Springs travertine terraces varies from 20 to 100 L/s, the withdrawal of these seemingly small amounts of water (25–60 L/s) might have major impacts on the discharge of Mammoth. For this reason it is important to examine the evidence upon which the recommendations of WRIR 91-4052 were based.

Geological Evidence. Chapter C of WRIR 91-4052 suggested that faults and other structures potentially connecting the Corwin Springs area and Mammoth Hot Springs could act as flow paths for thermal water. It also pointed out that at several times in the past 200 000 yr, and as recently as 19 000 yr B.P., travertine similar in composition to that now being deposited at Mammoth Hot Springs was deposited close to La Duke. Most of this travertine is now exposed in quarries 5–10 km south of La Duke. This evidence suggests that in the recent past, hydrologic connections probably existed between La Duke and Mammoth. WRIR 91-4052 dismissed the possibility of the two areas being connected now on the basis of evidence presented below.

Evidence From Stable Isotopes of Hydrogen and Oxygen. Measurements of the stable isotope abundance of both oxygen-18 and deuterium, expressed as $\delta^{18}O$ and δD, respectively, were determined in 1990 by Kharaka and his coauthors on water samples from the Church well, La Duke Hot Spring, and Mammoth Hot Springs. The $\delta^{18}O$ value in water from Mammoth Hot Springs was approximately 1‰ lower than the Church and La Duke water samples. The δD value was reported to differ by about 5‰ between the two areas. The authors stated that "The difference in the δD and $\delta^{18}O$ values of waters from the La Duke area and from Mammoth Hot Springs is an important indication that the two waters, even though ultimately meteoric, are not isotopically related."

Evidence from Deuterium Data. The δD values for samples collected in Mammoth Hot Springs vary from 141‰ to 149‰, while those from the La Duke area vary from 144‰ to 147‰. There is no difference in δD between the two areas, especially considering that the experimental error of measurement of δD is ±2‰, and natural variations in δD with time in these systems can easily exceed this value. Illustrations of the isotopic variability of the individual springs are presented in Table 1.

Even this limited data set shows a possible variation in δD of 2‰ within 4 months for these features. Although δD may be a conservative constituent of the water, the year-to-year and season-to-season variations of the δD of recharge to the spring systems is far greater than the difference between the springs as reported by Kharaka and his coauthors. Unpublished data on the δD of major rivers draining Yellowstone show a 13‰ seasonal and annual variation, and this is an indication of the minimum variation in δD to be expected in recharge for the hot spring systems. The isotopic variation in the rivers (and in recharge for the springs) in Yellowstone is due in part to the different trajectories and mixes of trajectories traversed by water vapor prior to precipitation over Yellowstone, both seasonally and from year to year. These major rivers integrate isotopic variations in precipitation that occurred over a large area and for a long time period. Precipitation that is responsible for the recharge of individual spring systems probably occurs over a much smaller area and can be expected to show even larger δD variations over time, resulting in large isotopic variation in the water discharged by the springs.

Although δD may be a conservative constituent of the water, the year-to-year and season-to-season variations of the δD of recharge to the spring systems are shown above to be as much as 13‰ in our small data set. Even though the mixing in the aquifer would tend to smooth variations in δD, it would not remove them entirely. The supposed difference between the springs as reported by Kharaka and his coauthors is small relative to the experimental measurement error and to the expected differences in the δD of recharge.

Evidence from ^{18}O Data. The water that exits as Mammoth outflow onto the travertine terraces at Mammoth Hot Springs is saturated with calcium bicarbonate and actively deposits travertine. This water, in common with several other travertine-depositing springs in Yellowstone, has derived much of its calcium bicarbonate by reaction of hot fluids with limestone at depth. In 1970, I documented changes in $\delta^{18}O$ that occur in such water during travertine deposition during an isotopic study of Mammoth Hot Springs. It is to be expected that Mammoth Hot Springs water has a $\delta^{18}O$ that is different from both meteoric water and hot-spring water that has not traversed carbonate host rocks. In contrast, the water that exits at La Duke Hot Spring has traversed shales, rather than limestone, and it therefore has not exchanged ^{18}O with carbonate in the host rocks. Although a minor amount of $\delta^{18}O$ exchange between water and silicates might have occurred, this water can be expected to have a $\delta^{18}O$ value similar to that of the meteoric water that recharges the spring system. In contradiction to statements made by Kharaka and his coauthors in Chapter F of WRIR 91-4052, ^{18}O is not a conservative constituent of the water in the Mammoth Hot Springs system.

The conclusion that I derive from the stable isotope data is that the similarity in δD and the small but expected difference in $\delta^{18}O$ values between the two areas cannot be used to prove either the hydrologic connection or nonconnection between the two areas.

Evidence from Helium Isotopes. Chapter F of WRIR 91-4052 notes that helium extracted from the Y-10 research well located in the Mammoth Hot Springs area contained a significant proportion of primordial ^3He, indicating a deep-seated source for at least some of this helium. WRIR 91-4052's authors use the fact that helium extracted from both the church well and La Duke Hot Spring have $^3He/^4He$ ratios approximately equal to that in atmospheric helium as further proof that the two sites are not hydrologically connected. However, the concentration of helium in the church well and from La Duke is many times greater than that in the Y-10 well. This high helium concentration in the two wells northwest of Yellowstone is probably the result of the radioactive decay of uranium and thorium contained in the Paleozoic shales traversed by the water prior to exiting at La Duke and the Church well. The dilution caused by this radiogenically produced ^4He would mask the small amount of primordial helium that might be present. The difference in the $^3He/^4He$ ratio between Mammoth–La Duke and the church well can be explained by the differences in the chemical compositions of the rocks traversed by the water exiting at these two places and therefore provides no information as to the possible hydrologic connection between them. The marine carbonates underlying Mammoth Hot Springs are low in elements that produce radiogenic helium.

Evidence from Lithium and Boron Isotopes. The isotopic compositions of lithium and boron differ in samples from these two areas. The concentrations of both lithium and boron are 5–10 times greater in the samples collected in the Mammoth area than in La Duke Hot Spring, the church well, and the Miller wells located ~0.5 km south of La Duke. These differences in concentration and isotopic composition can be the result of the different composition of the rocks traversed by water feeding the two areas. The authors of WRIR 91-4052 point out that differences in the major element concentrations in waters from these two areas can be explained by water-rock interactions in the different host rocks traversed by the waters, but they do not consider the possibility that minor elements are also affected by this same process.

DISCUSSION

In discussions concerning the possibility of a hydrologic connection between the Mammoth Hot Springs and La Duke areas, the authors of WRIR 91-4052 apparently considered only a direct path (A) between the two areas (Fig. 3). Another path (B) is through a common aquifer containing hot water (Fig. 3). The criteria used to identify the existence of path A are different from those used to identify path B.

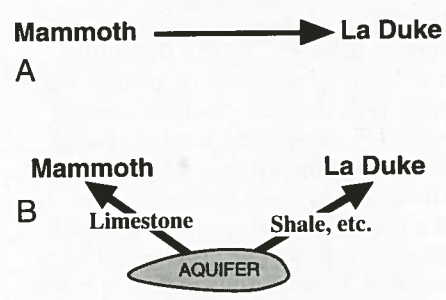

Figure 3. Possible paths for a hydrologic connection between the Mammoth Hot Springs and La Duke areas.

I argue that all of the reported isotopic and dissolved species differences between the water samples from the Mammoth and La Duke areas can be explained by water-rock interaction with the different rock types in the two areas. The calculation, presented in Chapter F of WRIR 91-4052 (p. F-28), concerning the amount of "Mammoth-type water" present in La Duke and other sites in the Corwin Springs area based on δD, $\delta^{18}O$, and the isotopes of B and Li, is therefore not relevant. These measured isotopic values cannot be used as evidence for or against a hydrologic connection between the two springs systems.

RISK ASSESSMENT

WRIR 91-4052's abstract (p. 2) concludes that:

> Decreases in discharge of thermal features in the Mammoth Hot Springs area can be avoided by limiting development to: (1) the natural flow of La Duke Hot Spring (7 L/s), (2) the use of downhole heat exchangers in wells, and under certain conditions, (3) fluid

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TABLE 1. STABLE ISOTOPIC COMPOSITION OF SEVERAL THERMAL FEATURES

Sample site	Date	δD (‰)
Miller Well*	March 15, 1989	148
	July 14, 1989	150
La Duke Hot Spring	March 6, 1989	145
	July 14, 1989	147

Note: From Friedman (unpub. data), 2σ error for these analyses = ±1‰. Values are given in per mil relative to V-SMOW.

*Well, 58.8 m (193 ft) deep, located ~0.5 km south of La Duke and containing thermal water that chemically resembles that in La Duke Hot Spring.

TABLE 2. SULFATE FLUX IN THE YELLOWSTONE RIVER NEAR LA DUKE HOT SPRING

Date	Sampling site*	Stream conc. (mg/L)	Thermal flow (L/s)	Water discharge (L/s)	Error (L/s) (Friedman)
September 12, 1989	YR at CS	25.31	46 600		
	YR at QW	23.59	(46 600)	64	±22
		1.72 (Δ sulfate)			
February 27, 1990	YR at CS	43.55	24 100		
	YR at QW	41.43	(24 100)	49	±13
		2.12 (Δ sulfate)			
May 16, 1990	YR at CS	15.62	111 000		
	YR at QW	14.87	(111 000)	67	±51
		0.75 (Δ sulfate)			
September 28, 1990	YR at CS	26.36	43 600		
	YR at QW	24.47	(43 600)	66	±20
		1.89 (Δ sulfate)			

*YR = Yellowstone River; CS = Corwin Springs; QW = Queen-of-the-Waters (several km above Corwin Springs).

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> production from wells at rates less than the total natural rate of outflow of thermal water into the Yellowstone River in the La Duke and Bear Creek areas. We estimate these natural discharge rates to be about 60 and 17 L/s, respectively. Under development option (3), it is necessary that production be obtained from the same reservoir that supplies the natural thermal-water outflow so that there is a reduction in this outflow that is close to the rate of well production. Fluid production from the existing geothermal well drilled by the Church Universal and Triumphant near La Duke Hot Spring at rates up to 25 L/s most likely meets these criteria, and therefore, *poses no discernible risk of decreasing discharge of the Park's thermal springs.*

Because the use of the outflow of hot springs collected as they discharge on the ground surface would not impact the subsurface thermal water aquifer, this flow has been considered "safe." The justification for increasing the amount of "safe" water from the amount now exiting at La Duke Hot Spring (7 L/s) to as much as 60 L/s derived from geothermal wells is the result of the discovery of sulfate-rich thermal water exiting along the banks and under the Yellowstone River in the vicinity of La Duke. This discovery led the authors of WRIR 91-4052 to conclude that this additional natural outflow, if captured, could also be safely diverted for beneficial use without danger to Yellowstone. WRIR 91-4052 states that the amount of sulfate-rich water escaping from these hidden springs could be measured with reasonable accuracy by the difference in sulfate flux in the Yellowstone River above and below the springs, and that this technique could also be used to monitor future use of this thermal water by pumping through the Church well or other nearby wells.

Monitoring of Underwater Thermal Springs in the Yellowstone River Near La Duke Hot Spring. In Chapter G of WRIR 91-4052, Sorey and his coauthors report four discharge values for the thermal spring waters that issue under the Yellowstone River in the vicinity of La Duke Hot Spring. Data from their Table G4 (p. G38) is reproduced in the first five columns of Table 2.

These authors do not assign errors to the values that they quote in their table. In column six of Table 2 I have calculated the probable error listed using the following protocol: (1) The precision of the stream discharge measurements is taken to be ±5% of the discharge. This is the error usually assigned to superior monitoring sites. (2) The precision of the individual sulfate values was determined by examination of records from the U.S. Geological Survey Quality of Water Laboratory. These records were of sulfate standard solutions measured periodically by ion chromatography at least four times during the analyses of a set of 50 water samples. Ten such sets were examined. The average standard deviation of the analyses of these standards was ±0.4 mg/L.

Thermal water discharge error equals calculated thermal water discharge multiplied by $\sqrt{E^2_{sulfate} + E^2_{discharge}}$, where $E_{sulfate}$ is the calculated percent error in Δsulfate using an analytical error of 0.57 mg/L for the difference in the two sulfate measurements (each measurement has a standard deviation of 0.4 mg/L), and $E_{discharge}$ is the percent error in the river discharge measurements (±5%). The following example calculation is shown for the first data set:

$$21.5 = 64\sqrt{\left(\frac{0.57}{1.72}\right)^2 + (0.05)^2}$$

The results are shown in the far right column of Table 2 as "Error."

The accuracy of the estimation of the flow of the thermal springs that empty into the Yellowstone River is a function of the river stage (discharge). At high river stage, the relative errors of measurement used to calculate the discharge of the springs are large. The average base flow of the Yellowstone River at Corwin Springs is ~22 000 L/s, and the average peak discharge is ~360 000 L/s. From an examination of the errors given in Table 2, it appears that the maximum accuracy with which the flow of the springs can be determined is ~10 L/s. To achieve this accuracy, the measurements of sulfate flux would be restricted, in most years, to the six-week period from mid-February through March when the river discharge is at its minimum. At other times of the year, the error in the determination of thermal water flow reaches unacceptably high values. The impossibility of accurately monitoring the flow of these thermal springs throughout the year calls into question recommendations regarding the possible use of their water by diversion via the church well.

WRIR 91-4052 also recommended that even larger diversions could be made of thermal water beyond the amount that was "identified" as now discharging in the Corwin Springs area, provided that monitoring wells be drilled close to the park boundary to ensure that the pressure in the aquifer feeding Mammoth Hot Springs did not change. WRIR 91-4052's authors also suggested that reinjection of extracted fluids would mitigate damage to Yellowstone's thermal features.

These recommendations do not provide additional safety for Yellowstone. To provide warning of possible impact to Mammoth Hot Springs, monitoring wells would have to be placed between Mammoth and the wells being pumped, and in hydrologic contact with the specific aquifer feeding Mammoth Hot Springs. As was pointed out in WRIR 91-4052 by Pierce and his coauthors (Chapter C), the aquifer that probably feeds Mammoth is the Mississippian age Mission Canyon Limestone, a formation in which fluid flow is concentrated in open passageways. WRIR 91-4052 also presents data on flow between sinkholes and connected springs in the Mammoth area (Chapter G). Flow rates are low, requiring several hours per kilometer (p. G12–G13). This makes the correct placement of the monitoring wells a difficult, if not impossible, task. Add to this the unknown (and probably unknowable) degree of pressure decline in the monitoring wells that *will not* result in irreversible damage to Mammoth, and the usefulness of monitoring wells in this situation becomes highly questionable. Reinjection of fluids can only be advantageous if the fluids are injected into what has been adequately proven to be the same aquifer from which fluids are being withdrawn. Also, considering the probable nature of the aquifer, reinjection methodology would be guesswork at best.

CONCLUSION

WRIR 91-4052 examined a number of alternative possibilities for using geothermal water in the Corwin Springs area. These range from one having no possible impact on the nearby thermal features of Yellowstone, to others that might well have an adverse impact. I have no criticism of the range of possibilities discussed in the report. In many places in the body of the report, the issue of possible damage to Yellowstone is objectively discussed. However, most people will only be concerned with the conclusions reached by WRIR 91-4052, and not with the detailed discussion, and it is with these conclusions that I take issue.

Consideration of all of the issues that I have discussed, together with background information on the negative impacts of geothermal development adjacent to other major geothermal areas of the world, led the National Park Service to prepare an Impact Analysis for presentation to Congress in which it stated that

> ...the NPS has concluded that there is sufficient probability of connection between geothermal systems in YNP and those in the Corwin Springs KGRA to warrant extreme concern over any development of KGRA geothermal resources. In order to protect the integrity of YNP geothermal resources, the NPS recommends no development of subsurface geothermal resources be permitted in the KGRA.

The then–Secretary of Interior would not permit this document to be presented to Congress.

Due in part to the recommendations of the U.S. Geological Survey and to considerations of the issue of taking private property, Congress in 1992 allowed the restrictions it had placed on development in the Corwin Springs Known Geothermal Resource Area to expire. However, in May 1993, the State of Montana passed legislation in an attempt to control development of thermal and other ground water in this area, and the most recent Congress (103rd) considered further legislation to protect Yellowstone.

In our quest for clean energy sources we need to be diligent and critical in examining issues relating to the environment in which the energy extraction is to occur. The recommendations regarding "safe" geothermal development made in WRIR 91-4052 might be satisfactory in a milieu other than a unique area such as Yellowstone. Careful examination of the evidence for possible environmental damage is necessary in an area in which the results of a misstep are as consequential as in this case. ■

Vincent C. Kelley and Leon T. Silver Graduate Fellowship

Department of Earth & Planetary Sciences
The University of New Mexico

The Department of Earth and Planetary Sciences at the University of New Mexico invites applications for the Vincent C. Kelley and Leon T. Silver Graduate Fellowship. The fellowship will be awarded on the basis of scholastic record and academic promise. The fellowship will provide a generous living stipend of $1400/month for 9 to 12 months, and up to $3000/year for travel and research expenses. The Caswell Silver Foundation will pay all tuition and university fees. The award is initially made for one year but is renewable for one additional year for individuals in the masters program and two additional years for individuals in the Ph.D. program. Preference will be given to, but not restricted to, applicants for the Ph.D. program.

An application for admission to the UNM Graduate Program, transcripts, Graduate Record Examination results (general and geology), three letters of recommendation, and a brief statement of research goals are required for consideration for the fellowship. Application materials may be obtained from:

Barry S. Kues
Chair
Department of Earth and Planetary Sciences
University of New Mexico
Albuquerque, NM 87131

The deadline for applications is January 31, 1995 for the Fall Semester of 1995.

The Geological Society of America

Congressional Science Fellowship 1995–1996

The Geological Society of America is accepting applications for the 1995–1996 Congressional Science Fellowship. The Fellow selected will spend a year (September 1995–August 1996) 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 to mid-career 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 $38,000 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 15, 1995

Members and Fellows Revisited

William R. Dickinson, GSA Past President

Over the past year or so, the GSA Council has taken a series of actions that (a) expand the regular membership by offering qualified graduate students the opportunity to become full Members while still paying dues and fees at the level established for Student Associates, and (b) streamline the procedures for advancement from Member to Fellow. The latter change has already borne fruit by encouraging the advancement of about as many Members to Fellows within the past six months as during the preceding year. An even quicker tempo of advancement would serve GSA well, by according appropriate recognition of scientific and professional maturity and respect to as many worthy Members as existing Fellows are able to identify.

Background

A little history provides perspective for the issue of advancing Members to Fellows. Until 1947, Fellow was the principle membership class. There were about 1000 then. In 1948, Member as a class was introduced and as a result, the percentage of Fellows declined precipitously, to about 40% by the mid-1950s, and then somewhat more gradually, to under 30% by the mid-1960s, when the trend was reversed briefly and the percentage of Fellows climbed temporarily to over 40% again, over the few years during which advancement was predicated solely upon self-application by Members having the requisite professional experience.

After the procedure for essentially automatic advancement was rescinded, the percentage of Fellows again declined precipitously, from about 40% in 1970 to under 30% in 1980, and then more gradually but steadily to about 20% in 1990. Even the absolute numbers of Fellows declined every year from 1975 (n = 3347) to 1993 (n= 2896). As about half our current Fellows are over 65 years of age, some wag has calculated that continuation of the present trend would mean that the percentage of Fellows must decline to zero by some projected date in the 21st century, simply because there would be no more Fellows left to nominate additional Fellows!

Streamlined Procedures

Believing that timely advancement from Member to Fellow is an entirely appropriate measure for mature and respected geoscientists affiliated with GSA, the Council has simplified procedures for nomination in two significant ways: (1) A nomination form prepared by one Fellow to provide documentation of experience and achievement can now simply be co-signed by two co-sponsoring Fellows, one of the two being from outside the organization with which the nominee is affiliated. There is now no need for co-sponsors to generate separate and independent documents. This change reduces the workload involved in making the case for advancement without modifying the tradition that three Fellows must solemnly affix their signatures in support of each nominee. (2) In the belief that the considered judgment of any three Fellows is sufficient to make the case for advancement, the requirement that each nomination be evaluated by a Council-appointed committee was eliminated at the recent Council meeting in Seattle, the sole caveat being that a bona fide vita be submitted in connection with each nomination to establish that the nominee has accumulated the required eight years of professional experience, for which no more than three years of graduate study may be substituted. In effect, Council will henceforth treat the three nominating and co-sponsoring Fellows as a self-appointed but fully sufficient screening committee for the purpose of approving any advancement from Member to Fellow.

Nominees will be asked only to sign a statement undertaking to help advance, through their own scientific and professional activities, the aims and goals of GSA, whose stated constitutional purpose is "the promotion of the science of geology." Otherwise, unless nominators ask nominees to provide a current vita, the advancement process should now be transparent to nominees; there will be no need for them to advance their own cause by arguing their own cases.

Call for Nominations

Extending full membership to qualified graduate students and easing the logistics for advancement of regular Members to fellowship are intended to strengthen GSA by cementing more geoscientists to our endeavors. Such schemes for broadening participation can only work, however, to the extent that we encourage students to join GSA, and to the extent that existing Fellows nominate for advancement to Fellow status those worthy Members whose achievements they have reason to know. The GSA Council hopes that all current Fellows will accept the responsibility of nominating those Members who have earned their respect. The Council stands ready to respond to the wishes of all current Fellows, but it needs their active collaboration! ■

For more information about fellowship nominations, contact the Membership Services Department; phone (303) 447-2020, ext. 116, or fax 303-447-1133.

New GSA Student Associates

The following 401 Student Associates became affiliated with the Society during the period from February 1994 through September 1994.

Moha Aadie
Ashley E. Abbott
Jerome Y. Amory
Douglas A. Anderson
Gregory J. Anderson
Janel R. Anderson
Sean E. Asbell
Soe Aung
Suzanne E. Bailey
Mark J. Ballerini
Victoria L. Bannister
Martin O. Barbour
Edy M. Barilla-Cruz
Holly L. Barnette
Richard P. Bart
Bax R. Barton
David H. Barton
Jason A. Bateman
Karen A. Batton
Janney M. Baumgras
Ethan F. Baxter
Rachel J. Beane
Adelheid Beck
Douglas E. Bell
Ellin Beltz
April A. Bemis
Michelle T. Benak
Nicole A. Bergeron
Jon P. Berntsen
Budhendra Lal Bhaduri
Margaret G. Bickmore
Jerry K. Bird
Jennifer L. Bishop
Gerald O. Black IV
David E. Black
Andrew F. Boettcher
Diane Borkowski
Pamela F. Borne
Rita M. Bouchard
Steve D. Bowman
Susan J. Brockner
Axel Brommer
Leslie H. Brown
Joanna R. Browne
Nick Brozovic
Matthew E. Brueseke
David A. Brunsting
Kenneth D. Bryan
Julia G. Bryce
Jeffrey D. R. Bryden
James R. Burke
Anna M. Busby
Noreen A. Buster
Carol L. Callaghan
Dominic A. Cammarota
Tracey L. Carpenter
Traci D. Cash
Scott C. Cassady
Brian J. Cassidy
Luke Martens Cates
Yu-Chang Chan
Steven W. Chapman
Gabrielle C. Chianese
Charles C. Cho
Julie L. Clark
Stephanie A. Cleaves
Monika K. Cloys
William C. Clyde
Susan M. Cobb
Sean L. Connin
Paolo Conti
Kolin F. Convertini
Jeffrey W. Cook
Sandra K. Cook
Michelle M. Corbin
Laura L. Cossey
Scott W. Costello
Carol LaVopa Creasey
Josh C. Crook
Kurt C. Cupp
Jason H. Curtis
Alula B. Damte
Joel S. Davidow
Ansley B. Davies
Adam M. Davis
David M. Davis
Chris S. de Fontaine
Laura De Santis
Michael C. Dean
Michael J. DeFrisco
Can Denizman
Gregory S. Dick
Robert W. Dillon
Henry D. Dominy
Holly J. Dong
Patsy J. Dudley
Jeffrey B. Dugan
Sam Earman
Heather M. Easterling
Jaelyn J. Eberle
Jerry A. Eide
Brent A. Elliot
William S. Elliott, Jr.
Rachel A. Eustice
Matthew J. Evans
Edward C. Farren
Katherine R. Farrier
Dori J. Farthing
Raymond G. Ferris
Rhea F. Fiedler
Linda M. Fisher
Frederick A. Flint
Karen R. Font
David G. Francis
Arjay J. Franczyk
Donald A. Friend
Robert T. Fryer
Eddy Z. Gaffar
Dennis C. Gamble
Juan-Carlos Garcia
Mark J. Garner
Shermaine Tara Gary
Thomas A. Gentry
Laurie A. Giannotti
Ian J. Gibbings
Liviu Giosan
Jeanne E. Glahn
Daniel J. Goetz
Jonathan L. Goldberg
Victor Gonzalez
Brian F. Gootee
Robert E. Graham
Scott E. Graham
Andrew P. Granese
Linda K. Granger
Gregory S. Green
James R. Green
Nancy L. Groom
Jose Dioscoro Guardiario
David M. Haasl
Travis S. Hammond
Matthew B. Hannum
John P. Hanzas, Jr.
Richard W. Harper
Connie M. Harris
David M. Harris
John P. Harris
Erik W. Harvey
David W. Hastings
Genevieve F. Healy
Verouika S. Heber
Laura A. Heberle
Cynthia G. Heller
Adam T. Henry
Frances A. Herlity
Niko Herzog
Jennifer Higgins
Richard L. Higgins
Thomas A. Highman
Hartford W. Hight
Ronald J. Hill
Rebecca B. Hinnefeld
Amy K. Hirschfeld
Justin O. Hirtzel
Amy Hochburg
Diana J. Holford
K. Aubrey Hottell
Douglas A. Howard
Kathryn E. Howard
Katherine E. Howell
David E. Hrutfoiord
John R. Hubeny
Elizabeth A. Hudson
Simon R. Hughes
Dominik Hungerbuhler
Janet V. Hurley
Mark T. Hutchison
Ken Israel
Andrew H. Ivester
Susan L. Jarmuz
Ernest R. Johnson
Thomas D. Johnson
Thereasa A. Jones
Brian R. Joy
Jeanne E. Kalvar
Christian A. Karkow
David J. Katz
Marian L. Kearin
William R. Keller
Joseph C. Kelly
Kathy M. Kenley
Carolyn A. Kincaid
Greg J. King
David M. Kinney
Donald S. Knapp
Kurt A. Knotts
Kevin W. Koepenick
Michael S. Krahmer
Tami A. Kreienkamp
Ilan Kreisel
Ganesh Krishna
Adam Kronen
Evelyn S. Krull
Thomas R. Kulp
Andrew C. Kurtz
Katherine M. Laddish
Ingrid M. Lagerklint
Scott D. Lancer
Carolyn D. Lane
Christian D. Langevin
Robert M. Langridge
Deidre Larson
Phillip C. Larson
Larissa L. Larwill
Peter R. Laudon
Brendan M. Laurs
Seung R. Lee
Steven E. Lee
Junghun Leem
Michael E. Leone
Peter M. LeTourneau
Miriam Renee Levy
Chunhong Li
Alyson Lighthart
Tomas K. Liogys
Chongxuan Liu
Ghislaine Llewellyn
Kevin J. Lloyd
Hilde D. Luk
Judy Lunardini
Danielle J. Luttenberg
Mohammad Madjdabadi
Laura D. Mallard
Manish A. Mamtani
Nathalie Marchildon
Thomas M. Marchitto
Jonathan A. Marcus
Lawrence G. Marken
Theresa L. Marks
Christopher Martin
Denny Joe Martin
Linda J. Martinez
George W. Mason III
Christina G. Massell
Raimundo J. Matos-Perez
Jamie L. McBeth
Michael J. McCormick
Cathleen E. McGinnis
Michael R. McHale
John T. McInnis
Jeffrey A. McKay
Lisa C. McNeill
Denise M. Melanson
Annie M. Mellen
Melinda A. Metz
Darin P. Meyer
Richard A. Meyers
Joseph C. Mier
Douglas S. Miller
Michael S. Miller
Yana L. Minnis
Roach W.G.L. Mmutle
Brian A. Monk
Wolfgang Mueller
Edward R. Muller
Jeffrey S. Munroe
Paul C. Murphey
Keenan M. Murray
Jeffrey A. Myers
Gregory D. Nash
Brent D. Newman
Barbara E. Newton
Mark D. Nicholls
Laura E. Norton
Robert C. Noto
Olatunde S. Oguntola
David W. Oldham
Eric L. Olson
Gary R. Overton
Pamela R. Owen
Daphne L. Owens
David H. Palmer
Heidi M. Palmer
Rodney M. Paris
Richard A. Parr
Bruce D. Pauly
Paul E. Pavone
Joel L. Pederson
Nayyer Pervez
Mark J. Peters
James J. Peterson
Carla L. Pfalzgraf
John L. Pfanner
Elayne M. Phillips
Michelle A. Pike
Scott R. Pim
Oleg V. Pinous
Michael A. Poage
Jonathan D. Price
Aurora Pun
Mazhar Qayyum
James D. Quinn
Dawn J. Randall
Brent H. Reck
Paula J. Reimer
Amy Sue Reinker
Dale L. Ridge
Christopher K. Ridgway
Peter E. Riemersma
Sean K. Rigby
Mark A. Riihiaho
Sergio A. Rivera
Angela L. Roach
Michael E. Rogers
Donald G. Rood
Tina I. Rouse
William A. Rueckert
Bruce F. Rueger
Sheba S. Russell
Luke T. Rutten
Catherine M. Saavedra
Sherry C. Sabo
Asa Sadi
Ali R.M. Salimullah
Elias Samankassou
Laura Ann Samrad
Sherry D. Samson
Noah J. Scales
William A. Schroeder
Jessica Rae Scott
Mara M. Segrist
Mark S. Servilla
Julie M. Sexton
Jennifer N. Sherman
Sarah B. Sherman
Anne Marie Sherry
Stephanie Shipp
Robert R. Sickler
Gregory S. Siek
Nicholas S. Sirek
Eric A. Skorseth
Richard W. Slaughter
Andrew G. Smith
Laryn M. Smith
Laurence C. Smith
Josef A. Sobieraj
Rachel E. Sours-Page
Daniel Spector
David A. Staska

Students *continued on p. 301*

New GSA Members

The following 297 Members were elected to membership by council action during the period from February 1994 through September 1994 (*indicates transfer from Student Associate to Member).

*Lon D. Abbott
Zuhair F. Al-Shaieb
Joanna M. Aldred
Charles K. Almeida
Tau Rho Alpha
Victor C. Andresen
*Abraham Araya
*Mark J. Arniola
R. David Bagaley III
Jeffrey E. Bahling
*Christopher M. Barletta
*Reese E. Barrick
Roger M. Baty
*L. Sue Beard
Alwynne B. Beaudoin
Kelly A. Beck
*Paul Bertetti
Michael M. Bessette
Alfredo Bezzi
*Paul R. Bierman
*Sarah E. Bigger
Craig R. Bina
Tasha M. Black
*Barbara Bloomfield
Wendy S. Boge
*Wendy A. Bohrson
Lennart H. Bornmalm
*Stephen K. Boss
Lori G. Bowman
John E. Boyer
Eric R. Bradley
*Hans-Martin Braun
Mark E. Breckmann
Kevin E. Brewer
*Roger D. Brewer
*Douglas R. Britton
*Paul A. Brizendine
Thomas S. Brooks
Stephen K. Brueckner
Bonnie J. Brunkhorst
Elizabeth M. Budzien
Werner Buggisch
Robert E. Busch, Jr.
Vladislav Y. Butenko
Jonathan M. Cain
*Keith B. Campbell
*Michael D. Campbell
Robert V. Carr
*Peter K. Cattaneo
Kyle M. Champion
Jon Christians
*Mark A. Ciampone
*Trenton T. Cladouhos
*Philippe Claeys
Michael Collie
*Jeffrey B. Connelly
*William M. Connolly
Terri L. Cook
Andrew S. Cooper
Scott B. Couch
Vicki J. Cowart
Melissa H. Cronce
*Valerie N. Croup
*Michael L. Curtis
Brian P. Cyr
Patricia H. Danziger
*Ralph L. Dawes
Hans De Bresser
Lawrence A. Delclos
Luis A. Delgado-Argote
*Kathleen A. Devaney
Robert P. Dickerson
Cynthia R. Domack
*Colby C. Drechsel
Carolyn L. Driedger
Julie A. Droste
*Wojciech M. Dubis
John A. Dunkhase
*William J. Dunlap
Dan R. Eberhart
W. Brian Ebersole
Jon A. Erskine
Dana B. Ertel
Thomas J. Evans
John M. Faustini
David A. Feary
Clark H. Fenton
*Paul E. Ferri
Rachel Fischer
Kenneth S. Fleck
Michelle C. Fleck
Ana L. Fonseca
*Robert Craig Ford
*Sarah J. Fowell
Gerhard Franz
Andrea K. Freeman
*Dorothy E. Freidel
*Charles P. Gaddy
Michael S. Galenski
Gregory S. Gartland
*Catherine L. Gaskin
*Laura A. Gatke
Alison K. Gee
*William F. Geers
*Sarah C. Gilbert
Timothy F. Giles
*Brian K. Giroux
*Shannon M. Goodwin
Andrew E. Gorton
Kaspar Graf
Bernhard Grasemann
*Daniel J. Greeman
*Brian E. Green
Mott T. Greene
*Jonathan E. Grimes
*Virginia C. Gulick
Cheryl D. Gullett
Miguel J. Haller
Stephen K. Hamilton
Roger D. Hammond
*Sherry M. Hanlin
*Laura A. Helsel
*Marc A. Herpfer
Steve A. Hester
*Christoph E. Heubeck
R. Patrick Highsmith
Stephanie L. Hobbs
Stephen R. Hoffine
Don F. Hoirup, Jr.
*Ray Huff
Karen W. Hurley
In G. Hwang
Yasuo Ikeda
Norma Iturrino
Trevor A. Jackson
Clara B. Jarman
*John W. Jenson
Marjorie J. Johns
*Claudia C. Johnson
Ivan M. Johnston
*Tracy D. Jones
Christine L. Karas
Charles W. Karns
*Carolyn Cannon Keith
Lynn I. Kelley
*Mary Ann Kelly
Randal T. Kenyon
*David A. Knoblach
S. Cragin Knox
Tom R. Kolbe
Coung V. La
Ed Landing
Maria E. Lara
Craig B. Larson
George V. Last
Hee Jun Lee
Marlene N. Leistico
Yvonne C. Leung
Alan Levander
*Victor M. Levson
Jonathan Levy
Leroy Long
Michael G. Lordson
*Yi Lu
William B. Lyons
Lara K. MacDonald
*Kenneth G. MacLeod
*Jerry F. Magloughlin
Richard J. Mandle
Kim Manning
*Ashley K. Marquette
Arturo Martin
*Ellen E. Martin
*Jonathan B. Martin
Jose M. Martinez
*Genaro Martinez-Gutierrez
Ryo Matsumoto
Michael Matthes
Michael G. McDonald
Craig J. A. McEwan
Donald A. McFarlane
Kathy A. McGuire
Scott A. McKeag
Michael R. McVan
*Joseph G. Meert
*John M. Memmi
Liu Menghua
Matt W. Mero
Paul R. Merritt
*Daniel J. Miller
*William G. Minarik
Giorgio Minelli
*Jeremy N. Mitchell
Michael E. Mitchener
Ricardo Mon
*Jennifer Morse
*MaryLynn Musgrove
*Micheal R. Myers
*Julie Newman
Gregory S. Olsen
Jennifer J. Ottoson
*Wayne L. Page
*William R. Page
Barbara M. Palen
Arthur N. Palmer
*William Q. Parkinson
Alex L. Pataray
*Frank J. Pazzaglia
Douglas J. Perisutti
*Andrew C. Phillips
*Nicholas Pinter
Lance B. Prothro
Catherine M. Pusateri
Paula J. Quinterno
Kerstin N. Ragde
*Kesler A. Randall
Paul Remeika
Alison K. Rempel
Thomas E. Repine, Jr.
*Ronald G. Resmini
*Linda S. Reust
*Grant A. Richardson
Robert John Rickard, Jr.
George T. Ring
Vicente G. Rodriguez
Jose Luis Rodriguez-Castaneda
Michael J. Rodtang
Philip T. Rogan
Greg Rowell
Julia L. Rowen
Tonia E. Rucker
*Randy K. Ruff
*Luigi Russo
Nanette S. Rutkowski
Scott Ryan
Alice C. Salisbury
Douglas S. Santo
Gregory S. Scallon
Martha A. Scholl
*Jennifer K. Schubert
William E. Schwake
*Deborah A. Schwieder
Philip A. Shane
*Stephen G. Shank
*Jennifer L. Shelton
Greg P. Shingler
Jason T. Shirer
Peter R. Siegfried
Mark G. Smelser
Donald W. Smith
Eric L. Smith
*Meera Sood
Terrance Sookdeo
Arthur E. Soregaroli
Michael Sorey
*Stacy M. Spires
Jeffrey D. Spooner
Jon J. Starn
Robert J. Sterrett
*John P. Stewart
Robert B. Stewart
*Lisa L. Stillings
Patricia Stroh
John Strunk
Olaf M. Svenningsen
Kenneth L. Taylor
Liane J. Terrill
Jon L. Thompson
Peter H. Thompson
Jeffrey J. Thuma
*Frank J. Tokar, Jr.
Stephen L. Tompkins
Bruce D. Trudgill
Ellsworth V. Vachon, Jr.
*David W. Valentino
Sarah J. Vaughn
Eutizio Vittori
W. Waldo Wakefield
Mike W. Wallace
Virginia M. Walsh
Mairo Wannier
Robert E. Warmbrodt
James A. Wasserbauer
Todd Watkins
Ruud Weijermars
*Robert W. Wellner
Thomas W. Whitehead
Nancy A. Whitmore
Van S. Williams
Thomas P. Wohlford
Sheryl L. Woomer
Jeffrey C. Wright
*Ming-Chee Wu
Takeshi Yamagata
Jerome E. Zaykoski
Essie Lynn Zeigler
Bradley R. Zolla ■

New GSA Fellows

The following 50 Members were advanced to Fellowship in October 1994.

Calvin G. Barnes
Myrl E. Beck, Jr.
Richard N. Benson
John Van Brahana
James G. Brophy
Edwin H. Brown
Andrew S. Cohen
Bruce L. Cutright
James I. Drever
Virgil A. Frizzel, Jr.
Kazuya Fujita
Susan J. Gaffey
Robert A. Gastaldo
Alexander E. Gates
George E. Gehrels
Dennis J. Geist
Eric L. Geist
Lindley S. Hanson
Paul L. Heller
Donald C. Helm
Janet S. Herman
Catherine J. Hickson
Melvin L. Hill
Shunso Ishihara
James Edward Kahle
Susan M. Karl
Naresh Kumar
David R. Lageson
Alan E. Leviton
Allan Ludman
Leslie D. McFadden
Paul A. Mueller
Charles A. Nittrouer
Judith Totman Parrish
P. Jonathan Patchett
D. Keith Patton
Thomas C. Pierson
Stuart A. Rojstaczer
Unni H. Rowell
Joaquin Ruiz
Michael P. Ryan
Cheryl M. Seeger
Frederick C. Shaw
Jon E. Spencer
Asahiko Taira
Tommy B. Thompson
Norman R. Tilford
Noel Tyler
Roy E. Williams
Leland W. Younker

Students
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Michael Steinmann
Robert W. Stephenson
Brian A. Stone
Zdena Sucha
Michael P. Suess
Marilyn W. Sullivan
Kimberly D. Sullivent
Anthony L. Sundie
Brenda A. Szitta
Nikolas J. Taranik
Christi A. Tarrant
Gwyneth Terry
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Cheryl M. Thompson
Randall L. Thompson
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1995 DIVISION OFFICERS AND NEWSLETTER EDITORS

GSA's twelve specialty divisions provide a focus for members interested in a particular discipline. The divisions hold annual business meetings in conjunction with the Society's Annual Meeting, and most divisions publish a newsletter periodically. Division membership totals are as of November 7, 1994.

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MEETINGS

GSA Penrose Conferences

August 1995

■ **Fault-related Folding,** August 22–27, 1995, Banff, Alberta, Canada. Information: David Anastasio, Department of Earth and Environmental Sciences, Lehigh University, Bethlehem, PA 18015-3188, (610) 758-5117, fax 610-758-3677, E-mail: dja2@lehigh.edu.

Fault Rocks, August 31–September 4, 1995, Leavenworth, Washington. Information: Jerry F. Magloughlin, Department of Geological Sciences, 1006 C.C. Little Building, University of Michigan, Ann Arbor, MI 48109-1063, (313) 747-0664, fax 313-763-4690, E-mail: jerry.magloughlin@um.cc.umich.edu.

October 1995

Mesozoic Evolution of the Cordilleran Continental Margin in Central and Southern California, October 6–11, 1995, Tehachapi, California. Information: Andrew Barth, Department of Geology, Indiana/Purdue University, Indianapolis, IN 46202-5132, (317) 274-1243, E-mail: ibsz100@indyvax.iupui.edu.

Correction
The correct E-mail address for David Anastasio, co-convener and contact person for the GSA Penrose Conference on Fault-related Folding, is dja2@lehigh.edu.

Short-Course Series

Practical Modeling of Three-Dimensional Contaminant Transport and Remedial Designs Using Modular Flow and Transport Models (MODFLOW/MT3D)

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1994 Meetings

December

25th Annual Underwater Mining Institute, December 1–4, 1994, Monterey, California. Information: Karynne Chong Morgan, Underwater Mining Institute, 811 Olomehani St., Honolulu, HI 96813-5513, (808) 522-5611, fax 808-522-5618, Internet: 70673.534@compuserve.com, Compuserve 70673,534.

American Geophysical Union Fall Meeting, December 5–9, 1994, San Francisco, California. Information: AGU Meetings Dept., 1994 Fall Meeting, 2000 Florida Ave., N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: meetinginfo@kosmos.agu.org.

Tectonic Evolution of Southeast Asia, December 7–8, 1994, London, UK. Information: Robert Hall, Geological Sciences, University College, Gower St., London WC1E 6BT, UK, phone 44-784-443592, fax 44-71-387-1612, E-mail (Internet): robert.hall@ucl.ac.uk.

Symposium on Inverse Problems: Geophysical Applications, December 12–14, 1994, Yosemite Fish Camp, California. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

1995 Meetings

February

Mathematical and Computational Issues in the Geosciences, Third SIAM Conference, February 8–11, San Antonio, Texas. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

U.S. Geological Survey McKelvey Forum on Energy and the Environment: Application of Geosciences to Decision Making, February 13–16, 1995, Washington, D.C. Information: Dudley D. Rice, U.S. Geological Survey, P.O. Box 25046, MS 971, Denver, CO 80225, (303) 236-5711, fax 303-236-8822, E-mail: rice@bpgsvr.cr.usgs.gov.

Paleokarst: Macroscopic Dissolution Features in the Rock Record, February 17–21, 1995, Bahamian Field Station, San Salvador Island, Bahamas. Information: John Mylroie, Department of Geosciences, P.O. Box 5448, Mississippi State, MS 39762, (601) 325-8774, fax 601-325-2907.

March

American Association of Petroleum Geologists and Society for Sedimentary Geology (SEPM) Annual Convention, March 5–8, 1995, Houston, Texas. Information: Michelle Mayfield, AAPG Annual Meetings Manager, P.O. Box 979, 1444 S. Boulder Ave., Tulsa, OK 74101-0979, (918) 584-2555, fax 918-584-2274.

Prospectors and Developers Association of Canada Convention, March 5–8, 1995, Toronto, Ontario. Information: Prospectors and Developers Association of Canada, 34 King St. East, 9th Floor, Toronto, Ontario M5C 2X8, Canada, (416) 362-1969, fax 416-362-0101.

■ **Lunar and Planetary Science 26th Annual Conference,** March 13–17, 1995, Houston, Texas. Information: 26th LPSC, Publications and Program Services Department, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058-1113, (713) 486-2166, fax 713-486-2166. *(Abstract deadline: January 6, 1995.)*

GSA Northeastern Section Annual Meeting, March 20–22, 1995, Hartford, Connecticut. Information: Norman H. Gray, Dept. of Geology and Geophysics, University of Connecticut, 354 Mansfield Road, Storrs, CT 06269-2045, (203) 486-4434.

Oklahoma Geological Survey Workshop on the Ames Structure and Similar Features, March 28–29, 1995, Norman, Oklahoma. Information: Kenneth S. Johnson and Jock A. Campbell, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3031, fax 405-325-7069.

April

Sinkholes and the Engineering and Environmental Impacts of Karst Fifth Multidisciplinary Conference, April 2–5, 1995, Gatlinburg, Tennessee. Information: B. F. Beck, P. E. LaMoreaux & Associates, Inc., Box 4412, Oak Ridge, TN 37831, (615) 483-7483.

Geological Society of South Africa Centennial Geocongress, April 3–7, 1995, Johannesburg, South Africa. Information: Congress Secretariat, Centennial Geocongress, P.O. Box 36815, Menlo Park, 0102, South Africa, phone and fax 27-12-47-3398.

2nd International Symposium on Fractals and Dynamic Systems in Geoscience, April 4–7, 1995, Frankfurt am Main, Germany. Information: Jörn H. Kruhl, Geol.-Pal.Inst., JW Goethe-Universität, Senckenberganlage 32, D-60054 Frankfurt/M., Germany, 49-69-7982106, fax 49-69-7982958.

10th Himalaya-Karakoram-Tibet Workshop, April 4–8, 1995. Information: David A. Spencer, Geologisches Institut, ETH-Zentrum, CH-8092 Zürich, Switzerland, phone 41-1-632-3698, E-mail: daspencer@erdw.ethz.ch.

GSA Southeastern Section Annual Meeting, April 6–7, 1995, Knoxville, Tennessee. Information: Harry Y. McSween, Dept. of Geological Sciences, University of Tennessee, 306 G&G Building, Knoxville, TN 37996-1410, (615) 974-5498.

National Fossil Exposition XVII, April 7–9, 1995, Macomb, Illinois. Information: Gilbert Norris, 2623 34th Ave. Ct., Rock Island, IL 61201, (309) 786-6505.

Geological Society of Nevada Symposium III: Geology and Ore Deposits of the American Cordillera, April 10–13, 1995, Reno, Nevada. Information: Bob Hatch, Chairperson, Geological Society of Nevada, P.O. Box 12021, Reno, NV 89510, (702) 323-4569, fax 702-323-3599.

Mechanics of Jointed and Faulted Rock, Second International Conference, April 10–14, 1995, Vienna, Austria. Information: H. P. Rossmanith, Institute of Mechanics, Technical University Vienna, Wiedner Hauptstrasse 8-10/325 A-1040 Vienna, Austria, phone 43-1-58-801-5514, fax 43-1-587-58-63, E-mail: rossmanith@emch80.una.ac.at.

■ **Geology of Industrual Minerals 31st Forum,** April 23–29, 1995, El Paso, Texas. Information: Gretchen Hoffman, New Mexico Bureau of Mines and Mineral Resources, Campus Station, Socorro, NM 87801, (505) 835-5640, fax 505-835-6333, E-mail: gretchen@gis.nmt.edu.

Application of Geophysics to Engineering and Environmental Problems Eighth Annual Symposium, April 23–27, 1995, Orlando, Florida. Information: EEGS, Mark Cramer, P.O. Box 4475, Englewood, CO 80155, (303) 771-6101.

Third International Symposium on In Situ and On-Site Bioreclamation, April 24–27, 1995, San Diego, California. Information: Betty Weaver, Symposium Coordinator, The Conference Group, 1989 West Fifth Ave., Suite 5, Columbus, OH 43212-1912, toll-free (U.S. and Canada) 800-783-6338, or (614) 424-5461, fax 614-488-5747.

GSA South-Central/North-Central Sections Joint Annual Meeting, April 27–28, 1995, Lincoln, Nebraska. Information: Robert F. Diffendal, Conservation and Survey Division, 133 Nebraska Hall, University of Nebraska, 901 N. 17th Street, Lincoln, NE 68588-0517, (402) 472-7546; Page C. Twiss, Dept. of Geology, Kansas State University, Thompson Hall, Manhattan, KS 66506, (913) 532-6724.

May

Water Pollution Modelling, Measuring and Prediction Third International Conference, May 1–3, 1995, Porto Carras, Greece. Information: Liz Johnstone, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK, phone 44-703-293-223, fax 44-703-29-2853, E-mail: CMI@uk.ac.rl.ib.

1995 International High-Level Radioactive Waste Management Conference, May 1–5, 1995, Las Vegas, Nevada. Information: American Nuclear Society, 555 N. Kensington Ave., La Grange Park, IL 60525.

Geotechnica 95, Geosciences and Geotechnology Amid Ecological and Economic Considerations, May 2–5, 1995, Cologne, Germany. Information: Alfred Wegener Stiftung, Wissenschaftszentrum, Ahrstrasse 45, 53175 Bonn, Germany.

American Association of Petroleum Geologists Pacific Section Annual Convention, May 3–5, 1995, San Francisco, California. Information: Les Magoon, U.S. Geological Survey, 345 Middlefield Road, MS 999, Menlo Park, CA 94025, (415) 354-3006, fax 415-354-3224.

Water Resources at Risk, May 14–18, 1995, Denver, Colorado. Information: Helen Klose, American Institute of Hydrology, 3416 University Ave., S.E., Minneapolis, MN 55414, (612) 379-1030, fax 612-379-0169.

17th International Geochemical Exploration Symposium, Exploring the Tropics, May 15–19, 1995, Townsville, Queensland, Australia. Information: Russell Myers, 171GES, National Key Centre in Economic Geology, James Cook University, Townsville, Q4814, Australia, phone 61-77-814486, fax 61-77-815522.

Geological Association of Canada–Mineralogical Association of Canada Joint Annual Meeting, May 17–19, 1995, Victoria, British Columbia, Canada. Information: Chris Barnes, General Chair, SEOS, University of Victoria, P.O. Box 1700, Victoria, B.C. V8W 2Y2, Canada, fax 604-721-6200.

GSA Rocky Mountain Section Annual Meeting, May 18–19, 1995, Bozeman, Montana. Information: Stephan G. Custer, Dept. of Earth Sciences, Montana State University, Bozeman, MT 59717-0348, (406) 994-6906.

1995 World Geothermal Congress, May 18–31, Florence, Italy. Information: George Frye, Executive Director, International Geothermal Association, LBL 50C, Rms. 106–108, One Cyclotron Road, Berkeley, CA 94720, (510) 486-4584, fax 510-486-4889.

Basement Tectonics 12th International Conference, May 21–26, 1995, Norman, Oklahoma. Information: M. C. Gilbert, Conference Chairman, School of Geology and Geophysics, University of Oklahoma, 810 Sarkeys Energy Center, Norman, OK 73019-0628, (405) 325-3253, fax 405-325-3140.

Fifth Annual Goldschmidt Conference, May 24–26, 1995, University Park, Pennsylvania. Information: Suzanne St. Pierre, (814) 865-7557, fax 814-865-3749.

GSA Cordilleran Section Annual Meeting, May 24–26, 1995, Fairbanks, Alaska. Information: David B. Stone, Dept. of Geology and Geophysics, University of Alaska, Fairbanks, AK 99775-0760, (907) 474-7565.

National Association of Geology Teachers Eastern Section Annual Meeting, May 25–28, 1995, Toronto, Ontario. Information: Robert C. Lord, Conference Coordinator, Suite 1507, 1300 Marlborough Court, Oakville, Ontario L6H 2S2, Canada.

Walter A. Bell Symposium on Paleobotany and Coal Science, May 28–June 1, 1995, Sydney, Nova Scotia. Information: Erwin L. Zodrow, University College of Cape Breton, P.O. Box 5300, Sydney, Nova Scotia, B1P 6L2, Canada, fax 902-562-0119, or Paul C. Lyons, U.S. Geological Survey, MS 956, Reston, VA 22092, fax 703-648-4227.

June

SEG International Field Conference on Carbonate-hosted Lead-Zinc Deposits, June 3–6, 1995, St. Louis, Missouri. Information: Martin Goldhaber, U.S. Geological Survey, P.O. Box 25046, MS 973, Federal Center, Denver, CO 80225-0046, fax 303-236-3200, E-mail: mgold@helios.cr.usgs.gov.

35th U.S. Symposium on Rock Mechanics, June 4–7, 1995, Lake Tahoe, California–Nevada. Information: Jaak Daemen, Mining Engineering, MS 173, University of Nevada, Reno, NV 89557-0139, (702) 784-4309, fax 702-784-1766; or Richard Schultz, Geological Engineering, MS 173, University of Nevada, Reno, NV 89557-0139, (702) 784-4318, fax 702-784-1766.

Clay Minerals Society 32nd Annual Meeting, June 4–8, 1995, Baltimore, Maryland. Information: Patricia Jo Eberl, Clay Minerals Society, P.O. Box 4416, Boulder, CO 80306, (303) 444-6405, fax 303-444-2260.

Seventh International Symposium on the Ordovician System, June 12–16, 1995, Las Vegas, Nevada. Information: Margaret N. Rees, 7th ISOS, Dept. of Geoscience, University of Nevada, Las Vegas, NV 89154-4010, (702) 895-3890, fax 702-895-4064, E-mail: rees@nevada.edu.

■ **International Association of Geomorphologists, Southeast Asia Conference,** June 18–23, 1995, Singapore. Information: Avijit Gupta, IAG-SEA Conference, Kent Ridge P.O. Box 1135, Singapore 9111, Singapore. Faxes to Goh Kim Chuan, Division of Geography/NIE, Nanyang Technological University, Singapore, fax 65 469 8433, E-mail: gohkc@am.nie.ac.sg.

Water Resources and Environmental Hazards: Emphasis on Hydrologic and Cultural Insight in the Pacific Rim, June 25–28, 1995, Honolulu, Hawaii. Information: A. Ivan Johnson, A. Ivan Johnson, Inc., 7474 Upham Ct., Arvada, CO 80003, (303) 425-5610.

European Coal Conference, June 26–July 1, 1995, Prague, Czech Republic. Information: European Coal Conference '95, Faculty of Science, Charles University, Albertov 6, 128 43 Prague 2, Czech Republic, phone 42-2-24915472, fax 42-2-296084. *(Abstract deadline: February 28, 1995.)*

July

International Union of Geodesy and Geophysics XXI General Assembly, July 2–14, 1995, Boulder, Colorado. Information: IUGG XXI General Assembly, c/o AGU 2000 Florida Ave., NW, Washington, DC, (202) 462-6900, fax 202-328-0566, E-mail: iugg_xxiga@kosmos.agu.org.

Eleventh Symposium on Coastal Sedimentology, July 3–9, 1995, Niteroi, Brazil. Information: Cleverson Guizan Silva, Dept. de Geologia/LAGEMAR, Universidade Federal Fluminense, Av. Bento de Maria da Costa 115-a, Charitas, Niteroi, R.J. 24.370-190, Brazil, fax 55-21-711-9917.

First Australian Conodont Symposium and Boucot Symposium (in honor of Art Boucot), July 18–21, 1995, North Ryde, New South Wales, Australia, Information: Ruth Mawson, Centre for Ecostratigraphy and Palaeobiology, School of Earth Sciences, Macquarie University, North Ryde, NSW, 2109 Australia, 61-2-850 8336, fax 61-2-850 8428, E-mail: rmawson@laurel.ocs.mq.edu.au.

Seventh International Williston Basin Symposium, July 23–25, 1995, Billings, Montana. Information: W. Kipp Carroll, General Chairman, (406) 245-2367.

August

■ **Soil and Water Conservation Society 50th Anniversary Meeting,** August 6–9, 1995, Des Moines, Iowa. Information: Tim Kautza, Soil and Water Conservation Society, 7515 Northeast Ankeny Road, Ankeny, Iowa 50021, (800) 843-7645, ext. 12.

3rd International Field Conference and Symposium on Intraplate Magmatism (IGCP 336): Petrology and Metallogeny of Volcanic and Intrusive Rocks of the Midcontinent Rift System, August 22–September 1, 1995, Duluth, Minnesota. Information: Penny Morton, Dept. of Geology, University of Minnesota, Duluth, MN 55812, (218) 726-7962, fax 218-726-8275, E-mail: pmorton@ua.d.umn.edu.

Orogenic Lherzolites and Mantle Processes 2nd International Workshop, August 24–September 5, 1995, Granada, Spain. Information: H. G. Barsczus, Géofluides GBE/ISTEEM-C.P. 057, Université de Montpellier 2, 34095 Montpellier Cedex 5, France, phone 33-6714-3933, fax 33-6714-4774, E-mail: barsczus@dstu.univ-montp2.fr.

Mineral Deposits: From Their Genesis to Their Environmental Impacts, 3rd Biennial SGA Meeting, August 28–31, 1995, Prague, Czech Republic. Information: Jan Pasava, Czech Geological Survey, Klarov 131/3, 118 20 Praha 1, Czech Republic, phone 42-2-537011, fax 42-2-7980965.

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

Short-Course Series

Statistical Methods in Ground-Water Pollution

February 27-March 3, 1995

Instructors:
D. Helsel and E. Gilroy (USGS)

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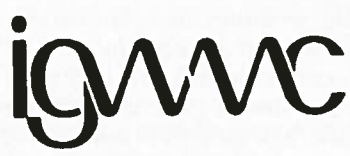

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GSA Today

GSAF UPDATE

Robert L. Fuchs

SAGE to Benefit from Wiley Gift

The scientific and educational publishing firm John Wiley & Sons, Inc., has recently made a pledge to GSA's Second Century Fund for Earth • Education • Environment. This contribution has been directed in support of the SAGE program. In notifying the Foundation of the grant, which is to be paid over 5 years, Vice Chairman Deborah E. Wiley expressed the company's confidence that the precollegiate education activities of GSA would ensure the health of geology teaching well into the 21st century.

John Wiley & Sons, Inc., is a publisher of professional scientific, technical, medical, and educational materials, as well as other nonfiction products, both in print and in electronic media. Founded in 1807, the firm is the oldest publisher in the United States. In addition to its operations in this country, Wiley has publishing, marketing, and distribution centers in Canada, Europe, Asia, and Australia. Wiley serves a broad client and customer base that includes scientists, professionals, educators, students, and the general public.

Second Century Fund Vice Chair and GSA Past President Brian Skinner, upon learning of the Wiley grant, stated, "I am very pleased to acknowledge this financial support of GSA and the SAGE program. Wiley's identification of precollegiate geology teaching as an item of special interest is clear recognition of the need to increase awareness of Earth among our youth and an endorsement of the Society's expanding activities in that direction." ■

Some Thoughts About 1994 Taxes

If you itemize your deductions, charitable gifts made by midnight on December 31 of this year can save you taxes when it is time to pay the Internal Revenue Service next spring. It is important to note, however, that your gifts must all be delivered or at least be mailed by that time. Back-dated checks written while watching the Rose Bowl game will not qualify as a 1994 deduction.

If you do not always itemize because your deductions do not exceed the standard deduction, consider bunching deductions in one year. Concentrating a number of deductions in 1994 and then making use of the standard deduction in 1995 might optimize your tax situation.

There are several ways to make year-end gifts—cash (by means of a check), securities, or a planned gift of a future interest arranged in 1994. Deductions for cash gifts may be as much as 50% of 1994 adjusted gross income, and for gifts of appreciated property as much as 30%.

Tax rates are higher this year, particularly at the upper end of the income spectrum. Further, some Social Security recipients will be taxed on up to 85% of their income from this source. If you are going to be experiencing this higher rate phenomenon, consider an extra charitable gift, particularly if it will keep you from graduating to the next higher level. A gift of the source of income, an oil and gas royalty for example, is another way to deal with this problem.

Appreciated assets—one of the best giving devices around—still carry their double tax whammy. First, by donating securities or other property in which you have a capital gain, you receive a tax deduction in the amount of the entire value of the gift on the day of the contribution, not what you paid for the property. Second, the capital gain that you would have incurred had you sold stock and made a gift of the proceeds disappears. Think of this as a joint deal with the government—the IRS joins with you in making a gift to the GSA Foundation by allowing you to contribute the capital gains tax that it would have collected if you sold the stock. Can there be a better way to make a year-end gift?

Last but not least, planned gifts can be part of year-end tax planning, for any such arrangements completed prior to December 31 affect the current year's tax position. If 1994 has presented you with an unusually high income situation or if you are looking at building retirement income, one of the four planned gift vehicles may be appropriate—pooled income fund, charitable annuity trust, charitable remainder trust, and charitable gift annuity. All have common features that include an immediate tax deduction and a future income stream. And in each case, funding with appreciated securities will improve the net return on your out-of-pocket money.

Please call the Foundation office or mail the accompanying coupon to obtain further information or receive answers to your specific questions. Ask for Donna Russell, Dorothy Palmer, or Bob Fuchs. ■

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In Memoriam

George C. Hazenbush
Incline Village, New York

Robert J. Horodyski
New Orleans, Louisiana
September 2, 1994

Lynn C. Jacobson
Alburquerque, New Mexico
December 26, 1992

J. G. Johnson
Corvallis, Oregon

Arthur A. Meyerhoff
Tulsa, Oklahoma
September 18, 1994

Roland B. Mulchay
Salt Lake City, Utah

Ralph J. Newton
Berkeley, California
August 8, 1994

E. C. Olsen
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Elwyn L. Perry
East Harwich, Massachusetts
February 2, 1994

Carlos Schubert
Miami, Florida
July 22, 1994

John A. Stokley
Lexington, Kentucky
September 27, 1994

Norman S. Wagner
Bakersfield, California

Memorial Preprints

The following memorial preprints are now available, free of charge, by writing to GSA, P.O. Box 9140, Boulder, CO 80301.

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John D. Haun

Guillermo Zuloaga
Guillermo Rodriguez Eraso

David Arthur Andrews
A. Robert Kinkel

A. E. (Ted) Ringwood
David H. Green

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William A. Oliver, Jr., Stephen D. Cairns

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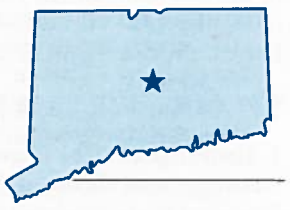
Carl Koteff, Wayne Newell

Final Announcement

NORTHEASTERN SECTION, GSA 30th Annual Meeting

Cromwell, Connecticut March 20–22, 1995



The University of Connecticut, Wesleyan University, and the Geological and Natural History Survey of Connecticut will host the Northeastern Section of the Geological Society of America Annual Meeting at the Radisson Hotel and Conference Center in Cromwell, Connecticut. The Eastern Section of SEPM, the Northeastern Section of the Paleontological Society (NE-PS), the New England Section of the National Association of Geology Teachers (NAGT), and the Association for Women Geoscientists will meet with GSA's Northeastern Section. The meeting will be conducted from 8:00 a.m. Monday, March 20, to 5:00 p.m. Wednesday, March 22. Field trips and short courses will be held on Saturday, March 18, Sunday, March 19, and Wednesday, March 22.

REGISTRATION

Anyone wishing to attend any of the technical sessions, exhibits, field trips, short courses, or the welcoming reception must register for the meeting. Registration may be accomplished in two ways: by returning the attached preregistration form with payment prior to February 28, 1995, or by registering at the information/registration desk on the day you arrive. You should be aware that spaces for some field trips, short courses, and special events are limited and may not be available at the time of on-site registration.

Preregistration. All participants are strongly encouraged to preregister as early as possible. Your preregistration form and payment must be received no later than February 28, 1995. Complete the attached preregistration form and return it with a check or money order in U.S. currency (payable to NE GSA '95) to Norman Gray, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045. Refunds on canceled preregistration will be made until February 28, 1995. No refunds will be made after that date except for canceled events. Preregistrants will be able to pick up their badges, tickets, meeting program, and other registration materials from a specially designated area at the information/registration desk in the lobby of the Radisson Hotel and Conference Center.

On-Site Registration. For those who cannot preregister, on-site registration will be available from 1:00 p.m. to 10:00 p.m. on Sunday, March 19; from 7:00 a.m. to 9:00 p.m. on Monday and Tuesday, March 20 and March 21; and from 7:00 a.m. to 12:00 noon on Wednesday, March 22, at the information/registration desk in the lobby of the Radisson Hotel and Conference Center.

The Northeastern Section of the GSA is unable to accept credit cards for preregistration. Visa and MasterCard will be accepted for on-site registration.

A limited quantity of *Abstracts with Programs* for the meeting will be available for purchase at the information/registration desk. To guarantee a copy, order one when you preregister.

LOCATION

The Radisson Hotel and Conference Center is on Route 372 just east of Exit 21 off Interstate I-91, 10 miles south of Hartford and 5 miles northwest of Middletown. The Hartford-Middletown area is serviced by Interstate routes I-91 and I-84, which intersect in Hartford and provide convenient and easy highway access from any site in the northeast United States. New York and Boston are each less than a 2-hour drive away. I-91 runs north from New Haven through the states of Connecticut, Massachusetts, and Vermont to the Canadian border; it intersects the Massachusetts Turnpike near Springfield, Massachusetts, which runs west to New York state and east to Boston. I-84 diagonally bisects the state and connects New York and Boston. Bradley International Airport, 22 miles north of Cromwell, is served by 18 commercial carriers offering "same plane" service from 65 U.S. and Canadian cities. Scheduled shuttle service is available to the meeting site at the Cromwell Radisson. Daytime temperatures during March range from the 30s to the 60s (°F); any combination of rain, snow, sleet, and sunshine should be expected.

ACCESS FOR THE DISABLED

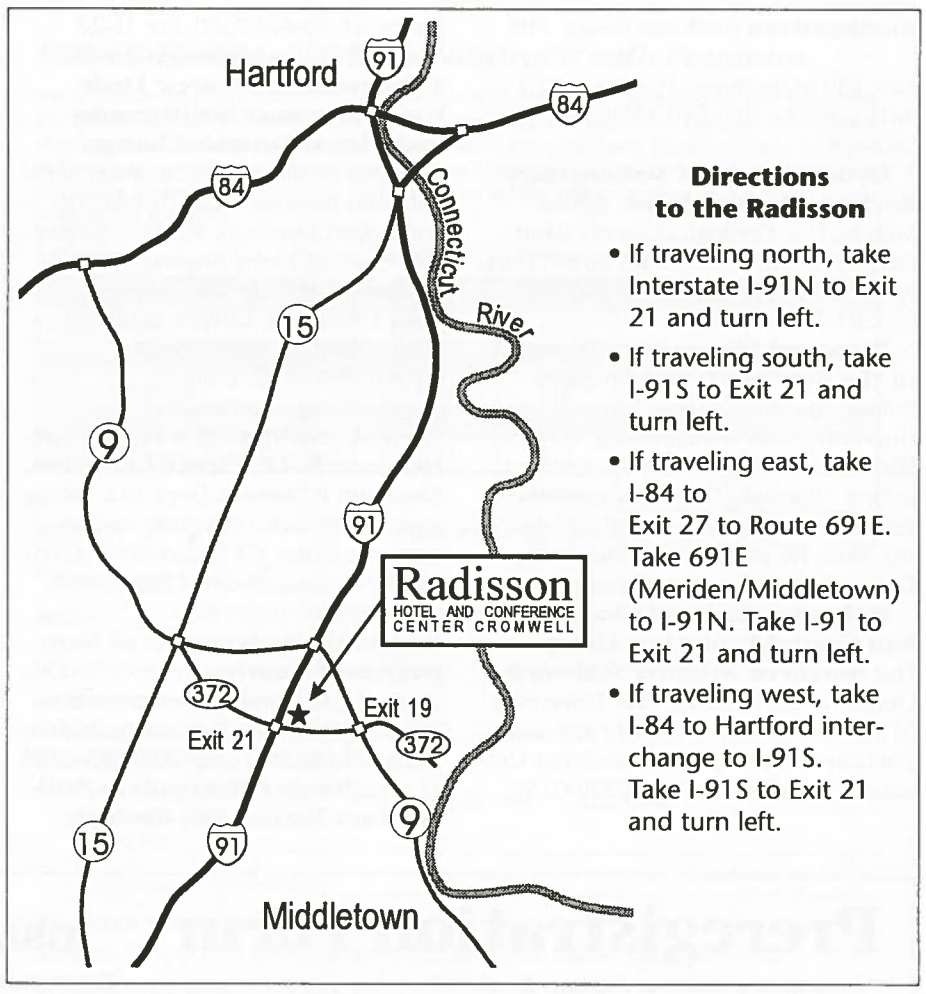
All technical sessions in the Radisson Hotel and Conference Center will be fully accessible to the disabled. Anyone with special needs intending to attend the meeting is urged to contact the meeting organizers as soon as possible.

TECHNICAL PROGRAM

The technical program will begin on Monday, March 20, and end at noon on Wednesday, March 22. Two screens, two 35 mm Kodak slide projectors, and one overhead projector will be available at each oral session. Authors are encouraged to bring their slides already loaded into circular trays (Kodak carousel type). A speaker-ready room will be available for previewing slides. If required, additional carousel trays may also be signed out from the speaker-ready room. The booths for the poster presentations will be 8 x 8 feet in area and will contain three 4 x 8 foot sheets on which thumbtacks, pushpins, or tape may be used. *Electrical outlets and tables will not be available in the poster booths unless specifically requested well in advance.*

Questions and suggestions regarding the audio-visual equipment and format of the technical sessions should be addressed to Raymond Joesten, Abstracts Coordinator, Department of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-4435, fax 203-486-1383, E-mail: joesten@geol.uconn.edu.

In addition to general technical sessions dealing with all disciplines of geology and related fields such as water resources, hydrology, and environmental science, the following special symposia and theme sessions are planned for the Cromwell meeting.



Directions to the Radisson

- If traveling north, take Interstate I-91N to Exit 21 and turn left.
- If traveling south, take I-91S to Exit 21 and turn left.
- If traveling east, take I-84 to Exit 27 to Route 691E. Take 691E (Meriden/Middletown) to I-91N. Take I-91 to Exit 21 and turn left.
- If traveling west, take I-84 to Hartford interchange to I-91S. Take I-91S to Exit 21 and turn left.

Symposia

1. **The Newark Supergroup: New Results from Old Rifts.** *Sponsored by the Eastern Section of SEPM.* Co-conveners: Elizabeth Gierlowski-Kordesch, Ohio University; and Bruce M. Simonson, Oberlin College. Contact Elizabeth Gierlowski-Kordesch, Dept. of Geological Sciences, Ohio University, Athens, OH 45701, (614) 593-1101, fax 614-593-0486, E-mail: gierlowski@ouvaxa.cats.ohiou.edu.
2. **Investigative Techniques for Contaminated Site Characterization.** *Sponsored by the Connecticut Ground-Water Association.* Dennis Waslenchuk, ALTA Environmental Corporation, 7 South Main Street, Marlborough, CT 06447, (203) 295-1377.
3. **The Petrology and Geochemistry of Archeological Materials.** *Sponsored by the Northeastern Anthropological Association.* Barbara L. A. Calogero, Dept. of Anthropology, University of Connecticut, Storrs, CT 06269-2179, (203) 486-3851, fax 203-486-1383.
4. **Biotic Responses to Tectonic-Environmental Events.** *Sponsored by the Northeastern Section of The Paleontological Society.* Constance M. Soja, Dept. of Geology, Colgate University, Hamilton, NY 13346, (315) 824-7200, fax 315-824-7187, E-mail: csoja@center.colgate.edu.
5. **Chronology and Paleoenvironmental Record of the Last Deglaciation of New England.** Co-conveners: Janet Radway Stone, U.S. Geological Survey, and Gail M. Ashley, Rutgers University. Contact Janet Radway Stone, U.S. Geological Survey (Hartford), Room 525, 450 Main Street, Hartford, CT 06103-3013, (203) 240-3060, fax 203-240-3783.
6. **Mesozoic Paleontology and Ecology.** Nicholas G. McDonald, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 658-4444.

THEME SESSIONS

Scheduled theme sessions are listed below with the conveners.

1. **Magmatism Associated with Mesozoic Rifting in Eastern North America.** Co-conveners: Anthony R. Philpotts and J. Gregory McHone. Contact J. Gregory McHone, Graduate Liberal Studies Program, Wesleyan University, Middletown, CT 06459-0519, (203) 685-3339, E-mail: jmchone@willet.wesleyan.edu.
2. **Geology of the Central Appalachian Piedmont: Tenth Annual Workshop.** Mary Louise Hill, Dept. of Geology, Temple University, Philadelphia, PA 19122, (215) 204-8226, fax 215-204-1532.
3. **Lithotectonic Terranes in the Northern Appalachians: Evidence from Structure, Petrology, Geochemistry, Geophysics, and Paleontology.** Robert P. Wintsch, Dept. of Geological Sciences, Indiana University, Bloomington, IN 47401, (812) 855-4018, E-mail: wintsch@ucs.indiana.edu.
4. **New or Innovative Applications of Geophysical Data to Environmental Studies.** Co-conveners: S. Peter Haeni, U.S. Geological Survey, and John Williams, U.S. Geological Survey. Contact S. Peter Haeni, U.S. Geological Survey (Hartford), Room

Northeastern *continued on p. 306*

REGISTRATION FEES

	Advance*		On site	
	Full Meeting	One day	Full Meeting	One day
Professional—Member	$60	$45	$75	$45
Professional—Nonmember	$75	$40	$90	$50
Student—Member	$20	$20	$25	$25
Student—Nonmember	$30	$30	$35	$35
K–12 Earth Science Teachers	$30	$15	$35	$35
Guest/Spouse	$15	$15	$15	$15

Deadline is February 28, 1995.

Northeastern *continued from p. 305*

525, 450 Main Street, Hartford, CT 06103-3013, (203) 240-3299, fax 203-240-3783.

5. **Hydrogeology of Sedimentary Rocks in the Northeast.** Robert Melvin, U.S. Geological Survey (Hartford), Room 525, 450 Main Street, Hartford, CT 06103-3013, (203) 240-3060, fax 203-240-3783.

6. **Rock and Mineral Ore Deposits in the Northeast.** Co-conveners: Robert Altamura, Pennsylvania State University, and William Kelly, New York State Geological Survey. Contact Robert Altamura, Dept. of Geosciences, Pennsylvania State University, University Park, PA 16802, (814) 863-1665, E-mail: boba@gaia.essc.psu.edu.

7. **Holocene Sea Level Changes and Coastal Evolution Along the Northern Atlantic Seaboard.** Orson van de Plassche, Free University of Amsterdam, c/o Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06359-0139, phone 31-20-444-7380, fax 31-20-646-2457, E-mail: plao@geo.vu.nl.

8. **Biogenic Structures: Their Use in Sequence Stratigraphy and Global Eustatic Change.** *Sponsored by the Eastern Section of SEPM.* Kathleen Browne, Rider University, and Robert Demicco, SUNY-Binghamton. Contact Kathy Browne, Dept. of Geological and Marine Sciences, Rider University, Lawrenceville, NJ 08648-3099, (609) 895-5408, fax 609-895-5782, E-mail: browne@enigma.rider.edu.

9. **The Usefulness of a Field Experience in K–12 Science Curricula.** Randolph P. Steinen, Dept. of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-1390, fax 203-486-1383, E-mail: steinen@geol.uconn.edu.

10. **The Hydrodynamics of New England Estuaries.** Peter C. Patton, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 685-2208.

11. **Freshwater Wetlands as Sedimentary Basins: The Geologic Record.** Co-conveners: Robert M. Thorson, University of Connecticut, and William Neiring, Connecticut College. Contact Robert M. Thorson, Dept. of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-4434 , fax 203-486-1383, E-mail: thorson@geol.uconn.edu.

SPECIAL POSTER SESSIONS

1. **Undergraduate Research in Geology and Related Fields.** *Sponsored by the Geology Division, Council on Undergraduate Research.* Larry Malinconico, Office of the Provost, Lafayette College, Easton, PA 18042, (610) 250-5070, E-mail: malincol@lafvax.lafayette.edu.

NOTE: Papers submitted to the Undergraduate Research Poster Session must be so designated on the abstract form. Posters may be coauthored by graduate students, faculty members, or other professionals.

2. **Side Scan Images of Coastal New England and New York.** Co-conveners: Suzanne O'Connell, Wesleyan University, and Ralph Lewis, Connecticut Geological Survey. Contact Suzanne O'Connell, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459-0139, (203) 685-2262, E-mail: soconnell@eagle.wesleyan.edu.

PANEL DISCUSSION AND PUBLIC FORUM

Remediating Groundwater Contamination: Have We Been Wasting Our Time or Is There Hope? Gary A. Robbins, Dept. of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-1392, fax 203-486-1383. Monday, March 20, 7:00 p.m. to 9:30 p.m.

EVENING DISCUSSION (KEG) AND POSTER SESSION

Toward New State Surficial and Bedrock Maps. Sponsored by the Geological and Natural History Survey of Connecticut.

Co-conveners: Ralph Lewis, Connecticut Geological Survey, and O. Don Hermes, University of Rhode Island. Contact Ralph Lewis, Connecticut Geological Survey, 1084 Shennecossett Road, UConn, Avery Point, Groton, CT 06340, (203) 445-3473. Monday, March 20, 7:00 p.m. to 9:30 p.m.

STUDENT AWARDS

Awards will be given for the best paper and best poster presentation by a student. Although the name of the faculty mentor may appear as the junior author, the major part of the paper or poster session must represent original work by the student. NOTE: Papers submitted by students must be so designated on the abstract form.

SHORT COURSES

Two short courses are planned for the Connecticut meeting. The courses are scheduled for Sunday, March 19, and Wednesday afternoon, March 22. Preregistration is required.

Digital Geologic Mapping Using CARIS, MS Windows and GEMM. Henk W. Van De Poll and Paul F. Williams, Dept. of Geology, University of New Brunswick, Fredericton, NB E3B 5A3, Canada, (506) 453-4803, fax 506-453-5055. March 19, 9:00 a.m. to 5:00 p.m., Room 233, Beach Building, Dept. of Geology and Geophysics, University of Connecticut, Storrs. Cost: $100.

The advantages of computer-based geological mapping to facilitate map production, map maintenance (updates), and map output (color printer or plotter) are becoming increasingly recognized by practicing geologists throughout the world. Digital geological maps also allow quick integration of map data with other earth science data in digital format (for example, geophysics, geochemistry, and satellite imagery) as well as database information.

Participants of the course will be shown the use of the commercially available CARIS (Computer Aided Resource Information System), GEMM (Geological Mapping Module) developed by geologists for geologists at the Department of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada. Contents of the one-day course will include the following: brief introduction to geographic information systems and digital geological mapping—their place and use in modern geology as an integrative

Northeastern *continued on p. 307*

Preregistration Form

GSA Northeastern Section

Cromwell, Connecticut • March 19–22, 1995

Preregistration deadline: February 28, 1995.
(No refunds after February 28, 1995.)

Please print clearly. This area is for your badge.

Name as it should appear on your badge

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City State

Mailing Address

City State ZIP Code

Country (if other than USA)

( ) ( ) ( )
Business Phone fax Home Phone

Please indicate if you will need services to accommodate a disability ☐ Yes

Circle member affiliation (to qualify for registration discount):
☐ GSA Member #_____, ☐ NAGT, ☐ PS, ☐ SEPM, ☐ AWG, ☐ CESTA, ☐ CGA

Guest Information. Please print clearly. This area is for your badge.

Name as it should appear on your badge

City/State or Country

REGISTRATION	BY FEBRUARY 28 Full Meeting	BY FEBRUARY 28 One Day	ON SITE Full Meeting	ON SITE One Day	Qty	Amount
Professional Member	$60 ☐	$35 ☐	$75 ☐	$45 ☐	1	$_____
Professional Nonmember	$75 ☐	$40 ☐	$90 ☐	$50 ☐	1	$_____
Student Member*	$20 ☐	$20 ☐	$25 ☐	$25 ☐	1	$_____
Student Nonmember	$30 ☐	$30 ☐	$35 ☐	$35 ☐	1	$_____
K–12 Teacher	$30 ☐	$15 ☐	$35 ☐	$15 ☐	1	$_____
Guest/Spouse	$15 ☐	$15 ☐	$15 ☐	$15 ☐	____	$_____

SPECIAL EVENTS			
Welcoming Reception	FREE	1	$_____
NAGT Business Meeting and Luncheon	$ 15	1	$_____
Association for Women Geoscientists Breakfast	$ 12	1	$_____
Paleontological Society Luncheon	$ 15	1	$_____
Northeast Section Reception and Banquet			
Cornish Game Hen	$ 27	1	$_____
Filet of Sole	$ 27	1	$_____

FIELD TRIPS			
1. Paleoenvironmental Traverse Across the Early Mesozoic Hartford Rift Basin	$ 20	1	$_____
2. Lithotectonic Terranes in South-Central New England	$ 20	1	$_____
3. Travels on the Long Tidal River: Quaternary History and Geology of the Connecticut River	$ 60	1	$_____
4. Lake Sequences in the Central Hartford Basin, Newark Supergroup, Connecticut	$ 20	1	$_____
5. Window into the Holyoke: The Tilcon Traprock Quarry, North Branford, Connecticut	$ 20	1	$_____
6. Tectonics, Wall-rock Alteration and Emplacement History of the Lantern Hill Giant Quartz Load, Avalonian Terrane, Southeastern Connecticut	$ 20	1	$_____

SHORT COURSE			
1. Digital Geological Mapping Using CARIS, MS Windows, and GEMM	$100	1	$_____
2. The Electronic Total Station—A Versatile, Revolutionary New Geologic Mapping Tool	$ 20	1	$_____

TOTAL FEES ..... **$**_____

Remit in U.S. funds payable to: 1995 GSA Northeastern Section Meeting
(All preregistrations must be prepaid. Purchase Orders or credit cards not accepted.)

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MAIL TO: NORMAN GRAY
Department of Geology and Geophysics
University of Connecticut
354 Mansfield Road
Storrs, CT 06269-2045

Northeastern *continued from p. 306*

technology; data entry to produce a geological map using the CARIS-GEMM; topology, color fill, legends, borders, etc., of the geological map; and demonstration of a GIS (CARIS) in a typical mineral exploration setting showing the integration of air photo, geological, geophysical (airborne and ground), geochemical, trenching, and diamond drilling results of the Nugget Pond gold prospect, Newfoundland.

The Electronic Total Station—A Versatile, Revolutionary New Geological Mapping Tool. Norman H. Gray, Anthony R. Philpotts and Randolph P. Steinen, Dept. of Geology and Geophysics, University of Connecticut, Storrs, CT 06269-2045, (203) 486-4435, fax 203-486-1383. Wednesday, March 22, 1:00 p.m. to 5:00 p.m., Radisson Hotel and Conference Center. Cost: $20.

Electronic total stations are now used almost exclusively for routine engineering surveys, but they have not yet been used widely in geology despite their obvious potential and the fact that the equipment is now no more expensive than a plane table alidade. Many geological features such as outcrops and geological contacts are irregular and require large numbers of surveyed points for accurate definition. This type of detail can now be collected rapidly with centimeter accuracy and stored in portable computers with electronic total stations. The data, which can be output as x, y, and z coordinates, can be employed in the field not only to construct geological maps, but also to determine the attitude of layering and the orientation of linear features, to determine stratigraphic height for section measurement, and to plot directly the profile view of folded structures. The data can also be transferred to geographic information systems (GIS) for computer-assisted cartography. The instruments are easily operated, require less skill and practice than their predecessors (the chain, transit, and plane table), and are much easier to teach to students. The significant increase in accuracy and amount of data on geological maps made with a total station is likely to open up entirely new ways of quantifying and analyzing geological structures.

This course will explain the operation of modern electronic surveying equipment and provide hands-on experience with the range of instruments available, including a "one-man" total station and field portable data-loggers. Participants will have an opportunity to experiment with a Visual Basic/Excel program, which completely automates the total station measurements, subsidiary calculations, and plotting for "plane-table"–type geological mapping, strike and dip determination, section measurement, and profile view construction.

FIELD TRIPS

Six field trips are planned. The actual trips run will depend on weather conditions and sufficient registrations. In the event of cancellations, field trip registrations will be refunded. To keep costs as low as possible, several field trips will depend on most participants providing their own transportation or sharing vehicles. Limited seats in UConn vans will also be available. When you register, please state whether or not you can provide transportation for yourself and/or others. Field trip registration fees cover miscellaneous and special expenses, as well as a complete guide to all of the field trips. Food is extra for all trips.

If you are not familiar with Connecticut, you will be impressed by its handsome old houses, densely wooded regions, and great contrasts between urban and country settings. Connecticut weather in March can be mild and dry (60s and sunny) or cold, wet, and blustery. Snow is rare but possible during March. It is usually a good season to do geology, but dress appropriately. All trips will depart and return to the Radisson Hotel and Conference Center in Cromwell. You should assemble in the lobby or in the parking lot in advance of the time of departure.

1. **Paleoenvironmental Traverse Across the Early Mesozoic Hartford Rift Basin.** Nicholas G. McDonald and Jelle Z. de Boer, c/o Nick McDonald, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459, (203) 658-4444. Saturday, March 18, 8 a.m. to 5 p.m. Car/van pool. Cost: $20 (includes guidebook).

Following sections of a two-day trip described in the field guide, we visit important sites from east to west across the classic Mesozoic Connecticut Valley basin. Our focus is on the volcanic and nonmarine sedimentary rocks that can be used to reconstruct the sedimentary and tectonic paleoenvironments of the Late Triassic to Early Jurassic landscape. Stops are planned in the coarse clastic facies of the thick New Haven and Portland arkoses as well as the intermediate sequences among basalt flows, which show proximal alluvial fan and mid-fan facies; distal fan and lakeshore facies; alternating shallow-to-deep lacustrine facies; basalt flows; playa and shoreline facies; alluvial plain facies; and the unconformable and faulted western margin of the basin. We also address significant tectonic events of the basin as revealed during the trip and from other studies.

2. **Lithotectonic Terranes in South-Central New England.** Robert P. Wintsch, Dept. of Geological Sciences, Indiana University, Bloomington, IN 47405, (812) 855-4018, E-mail: wintsch@ucs.indiana.edu. Sunday, March 19, 7:30 a.m. to 6:00 p.m. Cost: $20 (includes guidebook).

On this one-day field trip we will examine the amphibolite to lower granulite facies rocks from the five easternmost terranes of New England: Avalon, Putnam-Nashoba, Merrimack, Central Maine, and Bronson Hill. Nine stops are planned, at least one in each terrane, which emphasize the typical lithologies and structures of each terrane. We will also examine rocks at or near two terrane boundaries, exploring the differences in appearance of variably metasomatized premetamorphic, synmetamorphic, and postmetamorphic ductile fault zones. The trip will include some of the stops from days 1 and 2 of the Boston GSA trip, crossing the Willimantic window, and the Glastonbury dome.

Discussions will focus on the regional significance of the local structural and metamorphic history of the rocks exposed at each stop. Arguments will be based, in part, on the application of thermochronologic and geochronologic data from the $^{40}Ar/^{39}Ar$ and U/Pb systems (much of it unpublished) from many individual stops. These and other structural, petrologic, and geochemical data will be used to build the case that these terranes were assembled in a hinterland propagating stack of thrust nappes during the Alleghanian, and that the final docking of Avalon was delayed until Alleghanian time.

The trip leaves at 7:30 a.m. from the Radisson Hotel and Conference Center lobby and will return by 6:00 p.m. Lunch is not provided, but fast food and hot coffee will be available for purchase at midday.

3. **Travels on the Long Tidal River: Quaternary History and Geology of the Connecticut River.** Suzanne O'Connell and Janet Radway Stone, c/o Suzanne O'Connell, Dept. of Earth and Environmental Sciences, Wesleyan University, Middletown, CT 06459, (203) 685-2262, E-mail: soconnell@eagle.wesleyan.edu. Sunday, March 19, 11:00 a.m. to 6:00 p.m. Car/van pool to the boat dock, then travel by chartered boat. Cost: $60 (includes guidebook) plus food (available on boat).

The historic Connecticut River remains mostly undeveloped along its lower sections. As it cuts across terrane boundaries from the Mesozoic rift valley into the Avalon at Long Island Sound, the river also exposes surficial and morphological features that record the last glaciation and river development. In addition, new shallow seismic and sonar techniques are revealing the materials and structures of the river basin itself. This trip uses a large, 149 passenger, heated boat especially chartered and equipped for participants who relish river geology and scenery. A running description and discussion of quaternary glacial and fluvial features will be presented, and research equipment will be demonstrated. The equipment includes state-of-the-art (digital with Chirp acoustics) side-scan sonar and sub-bottom profiler. For the cost of reproduction, participants can get printouts of side-scan images that show sandwaves, erosive surfaces, and boulders.

4. **Lake Sequences in the Central Hartford Basin, Newark Supergroup, Connecticut.** *Sponsored by the Eastern Section of SEPM.* Elizabeth Gierlowski-Kordesch and Phillip Huber, c/o Elizabeth Gierlowski-Kordesch, Dept. of Geological Sciences, Ohio University, Athens, OH 45701, (614) 593-1101, fax 614-593-0486, E-mail: gierlowski@ouvaxa.cats.ohiou.edu. Sunday, March 19, 8:00 a.m. to 5:30 p.m. Car/van pool. Cost: $20 (includes guidebook). Limit: 20

This trip will lead participants through lake sequences of the Jurassic Shuttle Meadow, East Berlin, and Portland Formations, which crop out in the central part of the Hartford Basin. Facies analyses and paleoenvironmental interpretation of the lake deposits and associated alluvial sequences will be examined. Additional information on the geologic and tectonic overview of the Hartford and nearby Pomperaug Basins will be supplied for discussion of basin analysis. Lunch is not included; we will have a lunch stop at Cromwell. Some walking will be required. Dress warmly!

5. **Window into the Holyoke: The Tilcon Traprock Quarry, North Branford, Connecticut.** *Sponsored by Tilcon Connecticut Inc.* J. Gregory McHone and Anthony R. Philpotts, c/o Greg McHone, GLSP, Wesleyan University, Middletown, CT 06459-0519, (203) 685-3339, fax 203-685-2901, E-mail: jmchone@willet.wesleyan.edu. Sunday, March 19, 1:00 p.m. to 4:30 p.m. Motorcoach. Cost: $20 (includes guidebook).

The middle formation of the three great flood basalts of southern New England (the Talcott, Holyoke, and Hampden) has provided crushed stone (traprock) for many major construction projects. The enormous (3-mile) face in the North Branford quarry of the Tilcon company reveals several coarse and fine-grained phases of the Holyoke basalt. The minerals and internal structures of this tholeiite, and its fantastic hummocky contacts with radiating columns between flows, are sure to provoke some stimulating discussions. Tilcon has generously sponsored a motorcoach bus for transportation. Their impressive operation and spectacular basalt cuts will be memorable.

6. **Tectonics, Wall-rock Alteration and Emplacement History of the**

Northeastern *continued on p. 308*

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Meeting	Deadline	Price	Quantity	Amount
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North-Central/South-Central	3/1/95	$15		$
Rocky Mountain	3/14/95	$10		$
Cordilleran	3/23/95	$10		$
Annual Meeting (New Orleans)	8/17/95	$22		$
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ON-SITE PURCHASES may be made in the registration area. Supplies may be limited.

Due to prohibitive postal costs and delays in overseas mailings, this offer for the advance copies is for U.S., Canada, and Mexico only.

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Lantern Hill Giant Quartz Lode, Avalonian Terrane, Southeastern Connecticut. Robert Altamura, Dept. of Geosciences, Pennsylvania State University, University Park, PA 16802, (814) 863-1665, E-mail: boba@essc.psu.edu. Sunday, March 19, 10:00 a.m. to 5 p.m. Car/van pool. Cost: $20 (includes guidebook).

The purpose of this field trip is to consider petrologic and tectonic characteristics of the Mesozoic Lantern Hill fault, and its associated giant quartz lode and altered wall rocks. New research has characterized extensional deformation along the most highly silicified part of the Lantern Hill fault zone, a regional fault whose major tectonic activity during the Middle Triassic preceded, by 19 million years, the earliest sedimentation in the Hartford rift basin. We will examine the emplacement history of at least nine episodes of quartz veining, which, based on plateau ages for muscovite, range in age from 255 to 238 Ma. Considerations include placing mineralization and coeval faulting into the plate tectonic framework of the southern New England Appalachians, especially the embryonic opening of the Atlantic Ocean.

The trip is planned as a leisurely day that will include a lunch break and refreshments at the end of the day atop Lantern Hill. Hiking is involved. Lantern Hill is the highest elevation on the coastal slope of Connecticut and on a clear day yields panoramic views of 30 miles or more across Long Island Sound. NOTE: Hard hat, steel-toed boots, and safety glasses are required while in the open pit quarry area.

EXHIBITS

Companies or organizations wishing to display or sell scientific equipment, publications, or other products, services, or public relations materials may rent a display area for the duration of the meeting. To attract interest, the exhibits area will share space in the Main Ballroom of the Radisson Hotel and Conference Center with the technical poster sessions. The 8 x 8 foot booths framed with 8-foot-high rear and 3-foot side drapes are available at $250 for commercial exhibitors and at $150 for educational or nonprofit groups or institutions. A table, two chairs, and a company sign will also be provided. The exhibit area will be open from 8:00 a.m. to 6:00 p.m. on Monday and Tuesday, March 20 and 21, and from 8:00 a.m. to 12:00 noon on Wednesday, March 22. The application deadline for exhibit space is February 28, 1995. Information and an exhibitors' brochure can be obtained from Milly Powell, Dept. of Geology and Geophysics, University of Connecticut, (203) 486-1382, fax 203-486-1383, E-mail: powell@geol.uconn.edu. Space will be allocated on a first-come, first-served basis.

PRIVATE RECEPTIONS

Arrangements can be made for alumni reunions, organizational get-togethers, and other private receptions during the meeting. To ensure that space is reserved, contact Milly Powell, Dept. of Geology, University of Connecticut. (203) 486-1382, fax 203-486-1383, E-mail: powell@geol.uconn.edu.

GUEST ACTIVITIES

The Hartford-Middletown area offers a wide variety of activities that may be of interest to guests, including the Mark Twain House and the Wadsworth Athenaeum Museum. There are a large number of additional museums and attractions within a 1–2 hour drive of Cromwell, including the Peabody Museum of Natural History, Mystic Seaport, and Sturbridge Village. Gamblers may appreciate the huge new casino at the Mashantucket-Pequot Reservation in southeastern Connecticut. Brochures, printed information, and a knowledgeable volunteer will be available at the NE-GSA information/registration desk to assist guests with sightseeing plans.

EARTH SCIENCE EDUCATION

Special activities are contemplated for K–12 and college earth science educators. The Connecticut Earth Science Teachers Association (CESTA) will staff a "classroom" in which new videos and educational software will be both demonstrated and available for previewing. A late afternoon symposium, "Usefulness of a field experience in the K–12 science curricula," and an evening K–12 teachers forum are planned at the Dinosaur State Park facility in Rocky Hill at which David Fastovsky will deliver a keynote address entitled "In the Tracks of Dinosaurs." Following the address, a CESTA panel will discuss the types of lesson plans that might be based on trackways and other field-oriented activities. To encourage attendance, a special, reduced one-day registration fee will be available to K–12 teachers.

ACCOMMODATIONS

A large block of rooms has been reserved for meeting participants and their guests at the Radisson Hotel and Conference Center in Cromwell, Connecticut. The hotel has ample free parking for all participants and is conveniently located just east of Exit 21 off I-91. All of the meeting exhibits will be located within the hotel building. For conference planning and to take advantage of attractive conference room rates, it is important to reserve your room before February 28, 1995. Guaranteed rates, which include applicable taxes, are $80.64 single, $80.64 double, $91.84 triple, or $103.04 for four persons.

SPECIAL EVENTS

NE-GSA Section Management Board Meeting. Sunday, March 19, 4:30 p.m. to 6:30 p.m. in Room 101, Radisson Hotel and Conference Center.

Welcoming Reception. An opening icebreaker will be held in the garden/ lower mezzanine/poolside area of the Radisson Hotel and Conference Center, Sunday, March 19, from 6:30 p.m. to 10:00 p.m. Liquid refreshments and hors d'oeuvres will be served. If renovations of the nearby Dinosaur State Park at Rocky Hill have been completed, shuttle buses will run to and from the park throughout the reception for those interested in viewing the outstanding trackways preserved there.

New England Section of NAGT Business Meeting and Luncheon. Monday, March 20, 12:00 noon to 1:15 p.m. Cost: $15; preregistration is required.

Eastern Section of SEPM Business Meeting. Monday, March 20, immediately following the last talk of the SEPM symposium, "The Newark Supergroup: New Results from Old Rifts." Refreshments will be served. The meeting is open to all SEPM members.

Association for Women Geoscientists Breakfast. Tuesday, March 21, 6:45 a.m. to 8:30 a.m. Cost: $12, preregistration is required.

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Housing Form

Code: AGEO
Date: 3/19–22/95

Radisson Hotel and Conference Center
Cromwell, Connecticut

Northeastern Section • Geological Society of America
Sunday, March 19–Wednesday, March 22, 1995

Arrival Date _____ Departure Date _____
Arrival Time _____ ☐ Car ☐ Airplane (flight number) _____

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*First night's deposit or credit information must accompany reservation. Credit card deposits will be processed 14 days prior to arrival. Refund of deposit will only be honored 14 days prior to arrival.
*Rooms may not be available for occupancy until 3 p.m. on the day of arrival. Check out time is 12:00 noon.
*If your reservation is not received by February 28, 1995, availability cannot be guaranteed.

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Send this form and remittance or credit card information to:
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Radisson Hotel and Conference Center
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CALL FOR APPLICATIONS AND NOMINATIONS FOR GSA BOOKS SCIENCE EDITOR

GSA solicits applications and nominations of persons qualified to serve as GSA Books Science Editor. The term of the current Editor will end December 31, 1995, and the new Editor will begin a three-year term at that time.

This is not a salaried position, but GSA pays expenses for secretarial assistance, mail, telephone, and copying and for travel to meetings of the GSA Publications Committee. The GSA headquarters staff handles copyediting and production of books from accepted manuscripts.

Interested persons should submit a vita, a list of publications, and a letter describing relevant qualifications, experience, and objectives. Nominations should include a letter and the nominee's written permission, vita, and publications list. Applications and nominations should be sent BEFORE FEBRUARY 15, 1995, to:

Donald M. Davidson, Jr., Executive Director
Geological Society of America
P.O. Box 9140
Boulder, CO 80301

Duties

- Encourage submission of appropriate manuscripts or collections of manuscripts to GSA for publication as a Memoir or Special Paper.
- Respond to inquiries, oral or written, about possible manuscripts.
- Inform prospective authors and volume editors about GSA policies and procedures.
- Appoint volume editor(s) and supervise selection of reviewers for multi-paper volumes.
- Select and recruit reviewers for single-paper volumes; send out manuscripts for review. Advise author(s) about necessary revision.
- Inform volume editors on procedures for review and revision of papers.
- Review each proposed volume upon receipt of final draft from author(s) or volume editors(s). If volume is up to standard, forward it to GSA headquarters with a recommendation for publication.
- Keep the GSA Committee on Publications and the headquarters staff informed about the flow of manuscripts and other GSA book business.

The GSA Books Science Editor should have

- Strong, broad background in geological sciences.
- Good organizational and English language skills.
- Willingness to invest the necessary time (up to 20 hours/week).
- Familiarity with many earth scientists and their work.
- Ability to make decisions.
- Perspective on trends in the geosciences and objectivity regarding subject matter .
- Patience, courtesy, and tact in dealing with authors and editors.
- Persistence in finding and recruiting suitable reviewers.

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Northeast Section of the Paleontological Society Luncheon. Tuesday, March 21, 12:00 noon to 1:30 p.m. Cost: $15; preregistration is required.

Annual Northeastern Section GSA Reception and Banquet. Tuesday, March 21, 7:00 p.m. to 9:00 p.m. Following dinner, John H. Ostrom will speak on "The Origin of Birds and Avian Flight." Banquet cost: $27; advance registration is required. The doors will be opened following the banquet in order that Ostrom's after-dinner talk may be heard by all.

FURTHER INFORMATION

The preregistration form and full payment must be received by the preregistration deadline of February 28, 1995. All forms received after February 28, 1995, regardless of when they were postmarked, will be held for on-site processing. We recommend that you copy the filled-out form for your records before mailing. An accompanying guest is defined as a non–earth scientist spouse or friend of a professional or student. Accompanying guests may attend social functions, but not technical sessions. Students must show a current student ID to obtain student rates. Students not having a current student ID when registering on-site or picking up their registration kit at the preregistration area will be required to pay the professional fee. Delegates who wish to attend only a short course or field trip must pay at least the one-day registration fee. Badges must be worn for access to all activities, Saturday, March 18, through Wednesday, March 22. Registration fees do not include provisions for the insurance of participants against personal accidents, sickness, theft, or property damage. Participants and accompanying guests are advised to take out whatever insurance they consider necessary. ■

1995 GeoVentures

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

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Ground transportation	Provided by participants	Provided by GSA
Physical requirements	None	May be physically demanding
Education	Daily classroom programs and field excursions	Informal, outdoor field instruction

GeoHostels

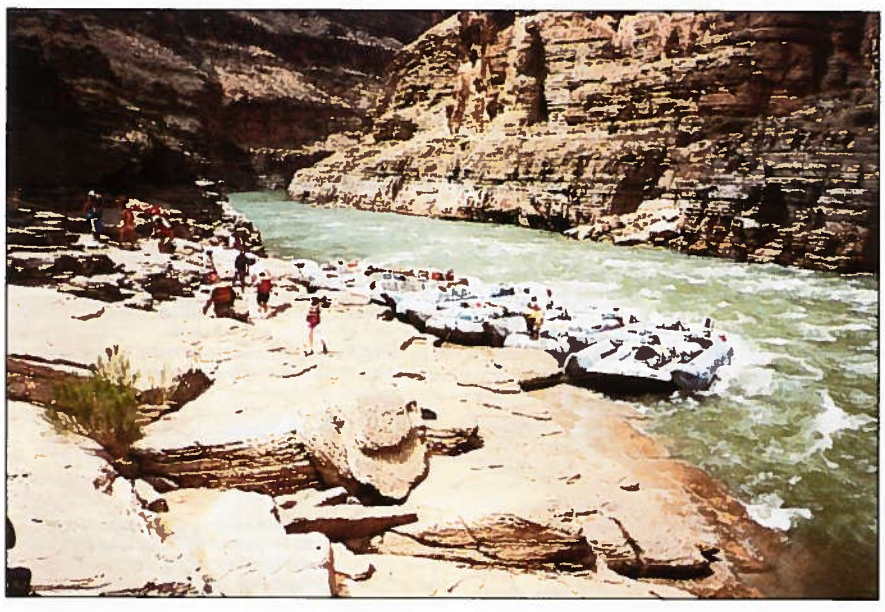
The Geological History of Southwestern Montana

Western Montana College
Dillon, Montana
Leader: Robert Thomas, *Western Montana College*
JUNE 17–22

Geology and Hydrogeology of Northern Colorado: Dinosaur National Monument to Steamboat Springs

Colorado Mountain College
Steamboat Springs, Colorado, and Vernal, Utah
Leaders: Gregory Holden and Kenneth Kolm, *Colorado School of Mines*
JUNE 24–29

GeoTrips



Tie-up at Havasu. *Photo by Andy Griscom.*

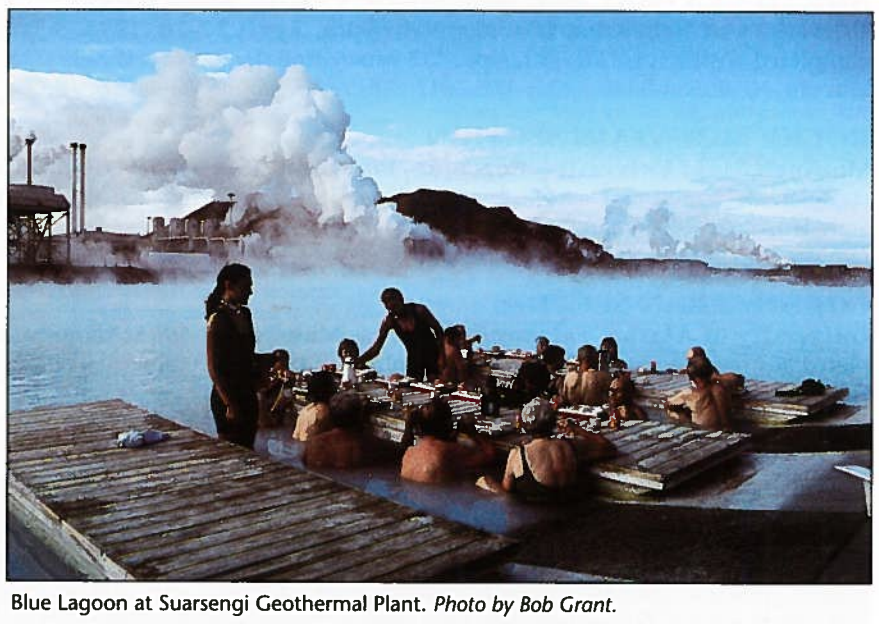
Grand Canyon

Lees Ferry down river to Pearce ferry
Takeout and return to Las Vegas
Leaders: Ivo Luchitta, *USGS—Flagstaff*
Stan Beus, *Northern Arizona University, Flagstaff*
APRIL 21–28

For details contact the GeoVentures Coordinators today:
Phone: 1-800-472-1988 ext. 134 or 141, or (303) 447-2020
E-mail: ecollis@geosociety.org *or* mball@geosociety.org
Fax: 303-447-0648

Space will go quickly, so get in touch with us today if you are interested. Detailed information on itineraries, registration fees, and travel arrangements will be sent on request. Obligation free. Questions welcomed.

Full Information in January *GSA Today*



Blue Lagoon at Suarsengi Geothermal Plant. *Photo by Bob Grant.*

Iceland

Volcanoes and Glaciers
Leader: Haraldur Sigurdsson, *Graduate School of Oceanography, University of Rhode Island*
JULY 16–30

Registration begins January 1, 1995

GSA ANNUAL MEETINGS

1995

NEW ORLEANS
BRIDGING THE GULF

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

General Chair: *William R. Craig, University of New Orleans*
Technical Program Chair: *Laura Serpa, University of New Orleans*
Field Trip Chair: *Whitney Autin, Louisiana State University*
See November *GSA Today* for a complete list of field trips.

Theme Session Proposal Deadline: ***January 2, 1995.***
See November *GSA Today* for theme invitation *or* the World Wide Web for invitation and proposal form.

The World Wide Web address at the Universal Resource Locator is: **http://www.aescon.com/geosociety/ index.html.** Theme proposal information appears under the header for the New Orleans Meeting.

1996

Denver, Colorado
October 28–31
Colorado Convention Center, Marriott City Center

General Chairs: *Kenneth E. Kolm and Gregory S. Holden, Colorado School of Mines*
Technical Program Chair: *John D. Humphrey, Colorado School of Mines*
Call for Field Trip Proposals: *Please contact the Field Trip Chairs listed below.*

Charles L. Pillmore, Ren A. Thompson
U.S. Geological Survey, MS 913, P.O. Box 25046
Denver Federal Center, Denver, CO 80225
phones: Charles A. Pillmore, (303) 236-1240
Ren A. Thompson (303) 236-0929

For general information on any meeting call the GSA Meetings Department, 1-800-472-1988 or (303) 447-2020, ext. 141; E-mail: mball@geosociety.org.

GSA SECTION MEETINGS

NORTHEASTERN SECTION

Radisson Hotel and Conference Center in Cromwell, Hartford, Connecticut, March 20–22, 1995. Submit completed abstracts to: Norman H. Gray, Department of Geology and Geophysics, University of Connecticut, 354 Mansfield Rd., Storrs, CT 06269-2045, (203) 486-4434. *Abstract Deadline was November 21, 1994.*

SOUTHEASTERN SECTION

Knoxville Hilton Hotel, Knoxville, Tennessee, April 6–7, 1995. Submit completed abstracts to: Robert D. Hatcher, Jr., Department of Geological Sciences, University of Tennessee, Knoxville, TN 37996-1410, (615) 974-6565. *Abstract Deadline: December 16, 1994.*

NORTH-CENTRAL and SOUTH-CENTRAL SECTIONS

University of Nebraska, Lincoln, Nebraska, April 27–28, 1995. Submit completed abstracts to: David Loope, 332 Bessey Hall, University of Nebraska, Lincoln, NE 68588-0340, (402) 472-2647 *Abstract Deadline: January 6, 1995.*

ROCKY MOUNTAIN SECTION

Montana State University, Bozeman, Montana, May 18–19, 1995. Submit completed abstracts to: David R. Lageson, Department of Earth Sciences, Montana State University, Bozeman, MT 59717-0348, (406) 994-6913. *Abstract Deadline: January 20, 1995.*

CORDILLERAN SECTION

University of Alaska, Fairbanks, Alaska, May 24–26, 1995. Submit completed abstracts to: Catherine Hanks, Geophysical Institute, University of Alaska, Fairbanks, AK 99775-0800, (907) 474-5562. *Abstract Deadline: January 30, 1995.*

Student Travel Grants

The GSA Foundation will award matching grants up to a total of $3500 each to the six GSA Sections. The money, when combined with equal funds from the Sections, will be used to assist GSA Student Associates traveling to the 1995 GSA Annual Meeting in New Orleans in November and to the 1995 Section meetings. Contact your Section Secretary for application procedures.

Cordilleran	Bruce A. Blackerby	(209) 278-2955
Rocky Mountain	Kenneth E. Kolm	(303) 273-3932
North-Central	George R. Hallberg	(319) 335-4500
South-Central	Rena M. Bonem	(817) 755-2361
Northeastern	Kenneth N. Weaver	(410) 554-5532
Southeastern	Harold H. Stowell	(205) 348-5098

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BULLETIN
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Positions Open

GEOCHEMISTRY, SYRACUSE UNIVERSITY

Syracuse University invites applications for an anticipated tenure-track appointment at the Assistant Professor level in the area of low-temperature geochemistry, to begin August 1995. We seek an individual who will contribute strongly to both research areas that are the foci of our department -- the Quaternary and Environmental Geology Research Group and the Geochemistry Research Group. The successful candidate will have research strengths that complement, but do not duplicate, existing research strengths of these groups. The research interests of the current Quaternary and Environmental Geology Faculty include hydrogeology, global and regional climate change , paleolimnology, and geomorphology. The research interests of the current Geochemistry Faculty include ground water geochemistry, radiogenic isotope geochemistry (Nd, Sr, and Pb) applied to problems in crustal evolution, tectonics, and paleoceanography. Candidates with expertise in fields such as trace element (e.g., ICP-MS) analysis, organic (e.g., GC-MC) analysis, light stable isotopic analysis, or TIMS analysis (U-Th disequilibrium, B) are encouraged to apply.

The successful candidate must be strongly committed to excellence in teaching at all levels from larger introductory undergraduate to smaller graduate courses. Although there is considerable flexibility in the course offerings of the new faculty member, the Department is actively seeking applicants who may be able to teach the introductory Mineralogy course in our undergraduate curriculum. It is expected that the successful candidate will develop an externally funded research program involving students. Candidates must have completed the Ph.D. by the time of appointment. Screening of applications will begin December 15 and will continue until the position is filled.

Applicants should send a curriculum vitae and three letters of reference to: Chair, Search Committee, Department of Earth Sciences, Heroy Geology Laboratory, Syracuse University, Syracuse, NY 13244-1070, (315) 443-2672 or 3710. Syracuse University is an Equal Opportunity/Affirmative Action Employer. Women and members of traditionally underrepresented groups are encouraged to apply.

STRUCTURAL GEOGRAPHY

The Department of Geography and Geology at Eastern Michigan University invites applications for a tenure-track faculty position at the rank of assistant professor in the field of structural geology. The appointment will begin September 1995; Ph.D. at the time of appointment preferred. Additional expertise in igneous or metamorphic petrology, geophysics, or economic geology is desired. The faculty member will be expected to teach Structural Geology and other courses in her or his field of expertise, and introductory Earth Science and Geology courses. Participation in the geology Field Camp, taught each summer in Colorado, is also required. Preference will be given to candidates with a strong background in geological/earth science education. The undergraduate geology program at Eastern Michigan is small but dynamic, and emphasizes teaching and student/faculty interaction. Applicants should send a curriculum vitae, description of teaching and research interests, transcripts, and the names, addresses, and telephone numbers of three references to Position F9503, 204 King Hall, Eastern Michigan University, Ypsilanti, MI 48197. Applications will be reviewd beginning November 15. We encourage women and members of minority groups to consider this opportunity and to identify themselves when applying. EMU is an affirmative action/equal opportunity employer.

UNIVERSITY OF CALIFORNIA, LOS ANGELES

Department of Earth and Space Sciences announces availability of a tenure-track Assistant Professor position for an Earth scientist in the area of Continental Tectonics, with emphasis on field work. Applicants must demonstrate an active program of creative research with potential connections to other specialties of the department. The appointee must also be an excellent teacher, both in the classroom and in the field. The Ph.D. degree will be required at the time of appointment. Applicants should send a curriculum vitae, statements on teaching competence and research goals, (p)reprints of all publications, and names of three referees to: Earth Scientist Search Committee, c/o Paul Davis, Chair., Dept. of Earth & Space Sciences, University of California, Los Angeles, CA 90024-1567. To guarantee consideration, applications must arrive by Jan. 16, 1995. UC is an equal opportunity employer; women and members of minority groups are encouraged to apply.

ASSISTANT PROFESSOR OF ARCHAEOLOGY BOSTON UNIVERSITY

Specialization in materials science, geoarchaeology, or palaeoecology preferred. Active research program and Ph.D. required; regional period/focus is open. Teaching assignments will include an introductory course in archaeological sciences. Applications/nominations and letters from three referees are due by January 15, 1995. Address: Professor James R. Wiseman, Chairman, Department of Archaeology, Boston University, 675 Commonwealth Avenue, Boston, MA 02215. An Equal Opportunity/Affirmative Action Employer.

ASSISTANT PROFESSOR GEOMORPHOLOGY OR QUATERNARY GEOLOGY

The Department of Geology of The University of Kansas invites applications for a tenure-track position of Assistant Professor with a specialty in geomorphology or Quaternary geology. The position will be available August 17, 1995, but a later starting date is possible. Primary consideration will be given to applicants with emphasis on surficial processes and their quantitative analysis. Duties include teaching at the introductory, undergraduate-major, and graduate levels; developing and maintaining an active program of research; working with other faculty members to develop a stronger area of emphasis in environmental geology and hydrogeology; and providing professional service to the Department, the University, and the profession.

Applicants should have the Ph.D. degree or be in the final stages of completing the degree. Candidates may be required to show proof of U.S. citizenship or approved permanent-employment status. A letter of application, a complete resume, and three letters of recommendation should be sent to Roger L. Kaesler, Search Committee Chairman, Department of Geology, The University of Kansas, 120 Lindley Hall, Lawrence, Kansas 66045-2124 (tel. 913-864-3338; fax 913-864-5276). Upon receipt of a letter of inquiry, we will send a detailed description of the position. Candidates should submit graduate-school transcripts. Review of completed applications will begin January 10, 1995, and will continue until the position has been filled. The department has adopted a policy to facilitate the accommodation of spouses. EO/AA employer. The University is committed to increasing the ethnic and gender diversity of its faculty, and we strongly encourage women and minority candidates to apply.

DARTMOUTH COLLEGE/ENVIRONMENTAL GEOCHEMISTRY

The Department of Earth Sciences at Dartmouth College invites applications for a new tenure-track assistant professorship in the field of environmental geochemistry. We are particularly interested in a person who integrates organic chemistry with geological and biological processes. Specialties might include: organic geochemistry, chemical hydrology, or biogeochemistry. The successful applicant will teach introductory and advanced-level courses in earth sciences and will participate in a graduate-level interdisciplinary program in the environmental sciences. Applicants should send a curriculum vitae, reprints, statement of research, and teaching interests, and a list of at least three references with addresses, phone, and fax numbers to: Earth Sciences Search Committee, Dartmouth College, 6105 Fairchild, Hanover, NH 03755. We urge candidates to submit applications by December 20, as interviews will take place January or February 1995. The appointment will begin July 1, 1995. Dartmouth College is an equal opportunity/affirmative action employer.

ENVIRONMENTAL MINERALOGIST/STRUCTURAL GEOLOGIST STATE UNIVERSITY OF NEW YORK AT OSWEGO

The Department of Earth Sciences at the State University College at Oswego, invites applications for a temporary position at the assistant professor level beginning Spring 1995. The successful candidate is expected to teach general education courses in Introductory Geology as well as Mineralogy, Petrology, and Structural Geology. Other courses may include Environmental Geology and Geochemistry (low temperature). We are especially interested in candidates who are able to contribute to our proposed Environmental Sciences program. The new program is centered around a strong geology core. In addition to teaching, this successful candidate will be expected to continue scholarly development and research.

Our department has a strong commitment to undergraduate liberal-arts education. We have our own computer laboratory for student use in research and course work. Computational facilities include networked Macintosh and DOS-based microcomputers, laser printer, pen plotter, and CD ROM drive. The department houses equipment for water and sediment sampling and analysis, as well as for preparation of thin sections. Zeiss and Nikon research microscopes are available for petrographic study of rocks and minerals.

We offer a B.A. and a B.S. in Geology and a B.S. in Geochemistry in cooperation with the Department of Chemistry. Our department also offers a B.A. and B.S. in Meteorology. We have four geologists, four meteorologists, and two astronomers at the present time.

The candidate should have a Ph.D. by December 1994. Review of applications will begin January 15, 1995; however they will be accepted until the position is filled. Send letters, resume and transcripts with three letters of recommendation Dr. David J. Thomas, Chair, Department of Earth Sciences, State University of New York, Oswego, New York 13126. Affirmative Action/EEO Employer

FLORIDA INTERNATIONAL UNIVERSITY

The Department of Geology at Florida International University invites applications for two tenure-track positions to be filled at the Assistant Professor level. Duties include teaching undergraduate and graduate courses and supervising graduate students (M.S. and Ph.D.) in hydrology. There is particular interest in individuals who incorporate the use (and preferably, collection) of field data into modeling of fluid flow/transport processes. The positions require earned doctoral degrees in the fields shown.

SUBSURFACE HYDROLOGY-HYDROGEOLOGY. The successful applicant is expected to conduct research on innovative approaches to fluid flow and/or transport in porous media. Possible research specialties include (but are not limited to) flow in fractured media, movement of nonaqueous-phase liquids in the subsurface, numerical modeling, stochastic analysis and prediction uncertainty in solute transport, or novel linkages between geophysics and subsurface hydrology.

SURFICIAL HYDROLOGY. The successful applicant will utilize innovative means to study surface and/or near-surface components of the hydrologic cycle. Possible research specialties include (but are not limited to) the spatial and temporal structure of infiltration and its relation to soil properties and/or topography, runoff generation, drainage networks and basin response, or hydrologic aspects of landscape evolution.

Appointments will begin April 7, 1995. Closing date for applications is January 19, 1995. To apply send a c.v., one-page statements of teaching and research interests, transcripts, and three letters of reference to: Prof. Gautam Sen, Search Committee Chair, Dept. of Geology, Florida Internaitonal University, Miami, FL 33199 USA (telephone: 305-348-2249; fax: 305-348-3877; Internet: seng@servax.fiu.edu). Florida International University is part of the State University System of Florida, and is an affirmative action/equal opportunity/equal access employer.

HYDROGEOLOGIST GEOLOGICAL SCIENCES DEPARTMENT UNIVERSITY OF CALIFORNIA AT SANTA BARBARA

The Department of Geological Sciences and the Environmental Studies-Hydrologic Sciences Program invites applications for a joint tenure-track position in Hydrogeology, available July 1, 1995. The position is to be filled at the assistant professor level. Applicants should have a broad geoscience backgorund with primary research interests centered on the role of fluids in the shallow earth. Applicants with specialization in aqueous geochemistry, sub-surface organic/solute transport, or a combination of the above are especially encouraged to apply. The successful applicant will be expected to build a strong research program and fulfill undergraduate teaching needs in hydrogeology, environmental geology, and engineering geology. A Ph.D. is required at the time of appointment. Submit resume, statement of research and teaching interests, and names of three references to: Dr. David Lea, Chair, Search Committee, Department of Geological Sciences, University of California, Santa Barbara, CA 93106-9630. Deadline: February 1, 1995. UCSB is an Equal Opportunity/Affirmative Action employer.

STRUCTURAL GEOLOGY/TECTONICS UNIVERSITY OF COLORADO, BOULDER

The Department of Geological Sciences is recruiting for a tenure-track faculty position in Structural Geology/Tectonics. Candidates at the Assistant Professor level are preferred, but candidates at all levels will be considered. Preference will be given to candidates whose specialty in Structural Geology/Tectonics complements ongoing teaching and research programs in regional and global tectonic studies, energy and minerals exploration, geophysics, geochemistry, and petrology. Candidate must have a strong background and experience in field aspects of the discipline. Ph.D. is required and post-doctoral/industrial experience preferred. The successful applicant will be expected to conduct an active research program, direct graduate students, attract external funding, and teach at the graduate and undergraduate level, including the introductory non-major program, and field geology. The position will start during August 1995; the Department will move into a new building during September 1997.

Applicants should submit a current Curriculum Vitae, a summary of current and proposed research and teaching interests, and arrange to have at least three letters of recommendation sent to the Structural Geology Search Committee, Department of Geological Sciences, University of Colorado, Boulder, CO 80309-0250. The deadline for applications is January 31, 1995. It is the applicant's responsibility to see that the letters of reference arrive before the deadline.

The University of Colorado at Boulder has a strong institutional commitment to the principle of diversity. In that spirit, we are particularly interested in receiving applications from a broad spectrum of people, including women, members of ethnic minorities, and disabled individuals.

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Opportunities for Students

Student Opportunities at UT-Dallas. The Programs in Geosciences at The University of Texas at Dallas are offering two fellowships as well as competitive assistantships to qualified students. The Excellence in Education Fellowship provides support for a highly qualified incoming geoscience graduate student. An annual stipend of $15,888 is provided. The Anton L. Hales Fellowship in geophysics, awarded to an exceptional incoming Ph.D. applicant, carries an annual stipend of $15,000 and a $500 travel allowance to attend geological and geophysical meetings. Teaching and research assistantships range from $8500 per nine months for M.S. and entry level Ph.D. students to $9900 per nine months for Ph.D. candidates after passing their qualifying exam. Additional summer salary is commonly available. Insurance benefits, waiver of out-of-state tuition and up to $1250 per year in tuition and fee supplements are included for supported students.

The University of Texas at Dallas is located in Richardson, a suburb of Dallas. It was created in 1969 as a component of University of Texas System. The University is a graduate and undergraduate institution continuing the tradition of research established in the Southwest Center for Advanced Studies, the private research institute that preceded the current campus. There are approximatley 8900 students of which a little less than half are graduates. Interested students are encouraged to contact Dr. Kent C. Nielsen, Head, Programs in Geosciences, The University of Texas at Dallas, P.O. Box 830688, Richardson, TX 75083-0688. Phone: (214) 690-2401, FAX 214-690-2537, E-mail: geosci@utdallas.edu.

University of Minnesota, Department of Geology and Geophysics, National Science Foundation Ph.D. Fellowships in Crustal-Scale Hydrology (GEOFLUIDS). Five 12-month, NSF fellowships are available to support interdisciplinary doctoral research and training in fluid circulation, composition, interaction, and history within the Earth's crust on topics as diverse as mid-ocean ridge processes, sedimentary-basin evolution, tectonics, climate change, ocean history, limnology, hydrogeology, and the fate of pollutants. GEOFLUIDS participants will benefit from exceptional facilities within the department including state-of-the-art instrumentaiton for stable isotope and radioisotope analysis, major and trace element analysis of aqueous (ICP-MS) and solid phases (Electron Microprobe),experimental and computational fluid-dynamics laboratories, sediment-core analysis, and hydrogeologic field sampling equipment including fluorescent dye-tracing capabilities. The GEOFLUIDS program also offers unique opportunities for interdisciplinary research initiatives in collaboration with governmental agencies, national laboratories, universities, and industrial affiliates. The deparment welcomes applications from highly motivated, imaginative students interested in interdisciplinary research in Earth processes. Applicants must be U.S. citizens or permanent residents and have obtained a bachelor's degree in a relevant discipline. Women and minority students, especially those from non-Ph.D. granting institutions, are encouraged to apply. Interested students should contact Dr. Mark Person, GEOFLUIDS Program Coordinator, University of Minnesota, Department of Geology and Geophysics, 310 Pillsbury Dr. SE, Minneapolis, MN 55455, or call (612) 625-7332, or E-mail: mperson@darcy.geo.umn.edu. The deadline for application is January 15, 1995, for study beginning the following fall. The University of Minnesota is an equal opportunity educator and employer.

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

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 1995. For information/applications, contact: Lorraine Olendzenski, Planetary Biology Internship, Department of Biology, Box 3-5810, University of Massachusetts, Amherst, MA 01003-5810. E-mail:pbi@bio.umass.edu. Tel (413) 545-3223. An Equal Opportunity/Affirmative Action Employer.

Call for Nominations

1995 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 1995 award will be presented at the autumn AASG meeting to be held during the GSA Annual Meeting in New Orleans. Members of the selection committee are Chairman Frank E. Kottlowski, New Mexico Bureau of Mines and Mineral Resources; John P. Kempton, Illinois Geological Survey; and Diane L. Conrad, Vermont Division of Geology and Mineral Resources.

CRITERIA FOR NOMINATION

Nominations can be made by anyone, based on the following criteria: (1) paper must be selected from GSA or state geological survey publications, (2) paper must be selected from those published during the preceding three full calendar years, (3) nomination must include a paragraph stating the pertinence of the paper, (4) nominations must be sent to Executive Director, GSA, he pertinence of the paper, (4) **nominations must be sent to Executive Director, GSA, P.O. Box 9140, Boulder, CO 80301.** ***Deadline: March 31, 1995.***

BASIS FOR SELECTION

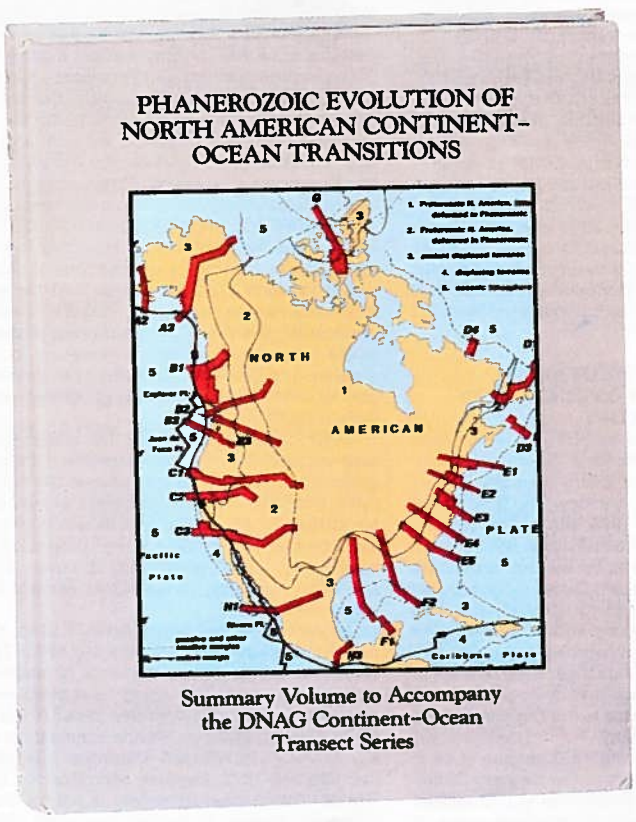
Each nominated paper will be judged on the uniqueness or significance as a model of its type of work and report and its overall worthiness for the award. In addition, nominated papers must establish an environmental problem or need, provide substantive information on the basic geology or geologic process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

1994 AWARD RECIPIENT NAMED

The 1994 award was presented at the GSA Annual Meeting in Seattle to Ronald W. Hoenstine and Ed Lane, Florida Geological Survey, for their paper *Environmental Geology and Hydrogeology of the Gainesville area, Florida,* Special Publication No. 33 (1991), Florida Geological Survey. The report deals with a wide range of environmental geology aspects, including land-use planning, resource management, and geologic hazards (such as karst subsidence and groundwater contamination), and is easily understood by nonscientists.

CONTINENT-OCEAN TRANSECTS

The Decade of North American Geology DNAG



This volume presents syntheses in twelve chapters of the tectonic evolution of continent-ocean transitions of North America (Canada-Mexico-U.S.A.) since the Precambrian. The syntheses are interpretations based on the 19 continent-ocean transects across North American margins published by GSA as part of its Decade of North American Geology (DNAG) series. The transitional region is the part of North America between the craton, little deformed in Phanerozoic time, and the modern ocean basins. The region developed heterogeneously within plate boundary zones that led to sequences of passive, collisional, and active margins that differ place to place. Nine chapters address individual segments of the transitional region, two consider active and passive margin tectonics topically, and one treats the evolution of Phanerozoic transitions of North America as a whole.

edited by R. C. Speed, 1994 CTV001, 514 p, indexed, hardbound, ISBN 0-8137-5305-8, $75.00

CONTINENT-OCEAN TRANSECTS

19 Transects (one yet to come) and one Tectonic Section Display packet in this series. Each Transect contains all or most of the following: Free-air gravity and magnetic anomaly profiles; heat flow measurements; geologic cross section with no vertical exaggeration; multi-channel seismic reflection profiles; tectonic kindred cross section with vertical exaggeration; geologic map; stratigraphic diagram; and an index map. All transects are on a scale of 1:500,000 and most include text.

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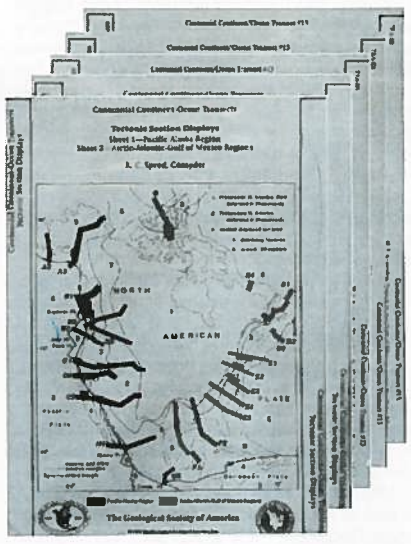

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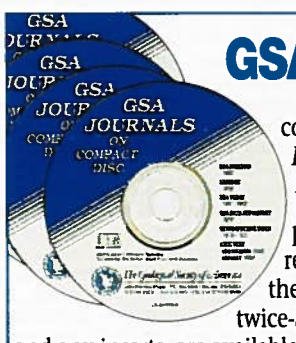

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