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INSIDE

On the Organization of American Plates in the Neoproterozoic and the Breakout of Laurentia

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ABSTRACT

Laurentia, the Precambrian core of the North American continent, is surrounded by late Precambrian rift systems. Within the supercontinent of Pangea, North America therefore constitutes a "suspect terrane" because its origin as a discrete continent and geographic location prior to the late Paleozoic are uncertain. Students of South American geology have long recognized evidence for the presence of a "southeast Pacific continent" to the west of the present Andean margin throughout the early to mid-Paleozoic. A geometric and geologic fit can be achieved between the Atlantic margin of Laurentia and the Pacific margin of the Gondwana craton. The reconstruction places the Labrador-Greenland promontory of Laurentia within the Arica reentrant of Gondwana. The enigmatic Arequipa massif along the southern Peruvian coast, yields ca. 2.0 Ga radiometric ages and is thereby juxtaposed with the Makkovik-Ketilidian province of the same age range in Labrador and southern Greenland. In the reconstruction, the ca. 1.0 Ga Grenville belt continues beneath the ensialic Andes of the present day to join up with the 1.3–1.0 Ga San Ignacio and Sonsas-Aguapei orogens of the Transamazonian craton.

Together with the recent identification of possible continuations of the Grenville orogen in East Antarctica and of the Taconic Appalachians in southern South America, the fit supports and refines suggestions that Laurentia broke out from between East Antarctica–Australia and embryonic South America during the Neoproterozoic, prior to the opening of the Pacific Ocean basin and amalgamation of the Gondwana supercontinent. This implies that there may have been two supercontinents during the Neoproterozoic, before and after opening of the Pacific Ocean. It therefore calls to question the existence of so-called supercontinental cycles. The basic configuration of some continental nuclei may have changed little since the Neoproterozoic, despite extensive tectonic modification of their margins. The Arica bight of the present day may reflect a primary embayment in the South American continental margin that controlled subduction processes along the Andean margin and eventually localized uplift of the Altiplano.

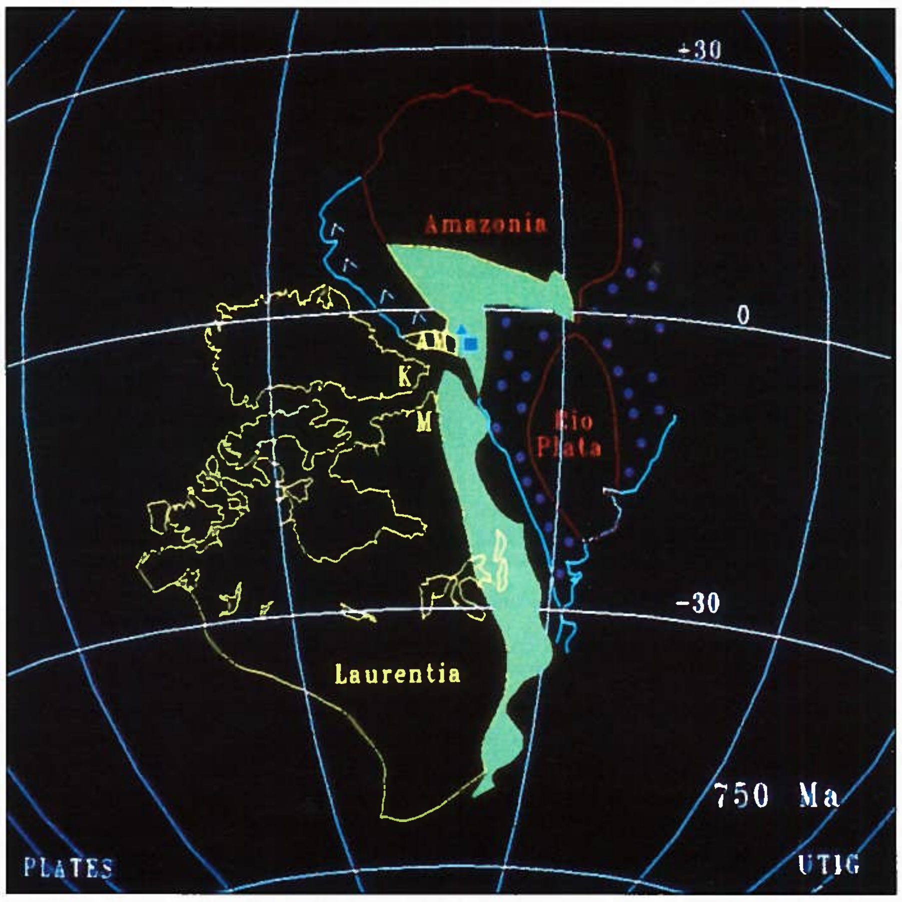

Figure 1. Computer reconstruction (orthographic projection) of the relation between the Laurentian craton (gold) and the South American part of the Gondwana craton (blue) proposed for the Neoproterozoic (ca. 1.0 Ga–550 Ma). The reconstruction is shown in an arbitrary reference frame close to that of present-day South America with small circles of latitude at 30° intervals intended for scale only. Green indicates the extent of the Grenville orogen in Laurentia (from Hoffman, 1989) and its suggested continuation into South America. Amazonian and Rio del Plata cratonic nuclei (red) and Pan-African belts (purple stipple) in South America are after Teixeira et al. (1989); locally the present-day Andes (white chevrons) completely obscure the basement. AM—Arequipa massif; K—Ketilidian province; M—Makkovik province; square—Belén province; triangle—San Andres No. 2 well.

LAURENTIA

The ancestral core of the North American continent was assembled by collisional tectonic processes by ca. 1.0 Ga (Hoffman, 1988). However, although the location of North America on Earth's surface can be convincingly established as far back as the Mesozoic opening of the Atlantic Ocean basin on the basis of marine geophysical data (Klitgord and Schouten, 1986), the origin of Laurentia as a discrete continent has remained obscure because it is surrounded by Neoproterozoic to Cambrian rift systems (Hoffman, 1989). Within Pangea it is a "suspect terrane" of uncertain prior geographic position (Coney et al., 1980). Conventionally, Laurentia has been positioned opposite northwest Africa in Paleozoic reconstructions, reflecting J. Tuzo Wilson's question: "Did the North Atlantic open, close, and then reopen?" (Wilson, 1966). It has also been conventional to restore the Appalachian margin of the Laurentian craton against northwestern Africa in late Precambrian reconstructions (e.g., Hatcher, 1989). There is, however, no firm geologic evidence for this reconstruction, and paleomagnetic data afford no longitudinal control. Thus, alternative reconstructions are permissible as long as they can account for observations such as the distribution of Avalonian rocks along the margins of North America, Europe, and Africa and the presence of Rokelide(?) basement and fossiliferous Paleozoic cover beneath the coastal plain of northern Florida (Hatcher et al., 1989). The rifted counterpart of the Pacific margin of the Laurentian craton is also obscure. Sears and Price (1978) suggested rifting from part of Siberia during the mid-Proterozoic. Bell and Jefferson (1987) drew attention to the similarity of the Neoproterozoic strata of western Canada and eastern Australia and suggested that they had been juxtaposed at that time, although no reconstruction of the cratons themselves was presented.

One of the linchpins of Du Toit's reconstruction of the Gondwana supercontinent prior to the opening of the southern oceans was the truncation of the early Mesozoic Cape fold belt at the Atlantic margin of southern Africa, and its apparent continuation in the Sierra de la Ventana that is truncated along the Atlantic margin of South America (Du Toit, 1937). The truncation of the Appalachian and Caledonian orogens along the margins of the North Atlantic provide similar evidence in support of Mesozoic separation of North America and Europe (Holmes, 1945; Kay, 1969). The termination of the Grenville orogen of Laurentia at the Labrador margin also appears to be explained by the presence of the Sveco-Norwegian province of the same age in the Baltic craton, although the connection through northern Britain is somewhat tenuous (Gower and Owen, 1984; Gower et al., 1990). In contrast, the termination of the Grenville and adjoining Yavapai-Mazatzal orogens at the Pacific margin of the Laurentian craton has lacked an obvious explanation, despite the presence of some Grenvillian-age rocks in northwestern South America (Dengo, 1985). Recently, however, Moores (1991) broke new ground by presenting a reconstruction with the East Antarctic–Australian craton juxtaposed with that of Laurentia in the Neoproterozoic. Dalziel (1991) supported this with a computer reconstruction and identified a possible counterpart for the Yavapai–Mazatzal–Grenville boundary, the Grenville front, near the head of the Weddell Sea embayment. These developments led to new theories regarding the configuration of a possible Neoproterozoic supercontinent (Dalziel, 1991, 1992; Hoffman, 1991).

Another potential "piercing point" (Crowell, 1959) along the margin of the Laurentian craton is provided by the southern termination of the Appalachian orogen. The effects of the collision of Laurentia with Africa to form Pangea are visible in the Ouachita orogeny and the terminal Alleghanian event of the Appalachian orogenic revolution (Hatcher et al., 1989), although the main Appalachian mountain range and the Ordovician structures of the Taconic orogen disappear southwestward beneath the Gulf of Mexico coastal plain. Again, until recently, this apparent truncation and the "hole" in the North American continent represented by the Ouachita embayment have remained unexplained. Dalla Salda et al. (1992a, 1992b) have suggested that the continuation of the Taconic orogen is to be found in the Famatinian belt of South America and possibly even farther south in the Shackleton Range of East Antarctica. Thus, several lines of evidence point to the possibility that, within Pangea, North America was an "exotic terrane" of intra-Gondwanian affinities that had traveled nearly 10 000 km along the proto-Andean margin of South America during the Paleozoic (Dalziel, 1991, Fig. 2; Dalziel et al., 1992).

GONDWANA

The North American affinities of the Precordilleran terrane that borders the present-day Andes of northwestern Argentina has been known for many years (Borrello, 1971; Ross, 1975; Ramos et al., 1986). Its Cambrian-Ordovician carbonate platform contains the Pacific realm Olenellid trilobite fauna of Walcott (1889). The presence of this fauna, and determi-

Laurentia *continued on p. 240*

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Engineering Geology Division

Charles W. Welby, Chairman, 1991–1992

Goals

Created in 1947 as GSA's first topical division, the Engineering Geology Division has continued to serve the membership of GSA in several ways. Its primary goal is to provide programs at the national and section meetings which afford GSA members in general, and Engineering Geology Division members in particular, opportunities to expand their knowledge and understanding of geologic principles and processes and to share with their colleagues new ideas and insights. A strong element in fulfilling this goal is the Division's publications program.

The Division considers it especially important that its programs address advances in the geosciences as they apply to civilization's occupation of Earth's surface and the use of various natural resources for the betterment of the human condition. Thus, a purpose of this article is to invite GSA members who are interested in seeing geologic information and principles properly and effectively applied in the regulatory field, in land-use planning, in proper design of civilization's infrastructure, and in lowering risk to lives from natural hazards to join the Division. The Engineering Geology Division solicits your active participation in its national and section programs and the various routes for sharing in print ideas and information about the science of geology and its application to civilization's needs.

It was recognized as early as 1907 that "application of geology to various uses of mankind and engineering structures" was one of the four basic divisions of what was then known as economic geology (Kiersch and Hatheway, 1991). Those who worked in these areas early became known as engineering geologists, because they collaborated with engineers in the design of structures and amelioration of geologic conditions that might have unfavorable impacts on those structures. Yet, this focus was a condition of the times, and since about 1960, the focus has spread to the broader aspects of the application of new knowledge and understanding about geology to the betterment of the human condition. We see things learned about natural hazards and ground water from the earlier days of engineering geology being applied to new problems and priorities. The earlier demonstrated need and demand by the public for improved site evaluation for dams, roads, aqueducts, and other infrastructure facilities carry over to today's society, where the public demands the same or better standards for waste disposal, ground-water clean-up and planning for ground-water protection, and evaluation of natural geologic hazards and the risks associated with them. The Engineering Geology Division provides a forum within GSA where attention to the scientific aspects of these problems is foremost in program planning.

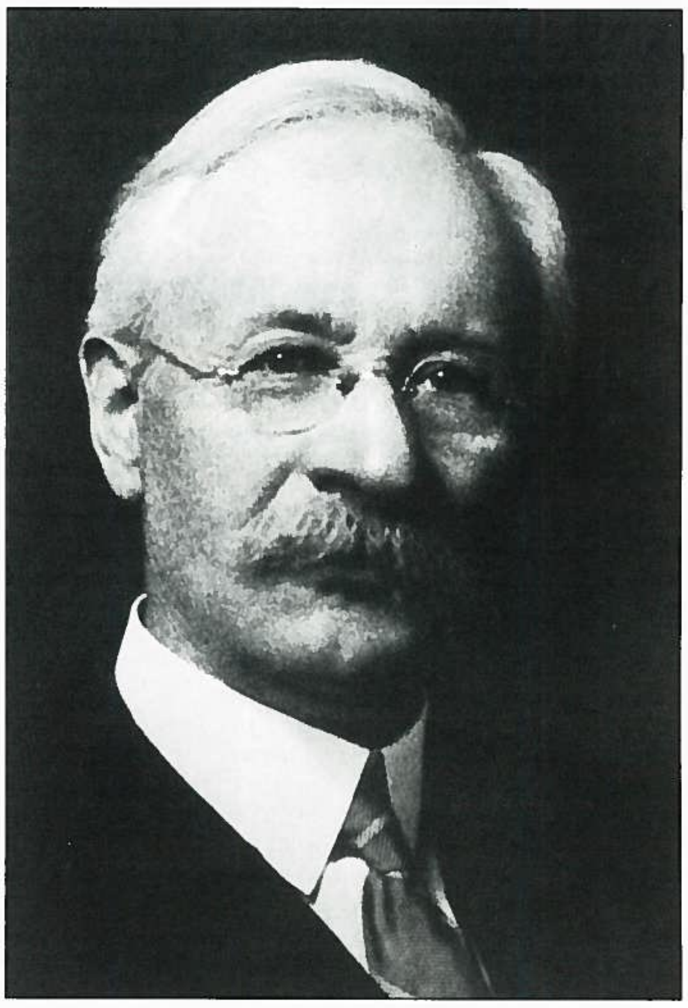
Division Organization

Officers of the Division consist of a chair, chair-elect, and secretary. The Management Board is composed of the three officers together with the immediate past-chair and a member-at-large. The officers and member-at-large are elected to one-year terms annually and begin serving their terms immediately following the GSA Annual Meeting. The chair-elect is also the program chair for the Division and serves on the Joint Technical Program Committee. Working with the officers are various committees and representatives to other organizations that have scientific interests similar to those of the members of the Engineering Geology Division.

Awards and Lectureships

The Division recognizes contributions to engineering geology with three awards: the E.B. Burwell, Jr., Memorial Award given for an outstanding publication; a Distinguished Practice Award; and a Meritorious Service Award for outstanding contributions to the Engineering Geology Division. In addition the Division presents an Anniversary Award to support graduate student research. The Division has in the immediate past refunded $50 of the tuition to each of the first three student members of the Division who register for a Division-sponsored short course.

In conjunction with the Association of Engineering Geologists, the Division supports the Richard H. Jahns Distinguished Lectureship. The purpose of the lectureship is to bring a distinguished engineering geologist to college and university campuses to discuss engineering geology as a science and as a career with undergraduate and graduate students.



Charles P. Berkey, president of GSA in 1941 and first chairman of the Engineering Geology Division in 1947 and 1948.

Publications and Other Activities

The most visible and long-continued of the Division's activities is its publications program. Together, the Reviews in Engineering Geology and the Engineering Geology Case Histories series bring important information to the general geological community as well as to Division members. Currently in press for the Case Histories series is a volume on landslides in the urban environment, covering both theoretical aspects and case histories. Another volume under consideration is one tentatively entitled "Urban Geology."

As with other GSA divisions, the Engineering Geology Division sponsors short courses, symposia, theme sessions, and field trips at both national and section meetings, as a Division and in cooperation with other divisions and groups within and without the GSA framework. Its long-range plan calls for increased emphasis on program participation at GSA Section meetings. Over the years the Division has been responsible for review of those abstracts submitted for national meetings on which the Environmental Geology box has been checked. It is working with the Institute for Environmental Education to bring interesting and useful programs on the environment to GSA members and others.

Benefits

What are the benefits of belonging to the Division? I suppose the answer depends upon what one considers a benefit. Certainly the Division's programs offer a variety of chances to learn more about how we can use geology for the general welfare and to participate in an interesting and exciting endeavor; they offer to each of us the satisfaction that we have contributed somehow to the advancement of the science and its application to civilization's needs. The dues help the Division help students, provide recognition to deserving colleagues, provide a lectureship designed for undergraduate and graduate students, prepare professional publications, and publish a quarterly newsletter. If you are interested in supporting endeavors to bring geology into the environmental scheme of things, the Engineering Geology Division is a great place to be.

Reference Cited

Kiersch, George A., and Hatheway, Allen V., 1991, History and heritage of Engineering Geology Division, Geological Society of America, 1940s to 1990, in Kiersch, G.A., ed., The heritage of engineering geology; the first hundred years: Boulder, Colorado, Geological Society of America, Centennial Special Volume 3, p. 109–128. ■

IEE Environmental Forum for Boston Annual Meeting

Proposal Deadline—December 15, 1992

BOSTON

1993 GSA Annual Meeting & Exposition
Boston, Massachusetts
October 25–28

The Institute for Environmental Education, in cooperation with the GSA Committee on Geology and Public Policy, is soliciting proposals for the 2nd Annual Environmental Forum to be held in conjunction with the 1993 GSA Annual Meeting in Boston, October 25–28, 1993. The IEE Annual Environmental Forum is intended to increase awareness among both geoscientists and the public of the role of geoscience in addressing environmental concerns.

Subjects particularly appropriate for the Boston forum include

- environmental issues relevant to Boston Harbor and the Gulf of Maine,
- energy needs of New England and the impacts of energy resource development, or
- environmental issues related to densely populated urban environments.

Although selection of the topic for the forum will take into consideration the geologic setting of the meeting place and environmental issues of particular interest there, the subject should have global significance. The speakers should present public interest, legal, regulatory, management, and other viewpoints, as appropriate, in addition to the purely scientific.

Proposals should include a brief summary of the proposed forum subject, perspectives to be represented (including possible proponents), and names of the person(s) who will serve as organizer(s).

Submit proposals no later than *December 15, 1992*, to

Fred A. Donath, Executive Director
Institute for Environmental Education
Geological Society of America
P.O. Box 9140
Boulder, CO 80301

GSA Grants Support Research

June Forstrom, Research Grants Administrator

General Grants

The purpose of the general research grants program is to provide partial support of master's and doctoral thesis research for graduate students at universities in the United States, Canada, Mexico, and Central America. Applicants need not be members of GSA. GSA strongly encourages women, minorities, and persons with disabilities to participate fully in this grants program.

To apply for one of these grants, you must fill out an application form, which is available from GSA Campus Representatives at geology departments in the United States and Canada, or from GSA headquarters (Research Grants Administrator, Geological Society of America, P.O. Box 9140, Boulder, CO 80301). Evaluations from two faculty members are required on GSA appraisal forms. The deadline for applications for the 1993 research grants program is *February 15, 1993.* Applications must be submitted on 1993 forms. The GSA Committee on Research Grants evaluates all applications and chooses those to be funded at its early spring meeting at GSA headquarters. Grants are awarded in April. In 1992, 533 proposals were received; 248 of them were funded. A total of $315,769 was awarded, the grants ranging from $394 to $2500; the average amount awarded was $1273.

Specialized Grants

Recipients of special awards are selected by the Committee on Research Grants from applicants to the general research grants program; the same application forms are used, and they must also be postmarked by *February 15.* It is not necessary for applicants to indicate that they wish to be considered for a specialized grant. The committee considers all qualified applicants when selecting recipients for special awards.

The Gretchen L. Blechschmidt Award was established to support research by women interested in achieving a Ph.D. in the geological sciences and a career in academic research. Special consideration may be given to women whose proposals are (1) in the fields of biostratigraphy and/or paleoceanography and (2) who have an interest in sequence stratigraphy analysis, particularly in conjunction with research into deep-sea sedimentology.

The aim of the John T. Dillon Alaska Research Award is to support scientific research that addresses earth science problems particular to Alaska. Special consideration may be given to students whose proposals are (1) field-based studies dealing with the structural and tectonic development of Alaska, and (2) studies that include some aspect of geochronology (either paleontologic or radiometric) to provide new age control for significant rock units in Alaska. Candidates with other objectives in Alaskan earth science research will also be considered.

The Robert K. Fahnestock Memorial Award is made annually to the applicant with the best application in the field of sediment transport or related aspects of fluvial geomorphology.

The Harold T. Stearns Fellowship Award is awarded annually in support of research on one or more aspects of the geology of Pacific islands and of the circum-Pacific region.

Division Grants

Seven of the 12 GSA divisions award grants for outstanding student research within the respective division's field of interest. The Committee on Research Grants will select candidates from the general research grant applicants for awards by the Engineering Geology, Geophysics (Allan V. Cox Award), Hydrogeology, Sedimentary Geology, and Structural Geology and Tectonics Divisions.

The Coal Geology Division awards the Antoinette Lierman Medlin Scholarship Award annually to the full-time graduate or undergraduate student who submits the best proposal of a research project in the field of coal geology. Detailed guidelines are available from the chairman of the Coal Geology Division Scholarship Committee, Sandra Neuzil, U.S. Geological Survey, Branch of Coal Geology, M.S. 956, Reston, VA 22092. The recipient of the award is announced in the fall.

The Coal Geology Division of GSA and the Symposium on the Geology of Rocky Mountain Coal jointly sponsor scholarships for research on coal in the Rocky Mountain and northern Great Plains coal provinces. Applicants must be masters or doctoral candidates doing research on coal in Arizona, Alberta, British Columbia, Colorado, Idaho, Montana, New Mexico, North Dakota, Saskatchewan, South Dakota, Utah, or Wyoming. However, the college or university where applicants are enrolled need not be in those states or provinces. Applications for Rocky Mountain Coal Scholarships can be obtained from GSA (address under General Grants) or from Gary B. Glass, Geological Survey of Wyoming, Box 3008, University Station, Laramie, WY 82071. The deadline for 1993 applications is *March 1, 1993.*

GSA's Quaternary Geology and Geomorphology Division established its J. Hoover Mackin Research Grants in 1974 to support graduate student research on Quaternary geology or geomorphology. Applications for this grant are available from the secretary of the division, Deborah R. Harden, Dept. of Geology, San Jose State University, San Jose, CA 95192-0102. The deadline for applications for 1993 is *February 15, 1993.* Grant awardees are announced in April.

Five GSA divisions—Archaeological Geology, Geoscience Education, History of Geology, International, and Planetary Geology—do not currently award grants for student research.

Section Grants

Recipients for research grants from the South-Central Section are selected from applicants to the GSA general research grants program who are recommended by the Committee on Research Grants to the Management Board of the South-Central Section for final selection. Eligibility is restricted to graduate students attending a college or university within the geographic area of the South-Central Section.

The South-Central Section also awards grants to undergraduate students; applications for these awards are available from the Section secretary, Rena M. Bonem, Department of Geology, Baylor University, Waco, TX 76798. Undergraduate student recipients are selected by the Management Board of the South-Central Section. The deadline for undergraduate applications is *October 15;* the grants are awarded in late December.

The North-Central Section awards grants to undergraduate students within the geographic boundary of the Section. For further information contact the Section secretary, George R. Hallberg, Iowa Geological Survey Bureau, Trowbridge Hall, University of Iowa, Iowa City, IA 52242.

The Southeastern Section awards grants for both undergraduate and graduate GSA Student Associates who are enrolled in an institution within the geographical boundaries of the Section. The grants are competitive. Application forms can be obtained from the Section secretary, Michael J. Neilson, Department of Geology, University of Alabama, Birmingham, AL 35294. The deadline for 1993 applications is *February 15, 1993.* The grants will be awarded in April.

The remaining three sections—Northeastern, Rocky Mountain, and Cordilleran—do not currently offer research grants. ■

Laurentia *continued from p. 237*

nation of a thermal subsidence curve that indicates rift-drift transition close to the Precambrian-Cambrian boundary, led Bond et al. (1984) to suggest that the proto-Appalachian and proto-Andean margins were juxtaposed in the late Precambrian. Recently Hoffman (1991) and I (Dalziel, 1991, 1992) used the same criteria, and the presence of a 1.3–1.0 Ga "Grenvillian"-age orogen on the western margin of the Transamazonian craton, to put forward similar hypotheses that Laurentia originated between East Antarctica–Australia and the Precambrian cratons of embryonic West Gondwana prior to the Neoproterozoic opening of the Pacific Ocean basin and amalgamation of the Gondwana supercontinent. The Paleozoic Famatinian belt, however, intervenes between the Precordilleran terrane and the Gondwana craton. Therefore, Dalla Salda et al. (1992b) have suggested that the carbonate platform was part of the interior of the Laurentian craton that was detached from the Ouachita embayment following collision with the South American margin of Gondwana during the Ordovician Taconic-Ocloyic (i.e., early Famatinian) orogeny (Dalla Salda et al., 1992a). Hoffman (1992) and I (Dalziel, 1992) both believe, on the basis of time-space considerations, that western Laurentia must have separated from the Pacific margin of East Antarctica–Australia in mid-Proterozoic (Windermere-?Beardmore) time. Paleomagnetic data indicate that Laurentia may have stayed close to the proto-Andean margin of South America during the late Precambrian opening of the Pacific Ocean basin and amalgamation of the Gondwana supercontinent, and during the Paleozoic (Dalziel, 1991, Fig. 2; 1992). Thus, the "south-east Pacific continent" that students of South American geology have for many years considered to have lain off the Andean margin of Gondwana during the Paleozoic (e.g., Dalmayrac et al., 1980) may have been Laurentia.

A LAURENTIA–SOUTH AMERICA FIT

The Appalachian margin of Laurentia has well-developed promontories and reentrants that are believed to reflect the configuration of the craton margin following Neoproterozoic rifting (Williams, 1964; Thomas, 1977, 1991; Hatcher et al., 1989). The most obvious promontory along the margin of the Laurentian craton, however, is located at the northern termination of the Appalachian orogen. I shall refer to this as the Labrador-Greenland promontory (Fig. 1). Although the present-day margin of southeastern Greenland resulted from Mesozoic rifting of Europe from North America, the presence of the craton margin in northwesternmost Scotland and central East Greenland indicates that this promontory must have been at least as pronounced at the end of the Precambrian as it is today. There is considerable similarity between the geology of the Baltic craton and that of northeastern Labrador and Greenland. Thus, in late Precambrian reconstructions, Baltica is usually restored to a position adjacent to the Labrador-Greenland promontory with an adjustment of relative orientation (Gower and Owen, 1984; Gower et al., 1990), although this is not necessarily the pre-Iapetus position. There is no reason why another, geologically similar, cratonic area could not have intervened.

The late Precambrian proto-Andean margin of the Amazonian craton can be identified in northernmost Argentina (Fig. 1). The Neoproterozoic to Lower Cambrian Puncoviscana Formation mainly comprises turbidites derived from the craton (Aceñolaza et al., 1988; Jezek et al., 1985), but it also contains shallow-water sedimentary strata with fossils comparable to those found in the southwestern United States (Aceñolaza and Durand, 1986). There is, therefore, despite limited exposure of the basement and overprinting by Andean orogenesis, evidence that these rocks may represent the remnants of a late Precambrian margin.

Tracing the Pacific limit of this margin yields what may be a critical clue to its origin. To the south it forms the boundary between Rio de la Plata craton and the Paleozoic Famatinian orogen (Dalla Salda et al., 1992a). To the north and west lies the Arequipa massif along the coastline of southern Peru that has puzzled students of Andean geology for many years. Located immediately to the north of the prominent Arica bight in the present-day continental margin, the Arequipa massif comprises high-grade metamorphic rocks (granulite facies) that yield radiometric dates on the order of 2.0 Ga (Cobbing et al., 1977; Dalmayrac et al., 1977). Its presence outboard of the Andean Cordillera has led several authors to suggest that it may constitute an exotic terrane that collided with South America, thereby contributing to orogenic uplift of the Cordillera in general and the Altiplano in particular (e.g., Nur and Ben-Avraham, 1982). Stratigraphic evidence, however, indicates that the Arequipa massif has been in essentially its present position along the Andean margin since the late Precambrian to early Paleozoic (Forsythe et al., 1992), and the Cordillera appears to be ensialic (Dalmayrac et al., 1980). The ca. 2.0 Ga rocks therefore appear to constitute part of the Transamazonian craton. The reentrant in the craton at the bight in the present-day continental margin may therefore be a feature dating back to its inception during late Precambrian to earliest Paleozoic rifting (see Dewey and Lamb, 1992).

Juxtaposition of the Atlantic margin of the Laurentian craton with the Pacific margin of the South American craton using the PLATES software of the Institute for Geophysics of the University of Texas at Austin shows that the Labrador-Greenland promontory is the correct size and shape to have rifted from the Arica reentrant (Fig. 1). Moreover, the reconstruction indicates that the Arequipa massif could be explained as a segment of the Makkovik-Ketilidian province of Labrador and southern Greenland (Hoffman, 1989; Gower et al., 1990). The Grenville province of Laurentia could have continued beneath the ensialic Andean Cordillera of the present day to join up with the 1.3–1.0 Ga San Ignacio and Sonsas-Aguapei orogens that border the Transamazonian cratonic nucleus (Litherland et al., 1985; Teixeira et al., 1989). These in turn could have been continuous with the Sveco-Norwegian province of Baltica (Fig. 2). Precambrian rocks have been found at two localities within the Andean Cordillera immediately to the east of the Arequipa massif. Rocks from the Belén massif of northernmost Chile and from a borehole in the Bolivian Altiplano have yielded ages of ca. 1.0 Ga (Lehmann, 1978; Pacci et al., 1981). Despite uncertainty regarding the significance of the result from the Belén rocks, a broadly "Grenvillian" age seems likely (Baeza and Pichowiak, 1988). Thus a candidate for the continuation of the Grenville front can be located within the Arica reentrant opposite the equivalent piercing point on the Labrador-Greenland promontory of Laurentia (Fig. 1).

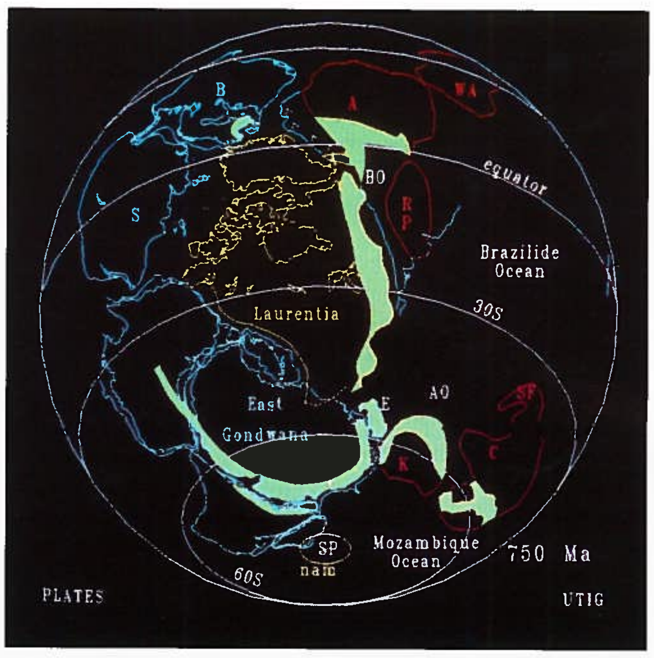


Figure 2. Reconstruction (orthographic projection) of the early to mid-Neoproterozoic supercontinent suggested to have assembled in the Grenvillian orogeny (ca. 1.3–1.0 Ga), prior to opening of the Pacific Ocean basin (~750 Ma). The relative positions of Laurentia, East Gondwana, the cratons of West Gondwana (red), and Baltica (B) are as discussed in this paper and in Dalziel (1992). The position of Siberia (S) relative to Laurentia follows Hoffman (1991). The supercontinent is shown in the reference frame a of paleomagnetic pole for Laurentia (SP = South Pole) of Park et al. (1989) determined from diabase dated by U-Pb (zircon) at 777 Ma in the Mackenzie Mountains, Northwest Territories, Canada. The gold small circle (nam) is the circle of confidence at the 95% level for this pole. Green indicates the extent of the Grenville orogen and its possible continuations. Gold A—Arequipa massif. Red letters: A—Amazonia, C—Congo craton, K—Kalahari craton, RP—Rio de la Plata craton, SF—São Francisco craton, WA—West African craton. White letters: AO—Adomaster Ocean (Hartnady et al., 1985), BO—possible additional Brazilide Ocean, E—Ellsworth-Whitmore mountains block of West Antarctica.

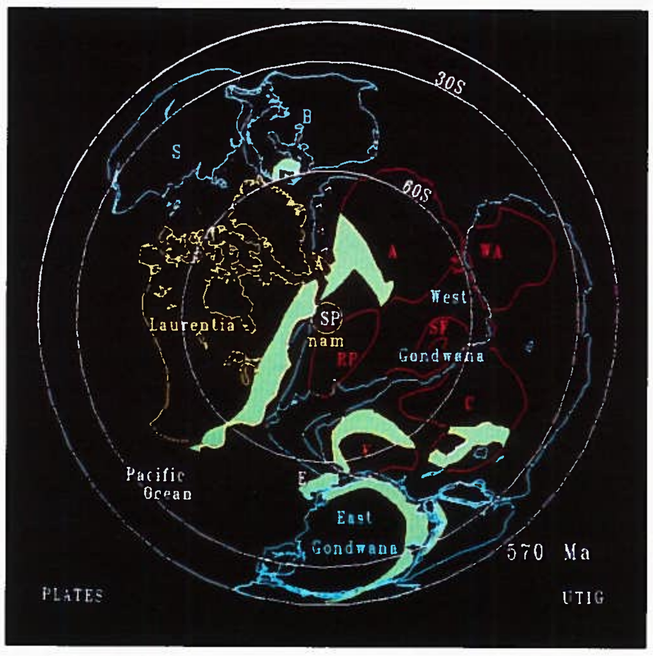


Figure 3. Reconstruction (orthographic projection) of the supercontinent suggested for the latest Precambrian (~570 Ma) following opening of the Pacific Ocean and amalgamation of Gondwana, but prior to opening of southern Iapetus (see Dalziel, 1992; Dalziel et al., 1992). The supercontinent is shown in the reference frame of the paleomagnetic pole (SP = South Pole) determined by Symons and Chiasson (1991) for the Callendar alkalic complex of Ontario dated by the K-Ar and Pb-Pb methods at 575 Ma. The gold small circle (nam) is the circle of confidence at the 95% level for this pole. Other letter designations as for Figure 2.

IMPLICATIONS

The geometric and geologic match of the Atlantic margin of the Laurentian craton and the Pacific margin of the South American craton constitutes additional evidence in support of the hypothesis that Laurentia originated between East Gondwana and the several cratons of West Gondwana (Moores, 1991; Dalziel, 1991, 1992; Hoffman, 1991). Thus, an early Neoproterozoic supercontinent (Fig. 2), assembled during the 1.3–1.0 Ga Grenvillian interval, may have included the Amazonian, West African, and Rio de la Plata cratons as well as Laurentia, Siberia, Baltica, East Gondwana, the Kalahari craton, and (possibly) the Congo–São Francisco craton.

As mentioned above, time and space considerations suggest that the Transantarctic–eastern Australian margin separated from Laurentia to open the Pacific Ocean basin at the time the Windermere passive margin developed during the mid-Neoproterozoic (Ross, 1991; Dalziel, 1992; Hoffman, 1992). However, stratigraphic data from western Newfoundland (Williams and Hiscott, 1987) indicate that, despite evidence of rifting along the Appalachian margin of the Laurentian craton at about that time (Hatcher et al., 1989), the rift-drift transition did not take place there until the earliest Cambrian (ca. 540 Ma; Compston et al., 1992) when thermal subsidence began (Bond et al., 1984; Bond and Kominz, 1991). As Gondwana appears to have amalgamated by about 600 Ma (see Dalziel, 1992, for discussion), a further implication of the proposed fit of the Labrador-Greenland promontory and the Arica reentrant is that Laurentia and Gondwana formed part of a different supercontinent in the late Neoproterozoic after the opening of the Pacific Ocean basin (Fig. 3).

This possibility needs to be taken into account in considering the envi-

Laurentia *continued on p. 241*

Laurentia *continued from p. 240*

ronmental changes that took place at the end of the Precambrian, and the emergence of multicellular organisms. The paleomagnetic poles from Laurentian rocks used to position the supercontinents in the reconstructions for 750 and 570 Ma (Figs. 2 and 3) are in keeping with the suggestion of Park (1992) that Laurentia may have moved across the South Pole near the Precambrian-Cambrian boundary. Two supercontinental assemblies during the Neoproterozoic in approximately the paleolatitudes shown, separated by the opening of the Pacific Ocean basin and the amalgamation of Gondwana, may help to explain the time-space distribution of glacial deposits formed during that interval (Chumakov and Elston, 1989). The hypothesis of a regular "supercontinental cycle" (Murphy and Nance, 1992; Turcotte and Kay, 1992; Hartnady, 1993), is called into question by the reconstructions, especially because Laurentia broke away from the late Neoproterozoic supercontinent soon after it had formed, and seems to have reunited with Gondwana three times during its Paleozoic journey around the proto-Andean margin of Gondwana (Dalla Salda et al.,1992a, 1992b; Dalziel et al., 1992). Amalgamation of several cratons to form supercontinents from time to time seems inevitable on the surface of a dynamic Earth of constant radius (Duncan et al., 1992).

A further implication of the proposed fit is that, despite significant modification of their margins as a result of Phanerozoic tectonism, the discrete cratons that separated during the Neoproterozoic were very robust entities indeed. For example, if the Labrador-Greenland promontory and the Arica reentrant are related as suggested here, the present-day Arica bight originated in a latest Neoproterozoic to earliest Paleozoic rift event (see Dewey and Lamb, 1992). Knowledge of the growth of the South Atlantic Ocean basin precludes major modification of the eastern margin of South America during the Mesozoic and Cenozoic. Paleomagnetic data suggest movement of small blocks along the Pacific margin into the Arica bight during the Mesozoic and Cenozoic (Beck, 1988), but there are no data to suggest that the bend in the Andean Cordillera there is secondary. Thus, the basic shape of the bight may be inherited from rifting of the Labrador-Greenland promontory of Laurentia from the Arica reentrant of Gondwana at a triple junction with a failed arm that formed the Paleozoic ensialic orogen between the Arequipa massif and the cratonic nucleus of Amazonia (Fig. 1; Dalmayrac et al., 1980). In that case the Altiplano may owe its existence to that ancient extensional event and to the consequent modification of Phanerozoic tectonic processes by the presence of the reentrant (Isacks, 1988; Scanlan and Turner, 1992).

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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.

ISSUE: Geologic Mapping: Implementing the National Geologic Mapping Act of 1992

This is the first half of a two-part Forum discussing the many facets of the National Geologic Mapping Act of 1992. The act, which was described in detail in the September 1992 *GSA Today* Washington Report, was also the subject of a Committee on Geology and Public Policy forum at the 1992 Annual Meeting.

PERSPECTIVE 1: The National Geologic Mapping Program

Charles J. Mankin, Oklahoma Geological Survey, Norman, Oklahoma

The availability and effective utilization of natural resources is fundamental to sustain human existence on planet Earth. A basic requirement for identification, delineation, and recovery of mineral commodities is the availability of detailed geologic mapping. Unfortunately, less than 20% of the United Sates is adequately mapped to meet these needs.

Growing concern over effective stewardship of our environment is producing a myriad of rules and regulations directed toward maintaining and improving our habitat. The ultimate repository of our waste products is the earth, and geologic maps are needed to identify and delineate the rock units that are capable of containing them effectively.

As the population of Earth continues to increase, the effects of natural hazards loom ever greater. The identification and mitigation of such phenomena require the use of detailed geologic maps.

Most industrialized nations have recognized the need for geologic mapping and have developed programs to produce such coverage. Unfortunately, the United States, presumed to be the most affluent and technologically advanced nation in the industrialized world, has the least coverage of detailed geologic mapping. An assessment by the Association of American State Geologists (AASG) found that only 11,000 of the 59,000 quadrangles (18%) covering the country have been mapped in sufficient detail to be useful in addressing state needs for resource development, environmental protection, and natural hazard identification and mitigation. Only one state, Kentucky, has been completely mapped at a scale of 1:24,000, and even in that state revisions are needed.

For these and a myriad of other reasons, the AASG in concert with the U.S. Geological Survey (USGS) began a planning process some four years ago to develop a geologic mapping program that would produce complete coverage of detailed surficial and bedrock geologic mapping for this nation in a realistic span of time.

At the outset, the joint committees recognized that the nation has substantial but declining capability in geologic mapping, although the USGS and the state geological surveys are publishing detailed surficial and bedrock geologic maps, the rate of production will not provide adequate coverage of the needed areas in any realistic span of time.

Furthermore, the number and capability of geologic mappers in the United States are clearly on the decline. In recent years, colleges and universities have decreased their attention to field training; some have eliminated such requirements altogether.

Because of these conditions, a plan was developed to introduce an authorizing bill to the Congress that would establish a national mandate to produce complete surficial and bedrock geologic mapping coverage at a scale that would meet national and regional needs for resource development, environmental protection, and identification and mitigation of natural hazards. The nominal mapping scale adopted was that of the standard topographic quadrangle map (1:24,000).

The proposed authorizing bill placed the national management responsibilities in the USGS, with advisory support from other involved federal agencies, state geological surveys, academia, and the private sector. The proposed program consisted of four elements: a federal geologic mapping component, a geologic mapping support component, a state mapping component, and a university field-training component (see Table 1).

The federal mapping component recognized the current federal mapping program that addresses national needs for geologic map coverage by the USGS and other federal agencies. The federal mapping support component addresses the ongoing efforts of the USGS to develop and maintain related data bases in stratigraphy, geochronology, paleontology, geophysics, and others. In addition, this component recognizes the need for the development of digital methods for managing and using geologic map data.

The state mapping component is directed toward meeting those needs for detailed geologic maps at the state and local level. It was recognized that such needs carry some responsibility for state support as well. Thus, the state mapping component was established as a matching-funds program with half of the funding to be obtained from non-federal sources.

The university field-training support component is designed to address the national decline in geologic field training. Grants to academic institutions for augmenting summer field-training programs will be provided with the expectation of increasing the number of qualified field geologists to meet the needs of the expanded national geologic mapping program.

It was recognized at the outset that the passage of a bill authorizing the establishment of a national geologic mapping program would require the support of a broad constituency. While the USGS and the AASG have compiled impressive statistics concerning the needs and the status of detailed geologic mapping in the United States, efforts at passage of such legislation would undoubtedly fail without a public response to support those identified needs.

To develop this public support, the AASG, through the state geological surveys, launched a major effort to identify companies, organizations, and individuals at the national, regional, state, and local levels. The results were impressive; this effort is largely responsible for the passage of the authorizing legislation.

The authorizing bill was introduced into the Senate by Senators Johnston (D—LA), Bingaman (D—NM), and Craig (R—ID) on May 23, 1991, and in the House of Representatives by Congressmen Rahall (D—WV), Vucanovich (R—NV), Brewster (D—OK), and McCurdy (D—OK) on June 25, 1991. The state geologists, working through various state-level groups, were able to enlist an impressive number of cosponsors for the House and Senate versions of the bill. At passage, the Senate bill (S. 1179) had 22 cosponsors, and the House bill (H.R. 2763) had 48 cosponsors. The result was that, following successful hearings, the bill passed both houses by unanimous consent and was signed into law on May 18, 1992, as Public Law 102-285, The National Geologic Mapping Act of 1992.

The passage of the act is a tribute to the dedication of the state geologists, their staffs, and literally hundreds of other individuals and organizations who were able to identify and develop constituencies in each state in support of the act. A valuable lesson for the geologic community is contained therein.

While the tendency is to bask in the light of the achievement, the second, and equally daunting task, it to secure the funding required to implement the act. The funding levels authorized by the act are shown in Table 1. To finally realize the long effort by many to develop and implement a National Geologic Mapping Program, a further concerted effort will be needed in the next session of Congress to secure the funding authorized by the act. That process has, in fact, already begun.

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TABLE 1. AUTHORIZED FUNDING LEVELS

FY	Federal Mapping	Federal Support	State Mapping	Educational Mapping
1993	$12.5	$ 9.5	$15.0	$0.50
1994	14.0	10.0	18.0	0.75
1995	16.0	10.5	21.0	1.00
1996	18.0	11.0	25.0	1.50

Note: Values are in millions of dollars.

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PERSPECTIVE 2: Toward a Better Economy and a Healthier Environment

Morris W. Leighton (President, Association of American State Geologists—AASG) and David L. Gross, Illinois State Geological Survey, Champaign, IL

If ever our nation required programs in support of both economic development and environmental protection, now is the time! And national geologic mapping is one of those programs. Recognizing the contributions that geologic maps can provide for these goals, Congress passed the National Geologic Mapping Act of 1992 to authorize a comprehensive nationwide mapping program, and President Bush signed the act on May 18, 1992.

In the face of the mounting federal debt, additional funding to fully implement the new program structure is still at issue, especially for the state mapping component and the educational component. The state mapping activities were authorized to start at a level of $15,000,000 for fiscal year 1993, growing to $25,000,000 in the fourth year. The educational component was authorized to start at $500,000, growing to $1,500,000 in the fourth year. Federal and support components together were authorized under the act to total $22,000,000 in FY 1993, growing to $29,000,000 in the fourth year. FY 1993 Congressional appropriations fall far short of the act's FY 1993 authorization levels and barely exceed the FY 1992 enacted budget. Obviously, additional appropriations that adequately support the state mapping and education components of the act as well as the federal components still are required.

To bring about the needed appropriations, the benefits of geologic mapping must be even more clearly stated to Congress than they were during the campaign to pass the authorizing act. The specific needs and priorities for geologic maps must be clearly established—both for the nation as a whole and for the individual states. Clear statements of what should be mapped and in what order will allow everyone to understand the magnitude of the problem, the cost, and the time and effort required to provide geologic maps at the detailed scale now needed. Also, the proper roles of the USGS and the state geological surveys must be clearly enunciated and appropriate operating procedures implemented for a cooperative, productive effort.

The benefits, operations matters, policy implications, and funding needs are being addressed currently by representatives from the business, professional, government, and education sectors. Forums such as this one and the panel discussion and open forum "Economic Benefits and Public Policy Issues of Geologic Mapping" held at the GSA Annual Meeting in Cincinnati help to bring the issues and needs into focus. The state geological surveys have been active for some time in gathering the required information and are working closely with the USGS in developing two reports to Congress on these subjects as required by the act.

One of the issues, that of clearly explaining to the public the potential benefits of geologic mapping, can be assisted in a number of ways: by more fully identifying the uses and users of maps, by adding to the anecdotal accounts of the impacts of geologic maps and by encouraging rigorous, quantitative benefit/cost studies. The most obvious use of geologic mapping information, and its most commonly known use, is in exploring, finding, and inventorying new fossil fuels and nonfuel mineral deposits, including ground water. Even in a relatively well explored region such as the United States, the use of geologic maps in mineral exploration and extraction is still leading to the creation of wealth and/or cost savings by the private sector.

Increasingly, however, the benefits gained from the information conveyed by geologic maps can be likened to those resulting from preventive medicine. The value of this information lies today as much in its use in avoiding future costs of environmental clean-up or in minimizing the impacts on public health and safety from natural and human-made disasters as in finding new mineral deposits. Maps of the nature of earth materials and their vertical and lateral distribution can be used to interpret, for example, the potential for ground-water contamination from a landfill, the probable response of earth materials to earthquakes, the potential for landsliding, and the risk of earth subsidence or collapse.

The benefits gained from the information conveyed by geologic maps can be likened to those resulting from preventive medicine.

Where they are available, geologic maps are being widely used as planning tools by business and industry and state and local government agencies, not only for locating, assessing, and developing mineral resources but also for locating, designing, and constructing safe sites for hospitals, schools, landfills, and other public and private facilities, and for developing zoning ordinances and building codes, assessing insurance risks, defining agricultural assistance programs, and assessing land and mineral values for taxing purposes. Geologic maps can thus be seen as a fundamental data base with numerous uses.

Anecdotal accounts strongly indicate the value of a vigorous geologic mapping program for promoting a healthy economy and a healthy environment. In 1979, following the detailed geologic mapping program in Kentucky, conducted cooperatively by the USGS and the Kentucky Geological Survey, Preston McGrain reported that the value of a six-foot-thick coal seam in a 195 acre tract discovered by the mapping program was equal to the entire cost of the mapping program for the State of Kentucky. McGrain cited other examples and estimated that, overall, the benefits of the Kentucky geologic mapping program outweighed the costs at least 50 times over.

Recent quantitative benefit/cost analyses have taken rigorous economic approaches to the estimation of benefits of map information. In 1991, the USGS applied a probabilistic economic model to two cases: a highway construction project around Washington, D.C., and a ground-water contamination problem in New Jersey. Both cases demonstrated that the value of the benefits of using geologic information more than recover the original cost of the mapping programs.

In 1991, Subhash Bhagwat and Richard Berg developed a quantitative model of the benefit/cost ratio of geologic mapping in Illinois based on a case study of a geologic mapping project in two counties in the northern part of the state. They compared the costs of cleaning up contaminated waste disposal sites to the costs of the geologic mapping program, completed in 1984. By assuming that some of the clean-up costs could have been avoided if relevant geologic information had been used at the time that sites for the disposal facilities were chosen, they showed benefit/cost ratios for the two-county area ranging from 12 to 27. These results took into account quantitatively only one type of benefit—the savings in clean-up costs. Values of other benefits of the geologic maps of the two counties, such as identification of mineral-resource locations or the nature of foundation conditions, would further increase the calculated benefit/cost ratios. It is clear from these studies that there is ample economic justification for conducting a nationwide federal-state cooperative geologic mapping program.

Geologic mapping for the purpose of providing geologic information to the public is a "public good," whose benefits extend over many generations, thus justifying its being funded with public money. The products of the geologic mapping programs authorized by the act are geologic information or knowledge that serves the entire society; no one will be excluded from receiving its benefits. In that respect, the purpose of the geologic mapping program is similar to that of national defense in helping to ensure national security or to that of clean air legislation aimed at reducing environmental risks to the public.

Knowing that geologic maps have many friends and no enemies and that less than 20% of the nation has been mapped in the detail required, the geological profession—the producers of geologic maps—and the users need to work together to establish priorities for the remaining areas in the United States, on the basis of identified needs in each state as well as identified national needs. Then a rational program must be developed to meet the priorities in an orderly way and with a clear indication of staffing plans and costs.

To enable these remaining steps to be done rapidly and thoroughly, the USGS and the AASG have met and agreed on an implementation program and are working jointly to analyze the nation's requirements for geologic maps and to develop the mechanisms for determining priorities for mapping and for equitably funding projects. They are working to put these mechanisms into place and to provide staffing plans for various possible funding levels.

Two separate reports to Congress, required by the provisions of the mapping act, are due on December 12, 1992, and March 12, 1993. The first report must describe how mapping goals and priorities will be set, what the staffing levels needed for successful implementation of the program are, and how the USGS will coordinate the program. The degree to which geologic mapping activities can be contracted to private mapping firms also must be evaluated. The second report will set out the overall structure for managing and operating the program, describe the roles of the USGS and the state geological surveys in the program, and provide the basic mechanisms for setting priorities, acquiring data and setting standards, and monitoring the results of the program.

The target of fully funding the national geologic mapping program

Forum *continued on p. 244*

Forum *continued from p. 243*

is clearly visible, but the full involvement, cooperation, and support of industry, the professional societies, and government agencies will be required to provide the proper focus and steady aim necessary to achieve this objective. Congress must be convinced that an initial appropriation at the level called for in the act is the right choice to make in the face of other demands for public funds and that continued appropriations at authorized levels will be required to reap the benefits of geologic mapping for economic development and environmental protection in a timely way.

PERSPECTIVE 3: U.S. Geological Survey's National Geologic Mapping Program

Mitchell W. Reynolds and John F. Sutter, USGS, Reston, VA

The Organic Act of 1879 chartered the USGS to examine "the geologic structure, mineral resources, and products of the public domain," and the agency became the principal federal creator and custodian of that information. Today, national issues such as geologic hazards, land-use planning, and mineral and energy resource assessments require a national geologic map data base. Prior to the late 1960s, geologic mapping and research by the USGS to establish the nation's geologic framework was funded by a Regional Mapping and Analysis Program, and the data base consisted of geologic map folios, geologic quadrangle maps, and a variety of economic geology maps. From 1969 to 1978, appropriations were mainly for mission-oriented geology and mineral resources surveys and mapping with an emphasis on small-scale (1:250,000) geologic maps. In addition, during the 1960s and 1970s, the USGS completed hundreds of detailed geologic maps in cooperation with states such as Kentucky, Connecticut, California, and Wyoming. From 1979 to 1988, studies within the Geologic Framework and Synthesis Program emphasized geologic processes, geologic synthesis studies, and limited systematic geologic mapping.

In 1983, concerned about a decline in systematic geologic mapping, at a time when demand for new geologic map information seemed to be increasing, the National Research Council (NRC) Committee on Geologic Mapping, together with the USGS, polled geologic map users to determine then-current and future usage of geologic maps. Early in the 1980s, the USGS and the state geological surveys developed a formal understanding to promote cooperative geologic work between the federal and state surveys. That understanding led the USGS to formulate a Federal-State Cooperative Geologic Mapping (COGEOMAP) Program, described in USGS Circular 1003. In FY 85, COGEOMAP became part of the USGS appropriation from Congress. During the first year, 21 cooperative geologic mapping projects were begun in 18 states. Since 1985, 45 states have participated in the COGEOMAP program.

In January 1985, a Committee Advisory to the USGS from the NRC described the need for a national geologic mapping program that should meet the following goals: (1) increase production of geologic maps; (2) improve coordination among federal, state, and university geologic mappers; and (3) adopt new technologies, including digital geologic map production. In response, the USGS established the National Geologic Mapping Program (including COGEOMAP) in FY 1988. The goals, objectives, and long-range plans of that program are described in USGS Circular 1020.

Since 1988, the USGS National Geologic Mapping Program has made significant advances. The program has nearly doubled the production of intermediate-scale (1:100,000) to large-scale (1:24,000) geologic maps. It has implemented formal coordination with other Federal agencies to establish their geologic mapping needs and develop national priorities. Federal-state cooperative geologic mapping activities increased more than twofold from FY 1985 through FY 1992. The program has begun to develop digital geologic map standards and menu-driven software packages for compiling geologic maps digitally as geoscience information systems (GIS) data bases. An ongoing series of economic studies (benefit/cost analyses) by the program is designed to demonstrate the societal value of digital geologic-map information in a wide variety of applications.

Even with this renewed emphasis and closer coordination, the demand for geologic map information by federal, state, and local agencies and the private sector far exceeds the capabilities of all geologic map producers to deliver the needed maps in a timely manner with the resources currently available. To identify potential solutions to this problem and to increase the nation's awareness of the need for accelerating geologic mapping, the USGS and the AASG held a series of informal meetings. The participants concluded that a formal nationwide geologic mapping effort was needed, and they developed a draft plan that would establish a partnership of federal, state, academic, and private-sector geologic mappers.

In 1991, during the first session of the 102nd Congress, parallel bills, then titled "The Geologic Mapping Act of 1991," were introduced in the U.S. House of Representatives (H.R. 2763) and Senate (S. 1179). USGS Director Peck testified as a representative of the Administration that modern geologic maps are of fundamental importance to the nation, but that the Administration could not support the legislation primarily because "the funding levels run counter to those of the Administration and to the efforts of Congress to move in the direction of a balanced budget." However, he also testified that "the USGS will continue, within existing funding levels, to work with other Federal and State agencies to accomplish the objectives for which H.R. 2763 is intended." An amended version of H.R. 2763, the "National Geologic Mapping Act of 1992," was finally passed by both houses of Congress and was signed into law (Public Law 102-285) by the President on May 18, 1992.

The Geologic Mapping Act of 1992 assigns to the USGS the responsibilities for planning, developing priorities, coordinating, and managing the geologic mapping program authorized by the act. The USGS is also given responsibility for establishing a national geologic-map data base. This data base will be archived as 1:100,000-scale quadrangles that represent, when appropriate, compilations based on larger scale geologic map information produced by the various geologic mapping partners and archived by either state or federal agencies. In addition to the 1:100,000-scale quadrangle maps, the national geologic-map data base will include national paleontologic, geochronologic, geophysical-map, and geochemical-map data bases.

In recent years the USGS has revitalized and expanded its activities in geologic mapping, and it is deeply committed to achievement of the goals of the act through its own work and through cooperation with state geological surveys and other producers of geologic maps. Through national cooperation, a modern geologic-map data base can become a reality for our nation. ■

Cole Memorial Research Awards in Geomorphology and Micropaleontology

Through the generosity of W. Storrs Cole, two awards for support of research are offered through GSA. The Gladys W. Cole Memorial Research Award provides research support for the investigation of the geomorphology of semiarid and arid terrains in the United States and Mexico. It is to be given to a GSA Member or Fellow between 30 and 65 years of age who has published one or more significant papers on geomorphology. Funds cannot be used for work already accomplished, but recipients of a previous award may reapply if additional support is needed to complete their work. The amount of this award in 1993 will be $7000.

The second award, the W. Storrs Cole Memorial Research Award, has been established to support research in invertebrate micropaleontology. This award will also carry a stipend of $7000 and will be given each year to a GSA Member or Fellow between 30 and 65 years of age who has published one or more significant papers on micropaleontology.

Additional information and application forms may be obtained from June R. Forstrom, Research Grants Administrator, GSA, P.O. Box 9140, Boulder, CO 80301.

All applications must be postmarked on or before February 15, 1993. Actions taken by the Committee on Research Grants will be reported to each applicant in early April.

These are two of GSA's most prestigious awards; all qualified applicants are urged to apply.

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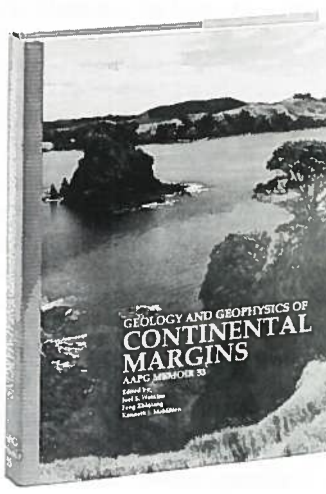

AAPG Memoir 53
GEOLOGY AND GEOPHYSICS OF CONTINENTAL MARGINS, edited by J. Watkins et al., (1992), 419 p., seismic foldouts, hardcover.
Cat #566 AAPG Member $59
List $82

For geologists and geophysicists studying the world's continental margins, this volume features sea-level and seismic stratigraphy studies, new data, and interpretation from the following areas:
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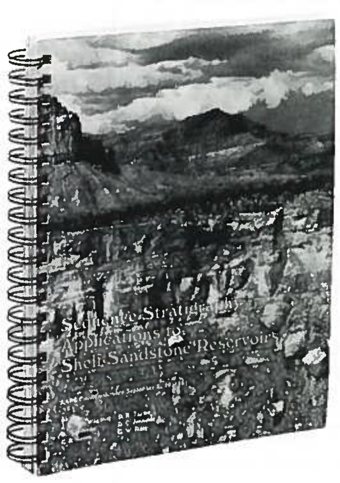

SEQUENCE STRATIGRAPHY APPLICATIONS TO SHELF SANDSTONE RESERVOIRS—OUTCROP TO SUBSURFACE EXAMPLES, by J.C. Van Wagoner et al. (1992), spiralbound, 16 foldout illustrations, color, 257 p.
Cat #547 AAPG Member $20
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Far more than a field guide, this volume illustrates, using outcrops and well log sections, the details of sequence stratigraphy correlation in the shelf sandstone environment. For researchers and field geologists, this book offers:
- Foldout correlation charts, both outcrop and well log, that illustrate sequence and systems tracts
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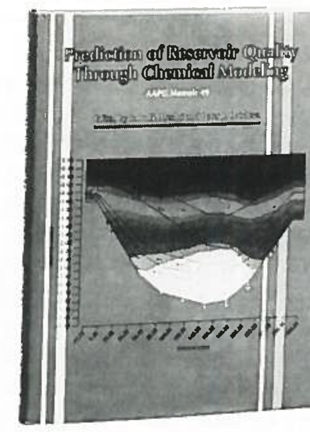
AAPG Memoir 49
PREDICTION OF RESERVOIR QUALITY THROUGH CHEMICAL MODELING edited by I.D. Meshri and P.J. Ortoleva (1991), 176 p., hardcover
Cat. #563 AAPG Member $46
List $69

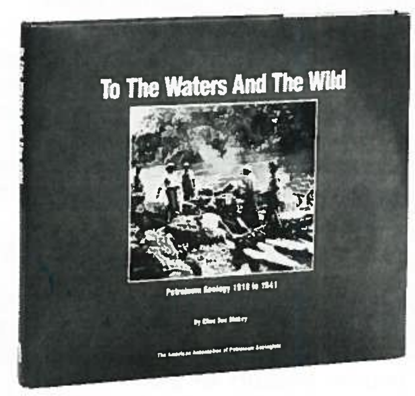


This is a collection of research papers focusing on diagenesis and chemical influences on rock properties and porosity and features ten information-packed chapter topics: Porosity Prediction in Sandstone using Erosional Unconformities, Facies Controls on Early Diagenesis, Chemical Models and Their Porosity Prediction, Rock-Water Interaction and Simulation of Diagenesis, Bulk Solution Disequilibrium in Aqueous Fluids, Dissolution and Precipitation Kinetics of Kaolinite, Diagenesis Through Coupled Processes, Interaction of Reaction, Mass Transport, and Rock Deformation during Diagenesis, Fluid-Rock Interaction in Thermal Recovery of Bitumen.
If you are interested in diagenesis, geochemistry, or reservoirs and aquifer porosity prediction, this is a valuable addition for your research library.

SEDIMENTOLOGY AND SEQUENCE STRATIGRAPHY OF REEFS AND CARBONATE PLATFORMS,
by Wolfgang Schlager (1992), Continuing Education Course Note #34, 71 p.
Cat #567 AAPG Member $14
List $20

Now, after several publications on clastic sequence stratigraphy, AAPG is pleased to offer this insightful volume on carbonate sequence stratigraphy by one of the world's acknowledged carbonate experts.Thought-provoking concepts and ideas discussed in this volume include:
- Sequence stratigraphy as a modern version of lithostratigraphy and thus, as a sedimentology concept.
- Sequences and systems tracts from the view of sedimentology concepts.
- Guidelines for application of sequence stratigraphy to reefs and carbonate platforms.

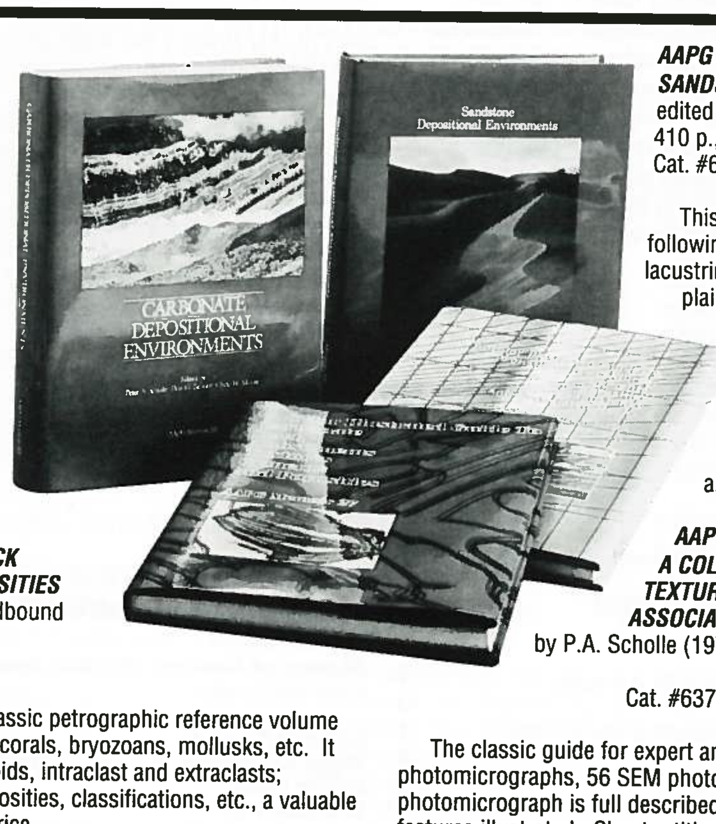
TO THE WATERS AND THE WILD—PETROLEUM GEOLOGY 1918-1941
by E.S. Blakey (1991), 207 p., hardbound
Cat. #713 One Price $38



The second petroleum geology history book by AAPG is a lavishly illustrated, fascinating personal account of geologists' adventures around the world. Featuring more than 100 unique duotone photographs, this book is a series of accounts written by the geologists who lived them, from Seminole, Oklahoma, to the jungles of South America to the deserts of Turkey, Iraq, and the Middle East. This is a fun book to read for all geologists and historians.

AAPG Memoir 33
CARBONATE DEPOSITIONAL ENVIRONMENTS
edited by P. A. Scholle, D.G. Bebout, and C.H. Moore (1983), color throughout, 708 p., hardbound
Cat. #656 AAPG Member $52
List $78

The definitive reference on carbonate environments, this tome features the works of such recognized carbonate experts as E.A. Shinn, P. Enos, J.E. Wilson, N.P. James, R.B. Halley, P.M. Harris, and many others. Diagrams, text and cross-sections examples from the modern and ancient records are fully discussed and illustrated for the following environments: subaerial, lacustrine, eolian, tidal flat, beach, shelf, middle shelf, reef, bark margin, fore-reef slope, basin margin, and pelagic.



AAPG Memoir 31
SANDSTONE DEPOSITIONAL ENVIRONMENTS
edited by P.A. Scholle and D. Spearing (1982), color throughout, 410 p., hardcover
Cat. #627 AAPG Member $46
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This leading reference features fully illustrated chapters on the following sandstone environments: eolian, glacial, alluvial fan, lacustrine, fluvial, deltaic, estuary, tidal flat, barrier island, strand plain, continental shelf, continental slope and submarine fan.
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Robert L. Fuchs

Retirement Income—Consider the Annuity

How do we pay the bills and maintain our lifestyles after retirement? This is a query on the minds of many GSA members. There is, of course, Social Security, but no one really believes that a comfortable living is possible solely from these monthly payments. Probably every member has some form of savings or estate development to supplement Social Security. Employer pension plans are common, including such variations as profit sharing, 401-K, and contributory savings plans. In addition, those planning for the future will invest to build up taxable and tax-free dividend and interest income, and purchase annuities in various shapes and forms.

The Charitable Gift Annuity and a modification known as the Deferred Payment Gift Annuity can provide retirement income while at the same time augmenting the endowment of the GSA Foundation. Since money passes from the donor to a charitable institution, there are favorable tax attributes in addition to annual payments to you and your spouse for life. This favorable tax treatment comprises a charitable income tax deduction in the year that the annuity is established, plus a tax-free return of principal once annuity payments commence. The Deferred Payment Gift Annuity varies from the basic plan in that payments to the annuitant commence at some preselected future date—for example at recipient age 65.

A GSA member, age 45, purchases an annuity from the Foundation by making a gift of $10,000 in 1992. The terms of the annuity specify that an annual annuity of $1940 will be paid to the donor or spouse for the balance of their lives, commencing at the donor's 65th birthday.

Two tax benefits are generated by this gift. First, there is a charitable income tax deduction of $5036 in 1992. Second, $190 of each annuity payment is a tax-free return of principal for 26.1 years.

There is a further wrinkle that can make this type of gift even more attractive from the tax standpoint. If the donor gives appreciated securities directly to the Foundation instead of cash as the corpus of the gift, the capital gains tax that would be paid on the profit in these securities if they were sold is completely avoided (see the following article). Thus, in carefully structuring the purchase of an annuity from the Foundation, the donor can obtain several benefits. These include an annual income for life, a current tax deduction, a partially tax free annual income stream, and the avoidance of capital gains tax if the gift consists of appreciated securities.

If this provision for future income could have a place in your retirement planning, please write the Foundation or call us at (303) 447-2020.

The Finer Points of Noncash Gifts

Most people think in terms of cash when considering a gift to an institution. When a decision is reached to make a donation, the giver usually sits down and writes a check to the recipient—church, school, charity, or professional society. A noncash gift is a transfer of property, real or personal. While slightly more complex to effect, a gift of property can provide greater personal satisfaction to the contributor, and, in the case of appreciated property, can generate significant additional tax benefits.

Stocks, bonds, and mutual fund shares are the most common types of appreciated property gifts and can serve as an example of the tax leverage inherent in this form of giving. Assume that Dr. Donor wishes to contribute $10,000 to the GSA Foundation's GEOSTAR program to support research. He has 200 shares of Blue Chip Corporation, which is currently trading on the New York Stock Exchange at $50 per share. His cost was $10 per share 10 years ago. If Dr. Donor sells this stock and is in the 28% income tax bracket, he would have to pay 28% of his $8000 capital gain as federal income tax, an amount of $2240. (I'm assuming the donor resides in a state with no state income tax, of which there are not many). The remaining cash available to give to GSA would be $7760. To fill out his planned $10,000 gift, Dr. Donor would need to sell a total of 278 shares of Blue Chip (if he has that many) in order to pay the taxes on the transaction and still make the desired $10,000 gift.

There is an easier and cheaper way. Dr. Donor merely takes his certificate for 200 shares of Blue Chip Corporation to a stock broker or to Blue Chip's transfer agent (always indicated on the stock certificate) and directs that the shares be transfered to the GSA Foundation. If the transfer is done on a day that the closing price is $50, GSA will have received a gift of $10,000 and Dr. Donor will have a deduction for tax purposes of $10,000. Timing determines the exact amount, since Blue Chip's stock price will fluctuate from day to day.

A financial double whammy is evident in this example. By giving stock directly to the Foundation, Dr. Donor has generated a full $10,000 tax deduction and avoided dilution of his gift by the tax bite on capital gains. The Foundation immediately sells the shares for $10,000 and, as a tax-free entity, has full use of the entire proceeds for the support of geologic research.

In addition to securities, real property, such as real estate or mineral interests, can be given to GSA as gifts of appreciated value. This is particularly pertinent to geologists who may receive royalties as payment for services performed.

Professor Phil Anthropist was given a 0.5% net smelter royalty on a small gold property in Mineral County, Nevada, as compensation for some mapping he did in the early 1980s. Now a mine is in production, the royalty is paying $1000 per month, and Professor Anthropist would like to donate half of this royalty to the Foundation to support research. With the assistance of legal counsel an assignment to the Foundation is executed, and the royalty is appraised by a mineral consulting firm at $36,000. GSA receives a gift for research of $500 per month. Professor Phil Anthropist has a tax deduction of $18,000 and continues to receive $500 per month royalty income.

As you can imagine, there are many fine points in the area of property gifts that are best handled by tax and legal experts. But if you think this is a way to make a gift to GSA with maximum tax leverage to you, call the Foundation office at (303) 447-2020 and ask for the free booklet, the Magic of Gifts of Appreciated Property. Or you can clip and mail the accompanying coupon to us, if you prefer. If the tax benefit is to be effective in 1992, don't delay. The year ends on December 31st. ■

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About People

GSA Member **Nancy J. Butkovich,** Pennsylvania State University, is the winner of the Geoscience Information Society 1992 Best Paper Award, for her paper "Discussion of the Use of Foreign Language Sources in Geological Journals" in *GIS Proceedings.*

GSA Fellow **William L. Chenoweth,** Grand Junction, Colorado, has been retained by the Civil Division, U.S. Department of Justice. He will advise and assist the Department on the administration of the uranium mines part of the Radiation Exposure Compensation Act of 1990.

GSA Fellow **Hanka Sobczak Chryssafopoulos,** Boca Raton, Florida, has been named a Fellow of the Society of Women Engineers.

Fellow **Margaret S. Leinen** has been appointed Vice Provost for Marine Programs and Dean of the Graduate School of Oceanography at the University of Rhode Island, Kingston.

Member **James M. Robertson** has been named Director and State Geologist of the Wisconsin Geological and Natural History Survey, Madison

Member **Janet L. Wright,** University of Nebraska—Lincoln, has been elected 1993 president of the Association for Women Geoscientists. Member **Sarah Stoll,** Sheboygan, Wisconsin, has been elected to another term as editor of the Association's journal *Gaea.*

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Oceanic Basalts. *P. A. Floyd, editor. Van Nostrand Reinhold, New York, 456 p., $127.95.*

For approximately the past 25 years, petrologists and geochemists have been intensively studying black rocks dredged, drilled, or submersible-sampled from the depths of the world's oceans. The results of individual studies on these rocks have been published in a diversity of forums, including a multitude of international research journals as well as Initial Reports volumes of the DSDP and ODP. Finally, a book has appeared that attempts to synthesize much of what is known about oceanic basalts.

Oceanic Basalts is subdivided into four distinct parts, which collectively comprise 15 chapters, most written by leading, active researchers in their respective fields. Part I addresses the structure of the oceanic crust and includes chapters on Surveying and Sampling the Ocean Floor, the Structure of the Oceanic Crust from Geophysical Measurements, and the Structure of the Oceanic Crust as Deduced from Ophiolites. As an ophiolite worker, I would give this latter chapter less than full marks; many of what I consider to be the seminal studies on this topic were not even referenced (e.g., R. Varga and co-workers' studies on Troodos; G. Harper and co-workers' studies on the Josephine; T. Juteau and co-workers' studies on Semail).

Parts II–IV deal entirely with geochemical and petrological aspects of oceanic basalts. Part II, entitled Processes, contains chapters on Mineralogy and Crystallization of Oceanic Basalts, the Experimental Phase Petrology of Mid-ocean Ridge Basalts, and Magmatic Processes in Oceanic Ridge and Intraplate Settings. Part II also contains this book's only chapter addressing the subsolidus aspects of oceanic basalts, Metamorphic and Hydrothermal Processes: Basalt-Seawater Interactions. Surely the wealth of data on this topic merits more than a single chapter in a book like this.

For the nonspecialist, Part III, Environments, may prove to be the most valuable aspect of this volume. Chapters in it review the petrologic and geochemical characteristics of five distinct oceanic basalt environments: Oceanic Islands and Seamounts, Back-arc Basins, Pacific Ocean Crust, Indian Ocean Crust, and North Atlantic Ocean Crust and Iceland. The book closes with two chapters, Stable and Noble Gas Isotopes and Oceanic Peridotites, grouped under the heading Sources.

Because *Oceanic Basalts* has a list price in excess of $100 (hard cover, but with no color or glossy plates), I believe that all students and most gainfully employed professionals will find this book well beyond their means. It's a real shame, because most students, researchers, and teachers in the hard-rock field really want to have this kind of book in their personal libraries. Frankly, I believe that our community would be better served if these sorts of review volumes were published exclusively by our scientific societies. I am convinced that the Mineralogical Society of America, for example, could have made this particular volume (in paperback) available at a fraction of the cost.

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Field Geology of High-Grade Gneiss Terrains. *C. W. Passchier, J. S. Myers, and A. Kröner, Springer-Verlag, Berlin and Heidelberg, 1990, 150 p., $19.50 (paper bound).*

In the early days of core complex research, one of my professors pointed to an old map of one and said "and this pink area is the pink of ignorance." The ignorance the professor referred to was the tendency to simplify the complex geology of high-grade gneiss terrains as "basement" or "Precambrian undivided" on geologic maps. Slowly, the "pink of ignorance" is being erased from modern geologic maps, owing to parallel advances in geobarometry and geothermometry, structural analysis, and geochronology, with developments in deep crustal geophysics acting as a catalytic agent. Now mappers in high-grade terrains have a rich arsenal of methods by which these complex terrains can be mapped and interpreted.

In this nicely illustrated book, Passchier, Myers, and Kröner bring their vast collective experience of mapping complex metamorphic terrains together into a compact, well-written field manual designed to help the experienced and inexperienced unravel the mysteries of these terrains. The book starts with a short tutorial on general mapping procedures and strategies and then moves into two substantial chapters about the development of fabrics and structures and their interpretation. These chapters are well illustrated with numerous diagrams and high-quality black-and-white photos. Much of the material in these as well as in subsequent chapters can be found in a variety of textbooks and journal articles (many of which are referenced), but there aren't many places where this material is so succinctly summarized and illustrated. I particularly liked the diagrams illustrating various shear-sense indicators and the companion text, although I would like to have seen the text and figures placed closer together to avoid continuous page flipping to match text and figure. This section could also benefit from a little more elaboration.

The next two chapters show how modern methods in metamorphic petrology and isotope geology can be used in concert with mapping to better interpret high-grade terrains. By necessity, these chapters are brief in comparison to the vast literature in these fields, but they do point the mapper in the

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right direction. All through these chapters the authors promote a synoptic approach to mapping, urging the mapper to synthesize modern structural analysis and petrology in the field. These two chapters are followed with an outline of some of the recent ideas on the formation and evolution of high-grade gneiss terrains. Those active in the field will find the material familiar, but the beginner will find this a useful summary of the literature. Most of the current models are reviewed, but the extension model was conspicuously absent. A challenging problem section follows. Here the authors present a self-test made up of a complex map and many field photos that they ask the reader to interpret. Of course, they kindly offer their interpretations but urge you not to read ahead until you have made your interpretive attempt.

This book is a very useful manual for geologists mapping in high-grade terrains, although seasoned veterans will probably not consult it very often. It will also be of value to those, such as the deep crustal geophysicist, who don't map but need to understand the work of mappers. Field course instructors with little background in high-grade terrains who suddenly find themselves with a field exercise in a gneiss terrain will definitely want to have this small, light, useful book handy.

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Geology and Ore Deposits of the Great Basin: Field Trip Guidebook Compendium. *Edited by Ruth H. Buffa and Alan R. Coyner. Geological Society of Nevada (P.O. Box 12021, Reno, NV), 1991, two volumes, 1161 p., with author and subject indexes; cloth, $75 including shipping.*

Earlier this year I favorably reviewed two volumes entitled *Geology and Ore Deposits of the Great Basin: Symposium Proceedings,* edited by G. L. Raines, R. E. Lisle, R. W. Schafer, and W. H. Wilkinson, which were from this same publisher. The two-volume field trip guidebook compendium, of 15 field trips with road logs, is intended as a companion to the *Symposium Proceedings*. The road logs have been edited to stand alone. They contain field stops and/or comments, in passing, on the critical stratigraphy and the outcrops of regionally significant geologic relations between the mines and mining districts that are the primary focus of the field trips. There are references to the articles in the *Symposium Proceedings,* but none of the papers published in those volumes are reprinted here. Included in these new volumes are brief summaries of the geology of a great many mines and drilled prospects. Also included is a number of expanded topical studies that were not presented at the symposium.

The area covered by these field trips extends from eastern California to western Utah with one stop each in southern Idaho and southern Oregon. Also included are geologic road logs for the three most traveled roads in Nevada: Reno to Elko on I-80; Reno to Ely on US 50; and Fallon to Las Vegas on US 95 and 95A. The extended topical studies include magma and ore deposit petrochemistry and geochemistry; regional tectonics of the Great Basin; structural styles in extended terranes; chemical and mineralogical classification of skarns; and Paleozoic and Mesozoic stratigraphic evolution of the northeastern Great Basin. Unfortunately, these topical studies are only listed in the individual guidebooks; they are not listed separately in the Table of Contents. Thus, they can be hard to find in so large a compendium.

The overall quantity and quality of regional geologic data contained within these two volumes is very impressive. The editing is good; there are only minor glitches. A very useful feature for so large a compendium is the provision of four separate indexes: Authors; Subject and Location; Mines, Projects and Districts; and Stratigraphy.

It would be hard to imagine a better introduction to the roadside geology of the Great Basin for a serious geological professional than these two volumes. In addition, a cross section of current thinking on the tectonic and economic significance of Great Basin geology is well represented in the four volumes of this series.

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Active Margin Basins *(AAPG Memoir 52). Edited by Kevin T. Biddle. American Association of Petroleum Geologists, Tulsa, Oklahoma, 1991, 324 p., $60 (AAPG members: $39).*

This beautifully produced volume should win an award for the most misleading title of any book published since the concept of plate tectonics was conceived! A more appropriate title would have been: "The Los Angeles (and a few other) basins." Two-hundred-and-sixty pages are devoted to the LA basin, and 59 pages describe the Taranaki basin (New Zealand), the Magdalena basin (Colombia), and the Falcon basin (Venezuela). The only thing these four basins have in common is that they formed in active tectonic settings, including variable amounts of strike slip.

The goal of the World Petroleum Basins series is to devote a significant part of each volume "to the detailed description of one maturely explored 'type' or 'model' basin, while additional summary papers would discuss other basins or provinces of similar type" (from the Foreword by K. Arbenz et al.). This approach only works if the basin classification scheme that results in designation of "type" or "model" basins is based on fundamental plate-tectonic concepts. It is my opinion that the Los Angeles basin is one of the most unusual settings on Earth (transrotational basin of Ingersoll, 1988). Therefore, it is a fundamental error to use it as a "type" or "model" for "active margin basins."

The editor (Biddle) admits the above shortcomings in his Introduction, and he does the best he can within the context of the series. Biddle provides an excellent Overview (chapter 1), which highlights the uniqueness of the Los Angeles basin, including the fact that it is by far the most productive basin *in the world,* when measured in hydrocarbons per volume of sediment. By this measure, it is more than an order-of-magnitude more productive than the Persian Gulf. Again, this is no "type" or "model" basin; if it were, there would be no economic need for petroleum geologists to find all that petroleum that would be oozing out of the ground, just like La Brea Tar Pits! The LA basin resulted from a unique and fortuitous combination of tectonic, structural, sedimentological, oceanographic, biological, and paleoenvironmental circumstances.

The greatest strength of this volume is as a source book for previously difficult to find (and/or proprietary) information. The chapters by Wright (structure), Blake (biostratigraphy), Jeffrey et al. (geochemistry), Yeats and Beall (stratigraphy), and Redin (submarine fans) summarize and reference more information about the LA basin than ever previously presented. It is easy to get lost in the detail, but if detail is desired, this is the place to find it. The chapter by Mayer presents a model for subsidence due to stretching within a transrotational setting. This "model" chapter provides a breather among the endless details of surrounding chapters.

The volume concludes with interesting but basically unrelated basin histories for the three other "active margin basins." I have sympathy for the authors of the last three chapters (Palmer and Bulte, Schamel, and Boesi and Goddard), whose interesting contributions will not likely be discovered by researchers in New Zealand, Colombia, and Venezuela, unless they happen to buy this book on the LA basin.

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Chapter 2 by Rintoul is an enjoyable historical summary of the discovery and production of "oil in an urban setting." How many of the millions of modern residents of southern California are aware of the central role played by oil in the explosive development of the nation's second-largest city? Most of the derricks are gone, but the legacy of oil in the LA basin persists.

In summary, this book is a beautifully produced volume on the Los Angeles basin. If that is your interest, then this is the first book you should buy. I highly recommend it to the growing ranks of environmental, engineering, and hydrological geologists looking for information on southern California. It is also highly recommended for academic researchers and students, and even petroleum geologists (the few that remain!). On the other hand, if you are interested in forearc, foreland, intra-arc, interarc, and other basins in active tectonic settings, and you buy this book by mistake, I told you so.

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Geostatistical Glossary and Multilingual Dictionary. *Edited by Ricardo A. Olea. Oxford University Press, New York, 1991, 177 p., $39.95.*

This volume is the work of a committee composed of some well-known geostatisticians—George Christakos, Isobel Clark, Michel David, André G. Journel, David G. Krige, and Ricardo A. Olea (chairman of the committee). Without any further ado, these names bring authority and prestige to this compilation.

The book is divided into two parts: the glossary (85 pages) and the multilingual dictionary (82 pages). The second part contains a two-way dictionary of English and seven other languages (Chinese, French, German, Greek, Portuguese, Russian, and Spanish).

This is the third volume in a series of Studies in Mathematical Geology. The first volume is entitled *Use and Abuse of Statistical Methods in the Earth Sciences* (1987), edited by William A. Size. The second volume, by Lawrence J. Drew, is *Oil and Gas Forecasting: Reflections of a Petroleum Geologist* (1990). These volumes do not meet the billing that "each volume in the series will deal with a specific technique of analysis" (Foreword to the series). Notwithstanding, all three volumes are worth reading.

This new volume has long been needed and will be an indispensible reference for all researchers and practitioners of geostatistics—English-speaking or otherwise. In my opinion, the Selected Bibliography at the end of Part I is probably the most valuable feature of the book, especially for the novice. The committee members and especially the chairman ought to be congratulated for a job well done.

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The Processes of Fossilization. *Edited by S. K. Donovan. Columbia University Press, New York, 1990, 303 p.*

The jacket of this book proclaims it as "the most comprehensive and authoritative conspectus of the field." With this as the advertisement I began reading this book with some skepticism. Unlike many published collections of papers, I found each of the chapters in this volume enlightening and well written. The breadth of subjects covered is admirable, although weighted toward topics concerning invertebrates. Modes of mineralization of fossils are discussed, but emphasis is largely on other aspects of taphonomy, including a robust chapter on the history of the field. Several chapters highlight the interesting and complex problems of shed animal parts (chapters on trilobites and echinoderms) or plant parts for paleoenvironmental interpretations. The chapter on the taphonomy and environmental significance of soft-bodied animals was particularly fascinating, given that this is a neglected area of taphonomy.

The only paper that left me, as a vertebrate taphonomist, unsatisfied was on vertebrate taphonomy; this chapter has a narrow focus. The book's strength is in the heavy emphasis on vertebrates from marine deposits, an area poorly covered elsewhere. The realm of depositional settings for vertebrate fossils, however, includes environments such as floodplains, lakes, stream channels, subaerial interdunes, and beaches, as well as the deep marine, making a summary of vertebrate taphonomy a particularly arduous task. Despite this difficulty, the volume as a whole does seem to live up to its billing and is a welcome contribution to the growing field of taphonomy.

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The Incomplete Guide to the Art of Discovery. *Jack E. Oliver. Columbia University Press, New York, 1991, $45 (hardbound), $17.95 (paperbound).*

This entertaining book contains a nice balance of anecdote and advice, geared particularly to students and young, aspiring scientists. I found myself agreeing with a significant part of what Oliver says, and even became somewhat agitated when one of the pitfalls he describes was close to one of my own shortcomings. This book should also be of value to a scientist considering a change in direction, or to a layman who is interested not so much in what a scientist does, but in the process of how new ideas originate. Obviously, not every topic relevant to discovery is covered, but overall, I think that the author has included what is central to the process.

The most important chapter in the book is probably "Strategies." In this chapter, the author admonishes to "avoid sidetracking to trivia." This is particularly apt advice for a mineralogist, as the types of problems in this subfield tend to be very detailed and focused, so that it is quite easy to become engrossed in the particulars and forget the larger scheme. One piece of advice that I thought was missing, or not sufficiently emphasized, is the importance of taking advantage of opportunities as presented, with the corollary that making good on one opportunity frequently brings new ones.

There are some contradictions in the book, and this may be appropriate, as the process and the end-product in science can be at odds. Specifically the idea of "skimming the cream," i.e., that one should focus on the relevant data, and sort out what is important, and what will solve the problem at hand, is contrary to the fact that science is built on data and painstaking observations. Oliver's response to this dilemma is that one should do both synthesis and compilation and that reaching the "right" answer on an important problem offsets the risk of being "wrong." Other important contradictions in science addressed by Oliver include the fact that though many strive, only a few will discover a new paradigm, and the role of chance in science.

It is doubtful that everyone who reads this book will find Oliver's philosophy palatable. Nevertheless, the book is thought-provoking, and I recommend it to those considering graduate school or launching a career in science.

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Earthquake Hazard Analysis. *Leon Reiter. Columbia University Press, New York, 1990, 254 p., $65.*

Leon Reiter states in the preface to his book that it is designed to provide help and information to seismologists, earth scientists, engineers, regulators, public officials, practitioners, and members of the general public interested in becoming better informed about earthquake-related issues. In addition to achieving his stated goal of presenting general information for the highly varied audience he has selected, many of the complex issues of earthquake hazard analysis are effectively presented as well. The length of the book (254 pages) certainly limits the extent to which each issue may be developed. Although those readers with a good earth science background will probably benefit the most, each reader regardless of particular expertise should gain from studying it. Some users of the book may disagree with the decision to omit discussion of liquefaction, given the experience gained from the Loma Prieta earthquake. The illustrations (particularly the graphs and diagrams) clearly illustrate a particular point without the confusing complexity found in many earthquake engineering-oriented graphs and diagrams. The writing is clear, to the point, and appropriately referenced. The use of mathematics is limited. Some may see this as desirable; others probably will consider this to be a weakness, in that less precise verbal descriptions are substituted for less ambiguous but perhaps less generally understood mathematical relations.

The book has technical merit without being overwhelming. It should be a part of university reading lists for many disciplines, particularly in the earth sciences. This book fills an important gap in the literature for senior and graduate-level classes in engineering geology. Practicing professionals will find it to be of great value in facilitating working with the literature and their colleagues in the many areas of earthquake hazard analysis.

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The Age of the Earth. *G. Brent Dalrymple. Stanford University Press, Stanford, California, 1991, 474 p., cloth, $49.50.*

Brent Dalrymple is an isotope geochronologist who became well known to the general public through his participation in the Little Rock trial concerning equal treatment of "evolu-

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The Geological Society of America

Congressional Science Fellowship 1993–1994

The Geological Society of America is accepting applications for the 1993–1994 Congressional Science Fellowship. The Fellow selected will spend a year (September 1993–August 1994) 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 earth scientists in early or mid-career. 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, 1993

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tion science" vs. "creation science." Although *The Age of the Earth* grew out of Dalrymple's preparations to be an expert witness, this book is just straight science, not a polemic against creationist ideas. The discussion goes far beyond the age of the Earth; it includes the ages of the Earth's oldest rocks, moon rocks, meteorites, and a brief treatment of ways to estimate ages of the elements and the universe. After a flurry of research in the mid-1960s to mid-1980s, our understanding of many of these ancient ages has become quite stabilized, and now is a fitting time for the appearance of an excellent book, such as this one, to explain and summarize the major discoveries.

Pitched in the style of articles in *Scientific American*, but written at a slightly higher technical level, the book is a good resource for geologists who are not isotope specialists, or it can be supplementary enrichment for graduate courses in tectonics or isotope geology. I have already shared parts of it with a public school teacher who wanted to get the facts straight for his eighth graders. It is very difficult to craft one's writing suitably for all potential readers. Dalrymple's clever way to introduce elementary vocabulary such as "deformation" or "quartzite" is to italicize the first usage of the term, but leave the definition to a glossary. Photographs and clearly structured diagrams and tables abound. A list contains 700 references dating to 1989.

The book progresses by stages from easy descriptions to abstract models based upon transcendental equations. Opening chapters convey the history of thought about the age of the Earth, from early interpretations of the Bible to the contributions of geology and physics of the 1800s. Chapter 3 presents the fundamentals of radioactive decay and the standard isotopic age methods. This is preparation for rather exhaustive discussions of the oldest known rocks (and even more ancient crystals of zircon contained therein) in the cratons of western Australia, North America, and southern Africa. Ages of moon rocks (Chapter 5) and meteorites (Chapter 6) are explored in the context of the origins of these exotic materials.

By far the heaviest subject is the use of Pb isotopes to date the origin of the Earth and Solar System (Chapter 7). Dalrymple first introduces the essential notions of the Holmes-Houtermans model, then delves into the history of the subject, a successful procedure in preceding chapters. In this instance, the early pioneers took many wrong turns as they groped toward an adequate understanding of Pb isotope systematics. The historical development becomes quite confusing, and it requires very careful reading.

It is a pleasure to read a book in which correct information is beautifully organized and lucidly presented, with a virtual absence of typos.

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In Memoriam

Francis Birch
Cambridge, Massachusetts

Paul Gemmill
Salt Lake City, Utah
February 1992

Richard P. Goldthwait
Wolfeboro, New Hampshire
July 7, 1992

Thomas S. Lovering
Santa Barbara, California
April 9, 1991

Andrew J. Mozola
Detroit, Michigan

Fritz E. Von Estorff
Scarsdale, New York
June 21, 1992

Paleomagnetism: Magnetic Domains to Geologic Terrains.

Robert F. Butler. Blackwell Scientific Publications, Boston, 1992, 319 p., $44.95 (paper bound).

Paleomagnetism is one of the most important building blocks in our understanding of plate tectonics. Yet many earth scientists have a poor understanding of the fundamental principles and the diverse applications of paleomagnetism. Butler's book is aimed at providing the interested earth scientist with a readable, relatively non-mathematical treatment of how paleomagnetism works, and it includes an up-to-date overview of current paleomagnetic research.

The first three chapters concentrate on establishing the fundamentals of paleomagnetism by introducing geomagnetism, magnetic mineralogy, and the origin of remanent magnetism. A highlight of this part of the book is a highly readable and lucid account of the physics of magnetism. Chapters 4 to 7 deal with paleomagnetic methodology, including sampling and laboratory techniques and the interpretation of paleomagnetic data. This is an excellent and well-illustrated treatment that will remove the element of mystery for the nonspecialist who may otherwise be confused by vector component plots, corrections for stratal tilt, statistical treatment of data and virtual geomagnetic poles, among other things.

In chapters 8 to 11, the reader is led through several published studies that deal with recent advances in paleomagnetic applications to rock magnetism, geochronology, paleogeography, and regional tectonics. This overview highlights many of the important issues and problems in modern paleomagnetic research and demonstrates that paleomagnetism will continue to play an important role in the earth sciences. These chapters also provide a useful review of the enormous body of paleomagnetic literature in each subject covered, and will prove to be a valuable resource for graduate-level courses, research students starting out in paleomagnetism, and the earth scientist who wants to dig deeper.

Mathematical derivations for some of the more important equations used in paleomagnetism are provided in appendices. This is an excellent approach, as it provides the necessary mathematical detail but avoids interrupting the text by what are usually lengthy mathematical derivations.

Butler has done a superb job of producing a cogently written, well-illustrated, accurate, and up-to-date text that should be circulated widely among paleomagnetists, nonspecialists, teachers, and students alike. This is a welcome contribution, as it represents one of the few paleomagnetic texts by an American author. The dominant use of American examples should help place the applications in a more familiar context for an American audience. A few minor points may be worth considering for future editions, however. I would prefer to see consistent use of SI units rather than the persistent use of both cgs and SI units. Some of the "advanced techniques" for establishing paleomagnetic stability (chapter 5) could be more adequately described. The treatment of paleomagnetic applications gives the misleading impression that the applications cited are the most important paleomagnetic research fields. This part of the book would be enhanced by a more complete treatment of the diverse avenues of paleomagnetic endeavor. For example, addition of a chapter dealing with applications to geomagnetism would be welcome, particularly the study of secular variation, polarity transitions, reversal models, and the geodynamo. This is especially so considering that a significant proportion of the paleomagnetic research community is dedicated to furthering our knowledge of the ancient geomagnetic field. Lack of detailed discussion of environmental magnetism is another serious omission. It would also be nice to see future editions published in a hard binding, particularly for libraries. My review copy is already looking somewhat the worse for wear. These points should not detract from an otherwise excellent contribution.

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Occurrence, Characteristics, and Genesis of Carbonate, Gypsum, and Silica Accumulations in Soils.

Edited by W. D. Nettleton. Soil Science Society of America Special Publication No. 26, Madison, Wisconsin, 1991, 149 p., $18 (paper bound).

The methods and perspectives of many earth sciences converge on the topics in this short, edited volume of seven research papers. Five papers deal with carbonates, leaving one each on gypsum and silica. Most of the literature on cemented carbonates, gypsum, and silica in weathered debris has been produced by geomorphologists and Quaternary stratigraphers looking for terrain and paleoenvironmental chronology. (Only tiny bits of this literature are cited in this volume.) However, developing a detailed descriptive and genetic understanding of these features has been left mostly to the soil scientists. This volume has its main value as an up-to-date summary of the pedological perspectives on these problems. It is also a demonstration of the pedologists' established kit of taxonomic frameworks as well as micromorphological and chemical analyses.

This volume is recommended to all earth scientists working on these topics. Soil scientists really do know

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how to look at these things close up. However, I found these papers much more interesting as a parallel scientific universe. Naming something can, it would seem, be an end in its own right for soil scientists. Their models of Quaternary environmental changes tend to be timid and their geomorphic understandings of sampling terrains are not always complete. On the other hand, the treatment of soils in the typical field geology or geomorphology report, if present at all, is typically inept or, at best, naive. What is not in this volume speaks loudly both against scientific compartmentalization and for expanding attempts at interdisciplinary collaboration on these important topics.

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Mid-Proterozoic Laurentia-Baltica. *Edited by C. F. Gower, T. Rivers, and B. Ryan. Geological Association of Canada Special Paper 38, St. Johns, Newfoundland, 1990, 581 p., $99.80 Canadian.*

For some time it has been clear that tectonism is a global process. A global geologic history of the Earth through most of the Phanerozoic can now be rolled forward like a movie, admittedly with some episodes poorly scripted or somewhat badly filmed, but with events generally well ordered in time and space and tied together by a coherent plot. Precambrian geologic history, however, has not been especially adaptable for geologic cinema. The uncertainties of regional correlations and relations among events in those ancient days have obfuscated the unifying theme and reduced much of Precambrian history to still shots or isolated episodes of jerky action that are of interest mainly to a small group of aficionados. Such stuff does not do much at the box office.

Mid-Proterozoic Laurentia-Baltica is a worthy attempt to break the provinciality of Precambrian geology and construct a story that plays on more than one of the present-day continents. The result is not analogous to first-run cinema; it is perhaps more like avant-garde film or home video. There are some good parts, some dull parts, and some parts that only close friends and confidantes of the writer, director, or producer could possibly appreciate. This evaluation is not intended to be flip or mean-spirited. The book is a thematic summary volume that arose from a symposium entitled "Middle Proterozoic Evolution of the North American and Baltic Shields" that was held in Newfoundland in 1988 under the joint sponsorship of the Geological Association of Canada's Precambrian Division and Project Working Group 217 of the International Geological Correlation Program. As such, it embodies the strengths and weaknesses that characterize most symposium volumes on regional geologic topics.

The thesis of the book is that during the mid-Proterozoic, which is defined arbitrarily and informally as the interval of Earth history from about 1.90 to 1.00 Ga, the North American craton and the Baltic area of northern Europe underwent a common tectonic evolution. The commonality of their mid-Proterozoic history strongly implies that these now-separated continental masses developed as a single entity through nearly a billion years of Precambrian time. This conclusion results from painstaking research by many workers on both sides of the Atlantic, and it rests very heavily on geochronologic and isotopic data that establish the critical linkages in time. Indeed, a strong message expressed throughout the volume is the essential role played by geochronology and isotope geology in the interpretation of complex Precambrian terranes.

The volume consists of 32 separate contributions organized into eight topical sections. The topical categories are (1) isotopes and crustal evolution; (2) geochronology; (3) regional case histories; (4) structural studies; (5) anorthositic magmatism; (6) anorogenic felsic magmatism; (7) mafic magmatism; and (8) sedimentary depocenters. Thirteen papers treat the Baltic Shield and the northwesternmost parts of the British Isles, 18 treat various aspects of the mid-Proterozoic terranes of North America, and one paper is a masterfully written introduction and synopsis by the volume editors.

Of these, six papers in particular caught my interest. The superb overview by Gower, Ryan, and Rivers has already been mentioned. A. Lindh and P.-O. Persson provide a succinct summary of Proterozoic granitoid plutonism in the Baltic Shield that integrates several isotopic and petrologic approaches to problems of granite tectogenesis. The paper by R. J. Wardle, B. Ryan, S. Philippe, and U. Scharer on the Goose Bay area of Labrador, Canada, is an impressive geological analysis of a very complicated part of the Grenville province. R. M. Easton's overview of meta-anorthosites in the Grenville is a welcome, systematic discussion of these variable and complex rocks. Similarly, the paper by O. T. Ramo and I. Haapala on the rapakivi granites of Fennoscandia is a well-organized description and discussion that helps the nonspecialist to better comprehend the physical attibutes and the petrogenetic problems of the rapakivi clan. Finally, the iconoclastic paper by D. Winston on the sedimentology and depositional setting of the Belt Supergroup and related rocks of western North America is sure to provoke reactions from Beltian experts. Winston argues that the Belt is not a continental-margin miogeoclinal deposit, but is instead a plexus of fluvial and lacustrine products that were deposited in isolated intracratonic basins.

Mid-Proterozoic Laurentia-Baltica is well produced and well edited, in keeping with the high standards of GAC publications. It is a volume that students of the Precambrian, geochronologists, and isotope geochemists will want to peruse. How many will wish to buy it at a price of nearly 100 Canadian dollars is another matter.

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GSA Penrose Conference

February 1993

Continental Tectonics and Magmatism of the Jurassic North American Cordillera, February 27–March 4, 1993, Havasu City, Arizona. Information: Dave Miller, (415) 329-4923, and Dick Tosdal, (415) 329-5423, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025; or Bob Anderson, (604) 666-2693, Geological Survey of Canada, 100 West Pender Street, Vancouver, B.C. V6B 1R8, Canada.

1992 Meetings

November

28th Annual Conference and Symposia: Managing Water Resources During Global Change, November 1–5, 1992, Reno, Nevada. Information: Raymond Herrmann, NPS, WR-CPSU, WRD, Colorado State University, Ft. Collins, CO 80523, (303) 491-7825.

Clay Minerals Society and Soil Science Society of America Joint Meeting, November 1–6, 1992, Minneapolis, Minnesota. Information: Jerry Bigham, Dept. of Agronomy, Ohio State University, Columbus, OH 43210, (614) 292-2001.

14th New Zealand Geothermal Workshop, November 4–6, 1992, Auckland, New Zealand. Information: 14th New Zealand Geothermal Workshop, University of Auckland, Private Bag 92019, Auckland, New Zealand, fax 64-9-373-7419.

Geology and Ground Water of the Savannah River Site Vicinity, South Carolina and Georgia, November 13–15, 1992, Augusta, Georgia. Information: Wallace Fallaw, Department of Geology, Furman University, Greenville, SC 29613, (803) 294-3361, fax 803-294-3001; Van Price, Westinghouse Savannah River Company, Building 735-A, Aiken, SC 29808, (803) 725-2035, fax 803-725-3272.

International Gas Research Conference, November 16–19, 1992, Orlando, Florida. Information: 1992 International Gas Research Conference, c/o Gas Research Institute, 8600 West Bryn Mawr Ave., Chicago, IL 60631, (312) 399-8300, Telex 253812 or 503802, fax 312-399-8170.

■ **Eastern Oil Shale Symposium,** November 17–20, 1992, Lexington, Kentucky. Information: Gaunita H. Caylor, Coordinator, University of Kentucky/OISTL, 643 Maxwelton Court, Lexington, KY 40506-0350, (606) 257-2820, fax 606-258-1049.

Geological Society of New Zealand and New Zealand Geophysical Society Joint Annual Conference, November 23–27, 1992, Christchurch, New Zealand. Information: David Shelley, Dept. of Geology, University of Canterbury, Christchurch 1, New Zealand, phone 64-3-667-001, fax 64-3-642-769.

December

Industrial-Minerals Development in Oklahoma Workshop, December 1–2, 1992, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm,. N-131, Norman, OK 73019, (405) 325-3031.

IGCP Project 274 Annual Meeting, Coastal Evolution in the Quaternary, December 7–15, 1992, Wellington, New Zealand. Information: Alan Hull, DSIR Geology & Geophysics, P.O. Box 30-368, Lower Hutt, New Zealand, +64(4) 569-9059, fax +64(4) 566-6168, E-mail: srlnagh@lhn.geo.dsir.govt.NZ.

1993 Meetings

January

Results of Drilling in Western Pacific Active Margins and Marginal Basins, January 18–21, 1993, Monterey, California. Information: Brian Taylor, University of Hawaii, 2525 Correa Rd., Honolulu, HI 96822, (808) 956-6649, fax 808-956-2538, E-mail: taylor@-elepaio.soest.hawaii.edu.

Quantifying Sedimentary Geochemical Processes, January 26–27, 1993, London, England. Information: Christine A. Johnson, Scientific Meetings Secretary, 6 Carlton House Terrace, London SW1Y 5AG, phone 071-839 5561, fax 071-930-2170, telex 917876.

February

Geologic Remote Sensing, 9th Thematic Conference, Exploration, Environment, and Engineering, February 8–11, 1993, Pasadena, California. Information: ERIM/Thematic Conferences, Nancy J. Wallman, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123.

Earthquake Engineering Research Institute 45th Annual Meeting, February 11–13, 1993, Seattle, Washington. Information: EERI, 499 14th St., Suite 320, Oakland, CA 94612-1902, (510) 451-0905, fax 510-451-5411.

Society for Mining, Metallurgy, and Exploration 1993 Annual Meeting, February 15–18, 1993, Reno, Nevada. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-3461.

March

GSA South-Central Section Meeting, March 15–16, 1993, Fort Worth, Texas. Information: John Breyer, Dept. of Geology, Texas Christian University, Fort Worth, TX 76129, (817) 921-7270.

■ **Lunar and Planetary Science 24th Annual Conference,** March 15–19, 1993, Houston, Texas. Information: 24th LPSC, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058-1113, (713) 486-2166.

Michigan Geological Survey Division Symposium, Michigan: Its Geology and Geologic Resources, March 18–19, 1993, East Lansing, Michigan. Information: Carol L. Skillings, Dept. of Natural Resources, Geological Survey Division, Box 30028, Lansing, MI 48909-7258, (517) 334-6976.

■ **GSA Northeastern Section Meeting,** March 22–24, 1993, Burlington, Vermont. Information: Barry L. Doolan or Rolfe S. Stanley, Dept. of Geology, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247.

Fluvial-Dominated Deltaic Reservoirs in the Southern Midcontinent Workshop, March 23–24, 1993, Norman, Oklahoma. Information: Kenneth S. Johnson, Oklahoma Geological Survey, University of Oklahoma, 100 East Boyd, Rm. N-131, Norman, OK 73019, (405) 325-3031.

GSA North-Central Section Meeting, March 29–30, 1993, Rolla, Missouri. Information: Richard Hagni, Dept. of Geology and Geophysics, University of Missouri, Rolla, MO 65401, (314) 341-4616.

April

GSA Southeastern Section Meeting, April 1–2, 1993, Tallahassee, Florida. Information: James Tull, Dept. of Geology, Florida State University, Tallahassee, FL 32306, (904) 644-1448.

Computer Simulated Mineral Exploration 22nd Workshop, April 1–30, 1993, Fontainebleau, France. Information: L. Zanone, Ecole des Mines de Paris, CGGM-IGM, 35, rue Saint-Honoré, 77305 Fontainebleau Cédex, France, phone (33 1) 64 69 49 30, telex 694 736 F, fax (33 1) 64 69 47 01.

Remote Sensing and Global Environmental Change 25th International Symposium, April 4–8, 1993, Graz, Austria. Information: Dorothy M. Humphrey, ERIM, P.O. Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 2290, fax 313-994-5123.

Mantle Composition, Structure, and Processes Workshop , April 4–8, 1993, Soda Springs, California. Send letters of application by Sept. 30, 1992, to: Jane E. Nielson, U.S. Geological Survey, MS 975, 345 Middlefield Rd., Menlo Park, CA 94025, (415) 329-4948, fax 415-329-4936; or B. Carter Hearn, Jr., U.S. Geological Survey, 959 National Center, Reston, VA 22092, (703) 648-6768, fax 703-648-6789.

Mechanisms of Deformation and Failure in Rocks and Ceramics, April 12–16, 1993, San Francisco, California. Information: Joanne Fredrich, TerraTek, Inc., University Research Park, 420 Wakara Way, Salt Lake City, UT 84108, (801) 584-2487, fax 801-584-2432. *(Abstract deadline: November 15, 1992.)*

Integrated Methods in Exploration and Discovery, April 17–20, 1993, Denver, Colorado. Information: SEG Conference '93, P.O. Box 571, Golden, CO 80402.

Canadian Quaternary Association, April 17–21, 1993, Victoria, British Columbia, Canada. Information: Environmental Geology Section, BC Geological Survey Branch, 553 Superior Street, Victoria, British Columbia, V8V 1X4, Canada, (604) 387-6249, fax 604-356-8153.

■ **Application of Geophysics to Engineering and Environmental Problems (SAGEEP), 6th Annual Symposium,** April 18–21, 1993, San Diego, California. Information: Mark Cramer, ExpoMasters, 7632 E. Costilla Ave., Englewood, CO 80112, (303) 771-2000, fax 303-843-6232.

Operationalization of Remote Sensing International Symposium, April 19–23, 1993, Enschede, The Netherlands. Information: J. L. van Genderen, ITC, P.O. Box 6, 7500 AA Enschede, The Netherlands, phone 31-53-874 254, fax 31-53-874 436, telex 44525 itc nl.

Geoscience Education and Training International Conference, April 21–25, 1993, Southampton, England. Information: Dorrik A.V. Stow or Esther Johnson, Dept. of Geology, University of Southampton, Southampton, SO9 5NH, England, phone 0703-593049, fax 0703-593052, telex: 47662 SOTONU G.

May

■ **Pacific Sections 1993 Convention,** American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, Society of Exploration Geophysicists, Association of Engineering Geologists, Society of Petroleum Well Log Analysts, Society of Core Analysts, and American Institute of Professional Geologists, May 5–7, 1993, Long Beach, California. Information: Don Clarke, City of Long Beach–Department of Oil Porperties, 333 West Ocean Blvd., Long Beach, CA 90802, (310) 590-6084.

GEOTECHNICA 1993, International Trade Fair and Congress for Geosciences and Technology, May 5–8, 1993, Cologne, Germany. Information: KölnMesse, Messe- und Ausstellungs-Ges.m.b.H. Köln, Messeplatz 1, Postfach 21 07 60, W-5000 Köln 21, Germany, phone (0)2 21/821-0, fax (0)2 21/821-25 74, telex 8 873 426 mua d.

USA/CIS Second Joint Conference on Environmental Hydrology and Hydrogeology, Industrial and Agricultural Impacts on the Hydrologic Environment, May 15–21, 1993, Arlington, Virginia. Information: American Institute of Hydrology, 3416 University Ave. S.E., Minneapolis, MN 55414-3328, (612) 379-1030, fax 612-379-0169.

INQUA Commission on Formation and Properties of Glacial Deposits Field Conference and GIS Workshop, Work Groups on Glacial Tectonics and Mapping Glacial Deposits, mid-May, 1993, Regina, Saskatchewan, Canada. Information: D. J. Sauchyn, Dept. of Geography, University of Regina, Regina, Saskatchewan, S4S 0A2 Canada, (306) 585-4030, fax 306-585-4815; or J. S. Aber, Earth Science, Emporia State University, Emporia, KS 66801, (316) 341-5981, fax 316-341-5997. *(Abstract deadline: February 1, 1993.)*

GSA Cordilleran–Rocky Mountain Section Meeting, May 19–21, 1993, Reno, Nevada. Information: Vanessa George, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

International Basin Tectonics and Hyrdrocarbon Accumulation Conference, May 25–June 15, 1993, Nanjing, People's Republic of China. Information: David Howell, U.S. Geological Survey, 345 Middlefield Road, MS 902, Menlo Park, CA 94025, (415) 354-5430, fax 415-354-3224.

June

■ **Case Histories in Geotechnical Engineering Third International Conference,** June 1–6, 1993, St. Louis, Missouri. Information: Shamsher Prakash, Conference Chairman, University of Missouri–Rolla, Rolla, MO 65401-0249, (314) 341-4489, fax 314-341-4729.

Global Aspects of Coral Reefs: Health, Hazards, and History, June 7–10, 1993, Coral Gables, Florida. Information: Global Reef Meeting, University of Miami/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33149-1098, fax 305-361-4632.

Geology and Confinement of Toxic Wastes International Symposium,

June 8–11, 1993, Montpellier, France. Information: Michel Barrès, BRGM—Département "Environnement," BP 6009, 45060 Orleans Cedex, France, phone 33-38 64 34 14, fax 33-38 64 30 13, Telex BRGM 780 258 F.

Rock Mechanics 34th U.S. Symposium, June 27–30, 1993, Madison, Wisconsin. Information: Bezalel C. Haimson, Dept. of Materials Science and Engineering, 1509 University Avenue, Madison, WI 53706, (608) 265-3021, fax 608-262-8353, E-Mail: haimson-@macc.wisc.edu.

NATO Advanced Study Institute on Feldspars and Their Reactions, June 29–July 10, 1993, Edinburgh, Scotland. Information: Ian Parsons, Dept. of Geology & Geophysics, University of Edinburgh, Edinburgh, EH9 3JW, UK, fax 44-31-668-3184.

July

Fluvial Sedimentology 5th International Conference, July 5–9, 1993, Brisbane, Australia. Information: Continuing Professional Education, The University of Queensland, Queensland 4072, Australia, phone +61-7-365 7100, fax +61-7-365 7099, telex UNIVQLD AA40315.

Geological and Landscape Conservation International Conference, July 17–24, 1993, Great Malvern, United Kingdom. Information: D. O'Halloran, JNCC, City Road, Peterborough, PE1 1JY, UK, phone 0733-62626, fax 0733-893 971.

Clays Control the Environment—10th International Clay Conference, July 18–23, 1993, Adelaide, Australia. Information: Conference Secretariat, Elliservice Convention Management, P.O. Box 753, Norwood, SA 5067, Australia, phone +61.8.332.4068, fax +61.8.364.1968.

August

Intraplate Volcanism International Workshop, The Polynesian Plume Province, August 1993, Tahiti, French Polynesia. Information: Workshop Tahiti 1993 Organization Committee, H.G. Barsczus, Centre Géologique et Géophysique, Case 060, Université de Montpellier II, 34095 Montpellier Cedex 5, France, phone 33-67-634-983, fax 33-67-523-908.

Geochemistry of the Earth Surface 3rd International Symposium, August 1–6, 1993, University Park, Pennsylvania. Information: Lee Kump, Dept. of Geosciences, Pennsylvania State University, 210 Deike Bldg., University Park, PA 16802, (814) 863-1274, fax 814-865-3191.

Belt Symposium III: Field Conference on New Geologic Perspectives of the Middle Proterozoic Belt-Purcell Basin, August 14–21, 1993, Whitefish, Montana. Information: Belt Symposium III, c/o Western Experience, Inc., 4881 Evening Sun Lane, Colorado Springs, CO 80917.

Mine Design International Congress, Mining into the 21st Century, August 23–26, 1993, Kingston, Ontario, Canada. Information: Peter Scott, Public Relations, ICMD/Relations publiques, CICM, Department of Mining Engineering/Département de génie minier, Queen's University/Université Queen's, Kingston, Ontario, Canada K7L 3N6, (613) 545-2212, fax 613-545-6597.

September

Coal Science 7th International Conference, September 12–18, 1993, Banff, Alberta, Canada. Information: David Brown, (403) 450-5200.

Fractography, Geological Society of London Thematic Meeting, September 13–14, 1993, London, United Kingdom. Information: M. S. Ameen, Geo-Science Limited, Silwood Park, Buckhurst Road, Ascot SL5 7QW, UK, phone 0344 872220, fax 0344 872438.

WORLDTech I, International Congress on Mining Development, September 15–17, 1993, Philadelphia, Pennsylvania.. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-9550, fax 303-979-3461.

Andean Geodynamics 2nd International Symposium, September 21–23, 1993, Oxford, England. Information: P. Soler, ISAG 93, ORSTOM, CS1, 213 rue Lafayette, 75480 Paris Cedex 10, France, fax 33-1 48 03 08 29. *(Abstract deadline: April 1, 1993.)*

Global Boundary Events (Interdisciplinary Conference of IGCP Project 293, Geochemical Marker Events in the Phanerozoic), September 27–29, 1993, Kielce, Poland. Information: Barbara Studencka, Muzeum Ziemi PAN, Al. Na Skarpie 20/26, 00-488 Warszawa, Poland, phone (4822) 217 391, fax (4822) 297-497; or Helmut H.J. Geldsetzer, Geological Survey of Canada, 3303 33rd St. N.W., Calgary, Alberta T2L 2A7, Canada, phone (403) 292-7155, fax 403-292-5377.

Accelerator Mass Spectrometry 6th International Conference, September 27–October 1, 1993, Canberra and Sydney, Australia. Information: AMS-6, ACTS, GPO Box 2200, Canberra ACT 2601, Australia, phone 61-6-249 8105, fax 61-6-257 3256.

October

■ **Basin Inversion International Conference,** October 4–9, 1993, Oxford, England. Information: Peter Buchanan, CogniSeis Development, Stanley House, Kelvin Way, Crawley, West Sussex, RH10 2SX, UK. *(Abstract deadline: April 1993).*

■ **Society for Organic Petrology 10th Annual Meeting,** October 9–13, 1993, Norman, Oklahoma. Information: Brian Cardott, Oklahoma Geological Survey, 100 E. Boyd St., Rm. N-131, Norman, OK 73019-0628, (405) 325-3031, fax 405-325-7069.

■ **Asociación de Ingeniéros de Minas, Metalurgistas y Geólogos de México XX Convención,** October 26–29, 1993, Acapulco, Guerrero, Mexico. Information: Fernel Arvizu Lara, AIMMGM, A.P. 4073, C.P. 06400 Mexico, D.F., Mexico.

November

■ **International Circum-Pacific and Circum-Atlantic Terrane Conference VI,** November 5–21, 1993, Guanajuato, Mexico. Information: Fernando Ortega-Gutiérrez, fax 52 (5) 548-0772; or David G. Howell, fax 415-353-3224.

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

1992 GSA SHORT COURSE NOTES FOR SALE

A limited number of short course notes are available from some of the courses presented at the Cincinnati Annual Meeting. Prices range from approximately $10 to $25 per copy. Credit cards are gladly accepted.

A list of available titles and prices will appear in the December issue of *GSA Today*, but if you would like this information now, please call:

Edna A. Collis
Meetings Department
1-800-472-1988

Reminders

CALL FOR NOMINATIONS

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 1994 officers and councilors must be received at GSA headquarters no later than **FEBRUARY 15, 1993.** Please send nominations and back-up material to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

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, 1993.**

For procedures and additional information, please refer to the October 1992 issue of *GSA Today*, or call headquarters at (303) 447-2020.

Send your nominations and required back-up material to the Administrative Department, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

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 $10,000, was endowed by Dr. and Mrs. Fred A. Donath.

For the year 1993, only those candidates born on or after January 1, 1958, are eligible for consideration. In choosing candidates for the Young Scientist Award, scientific achievement and age will be the sole criteria. Nominations for the 1993 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 1993 Young Scientist Award must be received at GSA headquarters by **FEBRUARY 1, 1993.** For procedures and additional information, please refer to the October 1992 issue of *GSA Today*, or call headquarters at (303) 447-2020.

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. Nominations and any supporting information may be addressed to Executive Director, Geological Society of America, P.O. Box 9140, Boulder, CO 80301.

Deadline for nominations for 1993 is **MARCH 1, 1993.** ■

November *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 104, Number 11, November 1992

CONTENTS

GEOLOGY

VOLUME 20
NO. 11
P. 951–1056
NOVEMBER 1992

GSA ANNUAL MEETINGS

1993

GSA Annual Meeting
Boston, Massachusetts
Hynes Convention Center
October 25–28

BOSTON

Chairman: James W. Skehan, S. J., Boston College

For information call the GSA Meetings Department, (303) 447-2020.

Call for Short Course Proposals Due December 1, 1992

Have you thought about giving a short course? The GSA Committee on Short Courses invites those interested in proposing a GSA sponsored or co-sponsored short course to contact GSA headquarters for proposal guidelines.

Short courses may be conducted in conjunction with all GSA annual or section meetings, but we are particularly interested in identifying short courses to be offered during the 1993 Annual Meeting in Boston or the 1994 Annual Meeting in Seattle.

Proposals for the Boston meeting must be received by **December 1, 1992.** Selection of courses will be made by February 1, 1993, leaving eight months for preparing course manuals and making arrangements.

For proposal guidelines or information contact: Edna A. Collis, Short Course Coordinator, GSA headquarters, 1-800-472-1988.

Call for Theme Session Proposals Due January 4, 1993

Submit proposals to Technical Program Chairman: Heinrich D. Holland, Dept. of Earth & Planetary Sciences, Harvard University, 20 Oxford Street, Cambridge, MA 02138, or Teresa S. Bowers, Gradient Corp., 44 Battle St., Cambridge, MA 02138.

Geology and Health—1993 Program Theme

"Geology and Health" will be the scientific theme of the 1993 GSA Annual Meeting in Boston. The health of humanity requires adequate natural resources and a benign environment. Achieving these requirements will depend ever more heavily on advances in the geologic sciences. The human family will need new insights, new techniques, and solutions to a wide range of local, regional and global problems. The symposia and theme sessions devoted to "Geology and Health" at GSA 1993 will address these needs. A GSA-wide symposium concerned with major environmental and resource issues is planned. It will be followed by several specialized symposia dealing with the health effects of minerals and of anthropogenic changes in the composition of the atmosphere, soils, surface waters, and ground waters. These symposia and a number of related theme sessions will focus attention on some of the human dimensions of the geologic sciences. The Boston Committee hopes that these sessions will also supply answers to some vexing questions and solutions to important problems.

FUTURE

Boston	October 25–28	1993
Seattle	October 24–27	1994
New Orleans	November 6–9	1995
Denver	October 28–31	1996

For general information on technical program participation (1993 or beyond) contact: Sue Beggs, Meetings Manager, GSA headquarters.

1993 GeoVentures—Plans in Progress

—Programs in place to date—

Santa Fe, New Mexico GeoHostel, June 5–11
Leader: Don Wolberg, New Mexico Bureau of Mines
Estimated Member Cost: $430

Yellowstone/Beartooth, Wyoming GeoHostel, July 17–23
Leaders: Greg Holden, Ken Kolm, Colorado School of Mines
Estimated Member Cost: $430

Iceland GeoTrip, August 1–15
Leaders: Haraldur Sigurdsson, University of Rhode Island
Haukur Johannesson, Iceland Geological Survey
Estimated Member Land Cost: $2650

More programs will be announced in December *GSA Today*.

CLASSIFIED ADVERTISING

Published on the 1st of the month of issue. Ads (or cancellations) must reach the GSA Advertising office one month prior. Contact Advertising Department (303) 447-2020, 1-800-472-1988, fax 303-447-0648.

Classification	Per Line for 1st month	Per line for each addt'l month (same ad)
Situations Wanted	$1.75	$1.40
Positions Open	$4.50	$3.80
Consultants	$4.50	$3.80
Services & Supplies	$4.50	$3.80
Opportunities for Students	$0.00	$1.35
Code number: $2.75 extra		

Agencies and organizations may submit purchase order or payment with copy. Individuals must send prepayment with copy. To estimate cost, count 54 characters per line, including all punctuation and blank spaces. Actual cost may differ if you use capitals, centered copy, or special characters.

To answer coded ads, use this address: Code # ----, GSA Advertising Dept., P.O. Box 9140, Boulder, CO 80301-9140. All coded mail will be forwarded within 24 hours of arrival at *GSA Today* office.

Situations Wanted

CARBONATE GEOLOGIST/PETROLOGIST. M.S., 12 years experience in surface and subsurface geology in the petroleum and coal industries. Strong in computer applications, field and lab work, electric log interpretation and analysis. Desires challenging industrial or government position in carbonate geology or a related field. Send inquires to: 10113 Kirk Dr., Yukon, OK 73099.

Positions Open

HYDROGEOLOGY
WRIGHT STATE UNIVERSITY

The Department of Geological Sciences invites applications for a tenure-track faculty position at the assistant professor level starting September 1993. Ph.D. or equivalent is required at the time of appointment. The successful candidate will join a 13-member faculty in a department with strong M.S. programs in hydrogeology and applied geophysics (52 grad. students — 39 hydrogeology), and will contribute to the development of a Ph.D. program. He/she will teach and develop externally funded research in areas that complement departmental strengths in hydrogeochemistry, hydrological modeling, and applied field studies. A background in transport and fate of organics, soil physics, GIS, or ground water management is desirable.

Related departmental facilities/equipment, supported by 2 technicians, include a hydrogeochemistry laboratory with AA, IC, a stable isotope processing lab, state of the art computing facilities, X-ray spectrographic and fluorescence equip., microprobe, soil mech. equip., ground penetrating radar and resistivity systems, truck-mounted drill rigs, truck-mounted seismic reflection systems, 17 field vehicles, an experimental watershed and a wetlands field area both w/ dedicated pumping, observation, and monitor wells. Opportunities exist for interaction with several departments including the Center for Ground Water Management.

Applicants are requested to send their curriculum vitae, transcripts, a statement of research and teaching interests, and names and addresses of three references by December 31, 1992 to Dr. Robert W. Ritzi, Department of Geological Sciences, Wright State University, Dayton, OH 45435, (513) 873-3455. Wright State University if an equal opportunity/affirmative action employer.

TENURE-TRACK POSITION IN LOW-TEMPERATURE GEOCHEMISTRY
UNIVERSITY OF NEW MEXICO

The Department of Earth and Planetary Sciences seeks a low-temperature geochemist for a tenure-track position beginning in August, 1993. We anticipate hiring at the Assistant Professor level. Minimum qualifications include a Ph.D. at the time of appointment with research expertise in one or more of the following areas: fate and transport of organic/inorganic constituents in geologic environments, geochemical cycling in aquatic environments, geochemistry of surfaces and corrosion of minerals, development/application of isotopic and other geochemical tracers. Candidates more than one year past the Ph.D. should have a strong publication record. The Department has a VG-354 mass spectrometer with 5 collectors and a Daly multiplier, as well as other excellent analytical facilities. Opportunities for collaboration with existing Departmental programs, especially hydrogeology, diagenesis, Quaternary geology, sedimentary geology, stable isotope geochemistry, and materials science; related programs in other Departments (e.g., Biology and Civil Engineering); and programs at nearby Los Alamos National Laboratory and Sandia National Laboratories. The successful candidate will be expected to develop and maintain active research and teaching (both graduate and undergraduate, including introductory level) programs. The Department has 19 full-time faculty and numerous technical support staff.

Applicants should solicit letters of reference from four referees to be sent to the Search Chair, and should submit a resume (including the names, addresses, and phone numbers of the four referees), transcripts, copies of selected publications (if appropriate), and a brief statement of research experience and interests to: Dr. Laura Crossey, Chair of Geochemistry Search Committee, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131. To ensure full consideration, applications and all letters of reference should be received by January 8, 1993. The University of New Mexico is an equal opportunity/affirmative action employer.

TENURE-TRACK POSITION IN GEOMORPHOLOGY
THE UNIVERSITY OF NEW MEXICO

The Department of Earth and Planetary Sciences is accepting applications for a tenure-track faculty position in geomorphology during the academic year 1993-1994 with the possibility of beginning as early as August, 1993. We anticipate hiring at the Assistant Professor level. Minimum qualifications: Ph.D. with specialty in geomorphology, completed by the time of appointment; research focus in fluvial and hillslope processes, with applications to climatic and tectonic geomorphology; including a strong field component. For applicants more than one year past the Ph.D., a strong publication record is essential. The successful candidate is expected to play a leading role in research activities related to the Quaternary Studies Program; to develop and maintain an active research and teaching program; and is encouraged to collaborate with other faculty in related fields that include soil geomorphology/paleoclimatology, hydrology, sedimentology, tectonics and volcanology. Undergraduate teaching responsibilities include geomorphology and participation in introductory physical geology. Graduate teaching will include advanced courses in quantitative geomorphology and other offerings relevant to Quaternary geology studies. The Department of Earth and Planetary Sciences has 18 full-time faculty and excellent laboratory facilities, including the Quaternary Studies Laboratory. New Mexico provides a spectacular geologic setting that enhances both teaching and research in the Department.

Applicants should submit a resume, transcripts, copies of selected publications, a brief statement of research experience and interests, and the names, addresses, and telephone numbers/fax numbers of four referees to: Dr. Les McFadden, Chair of Geomorphology Search Committee, Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131-1116. To ensure full consideration applications should be received by January 1, 1993. The University of New Mexico is an equal opportunity/affirmative action employer.

Services & Supplies

ZIP-A-DIP, Worlds fastest apparent dip calculator and cleverest protractor combined, has moved again to: ZIP-A-DIP, P.O. Box 10784, Eugene, Oregon 97440. Send for brochure or ZIP-A-DIPs: 1/$3.50; 2-10/$3.00 each; 11-49/$2.50 each; 50+/$2.00 each. ZIP-A-DIPs are super Christmas stocking stuffers.

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

Opportunities for Students

University of Minnesota. Opportunities with the Interdisciplinary Research Training Group (RTG) for "Paleorecords of Global Change: Understanding the Dynamics of Ecosystem Response." Rock magnetism and geochemistry (including isotopes) constitute strong research components. Stipend recipients must be citizens, nationals or permanent residents of the U.S. Applications and additional information for the following are available from Sue Julson, University of Minnesota, Ecology, Evolution and Behavior, 318 Church St., S.E., Minneapolis, MN 55455. Phone (612) 625-7677; fax: 612-625-4490.

Postdoctoral Fellowship available for research training. One year appointment, renewable second year. Application deadline January 1, 1993.

Graduate traineeship: 4-year traineeship available for graduate study in conjunction with interdepartmental RTG in above study. Application deadline January 15, 1993.

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).

Opportunity for Ph.D. Research — Stable Isotope Geochemistry and Petrology, Lehigh University. Funding is available at Lehigh University (beginning in the fall, 1993) to support the research of a Ph.D. student in the area of stable isotope geochemistry and petrology. This student would pursue 1) improvements in analytical techniques for routine nitrogen-isotope measurements of silicate samples and/or 2) novel applications of nitrogen isotopes in field-based petrologic studies. The ultimate goal of this research is to evaluate the potential of the nitrogen isotope system for contributing unique information regarding metamorphic fluid-rock interactions, magma sources and degassing, and large-scale volatile transfer. Ongoing field-based studies include investigation of fluid processes in subduction zones and mantle volatile budgets.

If interested, please contact Gray E. Bebout, Department of Earth and Environmental Sciences, Williams Hall 31, Lehigh University, Bethlehem, PA 18015-3188 (office 215-758-5831; internet - geb0@lehigh.edu) for further information and application materials. Applicants must have a B.S./B.A. or M.S. in the earth sciences. Lehigh University is an equal opportunity/affirmative action employer.

GSA SECTION MEETINGS

South-Central Section, Texas Christian University, Fort Worth, Texas, March 15–16, 1993. John A. Breyer, Department of Geology, Room 207, Sid Richardson Building, Corner of Bowie and Cockrell, Texas Christian University, Ft. Worth, TX 76129-0001, (817) 921-7270. *Abstract Deadline: November 20, 1992*

Northeastern Section, Sheraton Inn Conference Center, Burlington, Vermont, March 22–24, 1993. Barry L. Doolan or Rolfe S. Stanley, Department of Geology, Perkins Geology Hall, University of Vermont, Burlington, VT 05405-0122, (802) 656-0247. *Abstract Deadline: November 24, 1992*

North-Central Section, University of Missouri, Rolla, Missouri, March 29–30, 1993. Richard D. Hagni, Department of Geology & Geophysics, University of Missouri–Rolla, Rolla, MO 65401-0249, (314) 341-4616. *Abstract Deadline: December 2, 1992*

Southeastern Section, Florida State Conference Center, Tallahassee, Florida, April 1–2, 1993. James F. Tull, Department of Geology, Florida State University, Tallahassee, FL 32306-3029, (904) 644-5892. *Abstract Deadline: December 7, 1992*

Cordilleran and Rocky Mountain Sections, Reno Hilton (formerly Bally's Hotel), Reno, Nevada, May 19–21, 1993. Richard A. Schweickert, Department of Geological Sciences, Mackay School of Mines, University of Nevada–Reno, Reno, NV 89557-0138, (702) 784-6050; or Walter S. Sndyer, Department of Geosciences, Boise State Univesity, Boise, ID 83725, (208) 385-3645, fax 208-385-4061. *Abstract Deadline: January 26, 1993*

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 students traveling to the 1993 GSA Annual Meeting in Boston in October and to the 1993 Section meetings. Contact your section secretary for application procedures.

Section	Secretary	Phone
Cordilleran	Bruce A. Blackerby	(209) 278-3086
Rocky Mountain	Kenneth E. Kolm	(303) 273-3800
North-Central	George R. Hallberg	(319) 335-1575
South-Central	Rena M. Bonem	(817) 755-2361
Northeastern	Kenneth N. Weaver	(410) 554-5503
Southeastern	Michael J. Neilson	(205) 934-2439

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AGI Call for Nominations for 1993 National Awards

(Deadline: March 31, 1993)

Each year the American Geological Institute (AGI) makes nominations on behalf of its member societies for the four national awards that are briefly described below. GSA members have been invited to participate by recommending possible candidates.

Those who wish to make nominations are urged to do so by sending BACKGROUND INFORMATION or RESUMES of their candidates *BY MARCH 31, 1993*, to the *AGI Nominating Committee, 4220 King St., Alexandria, VA 22302-1507*; (703) 379-2480; fax 703-379-7563. A roster of nominations will be prepared for final selections by the Member Society Council at its meeting in June 1993.

William T. Pecora Award

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

The award recognizes contributions of those in the scientific and technical community as well as those involved in the practical application of remote sensing. Consideration will be given to sustained or single contributions of major importance to the art or science of the understanding of Earth through observations made from space.

Additional information may be obtained from the William T. Pecora Award Committee, Office of Personnel, Dept. of the Interior, MS-5203, MIB, Washington, DC 20240, Attention: Ann Meroney, (202) 208-5284.

National Medal of Science

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

There are now many younger American scientists and engineers who may be reaching a point where their contributions are worthy of recognition. The committee is giving increasing attention to these individuals as well as to those outstanding women and minority scientists who deserve recognition.

Additional information may be obtained by contacting the Secretariat Office, President's Committee on the National Medal of Science, NSF, 1800 G Street, NW, Washington, DC 20550, Attention: Susan E. Fannoney, (202) 357-7512.

Vannevar Bush Award

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

The award is given to a senior statesman of science and technology and complements the NSF's Alan T. Waterman Award, which is given to a promising young scientist. The two awards are designed to encourage individuals to seek the highest levels of achievement in science, engineering, and service to humanity.

The nomination should be accompanied by a complete biography and a brief citation summarizing the nominee's scientific or technological contributions to our national welfare in promotion of the progress of science.

Additional information may be obtained from the Vannevar Bush Award Committee, National Science Board, 1800 G Street, NW, Washington, DC 20550, Attention: Susan E. Fannoney, (202) 357-7512.

Alan T. Waterman Award

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

Candidates must be U.S. citizens or permanent residents and must be 35 years of age or younger, *OR* not more than five years beyond receipt of the Ph.D. degree by December 31 of the year in which nominated.

Candidates should have completed sufficient scientific or engineering research to have demonstrated, through personal accomplishments, outstanding capability and exceptional promise for significant future achievement.

Additional information may be obtained by contacting the Executive Secretary, Alan T. Waterman Award Committee, NSF, 1800 G Street, NW, Washington, DC 20550, Attention: Susan E. Fannoney, (202) 357-7512.

Remember: BACKGROUND INFORMATION or RESUMES of nominated candidates should be sent *BY MARCH 31, 1993*, to the *AGI NOMINATING COMMITTEE, 4220 KING ST., ALEXANDRIA, VA 22302-1507, (703) 379-2480, fax 703-379-7563.* ■

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