Vol. 3, No. 5 May 1993

GSA TODAY

A Publication of the Geological Society of America

INSIDE

Antarctic Plate: Tectonics from a Gravity Anomaly and Infrared Satellite Image

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ABSTRACT

Two separate sets of satellite geophysical data pertaining to the structure and development of the Antarctic plate have recently become available. Altimeter profiles of sea-surface topography yield gravity anomalies over the entire Southern Ocean, and the major features of the sub-ice structure of the continent can be discerned in radiometer images. Digital combination of the two data sets has generated a composite gravity anomaly–infrared satellite image of the Earth south of 60°S as viewed from above the pole. The combined image is particularly valuable for study of the relation between the tectonic development of the continental and oceanic lithosphere.

INTRODUCTION

We have developed a composite satellite image of the Antarctic continent and surrounding ocean basins (Fig. 1). The image combines recently declassified Geosat altimeter profiles of sea-surface topography in the Southern Ocean (south of 60°S) with Advanced Very High Resolution Radiometer (AVHRR) data from Antarctica. The Geosat satellite was launched by the U.S. Navy in 1985, and the altimeter profiles were prepared and distributed by the National Geodetic Survey (Cheney et al., 1991). The gravity anomalies shown were generated from high-density (~3 km or less track spacings) altimeter profiles collected between 1985 and 1988 (Fig. 2). The AVHRR data were acquired by four NOAA satellites during the period 1980 to 1987. The digital image mosaic of the AVHRR data (Fig. 2) was assembled by the National Remote Sensing Center (NRSC) in Britain, then rectified, and finally modified to remove seasonal ice. It has been published by the U.S. Geological Survey (USGS; Miscellaneous Investigations Series Map I-2284, 1:5 000 000, 1991).

GEOSAT ALTIMETRY

The Geosat altimeter uses a pulse-limited radar along a very accurate orbit to measure the topography of the ocean surface. Because the ocean surface is nearly an equipotential surface of Earth's gravity field, repeatable variations in sea-surface topography are assumed to be caused by actual variations in marine gravity. A new method was developed (Sandwell, 1992) to combine the six million Geosat observations into a grid of gravity anomalies. To suppress the long-wavelength radial orbit error, each profile was differentiated along-track to form a sea-surface slope profile. The ascending (southeast to northwest) and descending (northeast to southwest) slope profiles (Fig. 2) were then rotated and scaled to produce grids of north and east sea-surface slope. Finally, these grids were combined to produce gravity anomalies (Haxby et al., 1983). Long-wavelength anomalies (>1000 km) were constrained by a spherical harmonic gravity model complete to degree and order 40 (Marsh et al., 1990). Variations in gravity anomaly are displayed in the image (Fig. 1) as variations in hue ranging from violet (<–35 mgal) to orange (>35 mgal). In addition, false illumination from the right side of the image was used to highlight the short-wavelength anomalies. Between 60° and 72°S, the gridded gravity anomalies have accuracies of 1 to 5 mgal, so that features as small as 10 km can be resolved. Because the Southern Ocean is sparsely surveyed by ships, these gravity anomalies reveal many previously uncharted features, particularly seamounts and fracture zones (McAdoo and Marks, 1992).

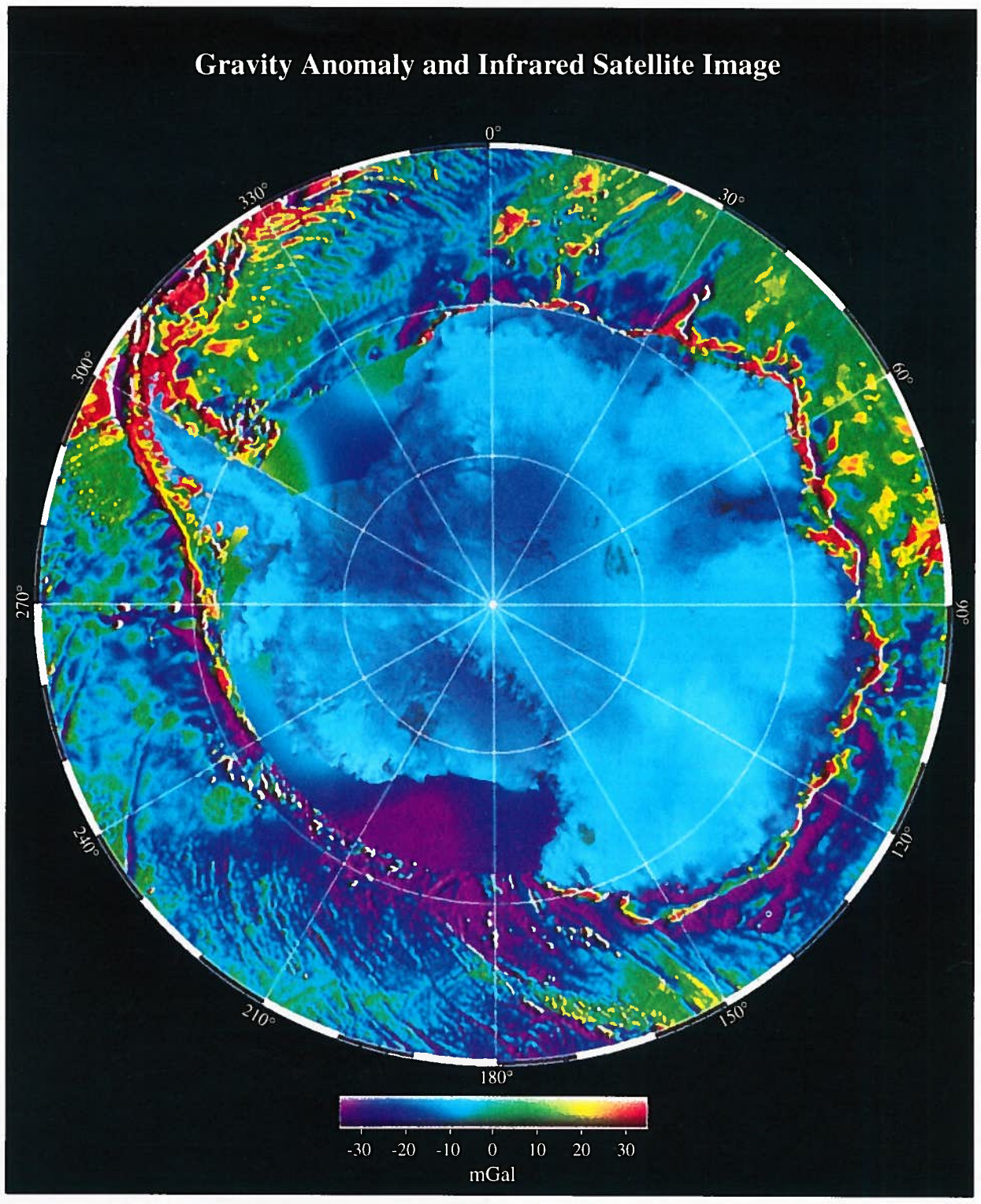

Figure 1. Composite gravity anomaly and infrared satellite image of the Antarctic continent and surrounding ocean basins south of 60°S (polar stereographic projection). Copyright 1992 by Scripps Institution of Oceanography and the Institute for Geophysics, University of Texas, Austin. To obtain a copy at a scale of 1:17 000 000, write to: Antarctic Image, Institute for Geophysics, University of Texas, 8701 Mopac Boulevard, Austin, TX 78759-8397.

RADIOMETRY

The AVHRR satellites collected images along 2400-km-wide swaths in five separate spectral bands ranging from the visible red to the far infrared. Because many of the image pixels were obscured by cloud cover, 34 sections from 25 separate image swaths were used by NOAA and NRSC to assemble the mosaic (Fig. 2). Cloud type, altitude, and position relative to the sun affect the different shapes and colors produced by the clouds and their shadows that partially obscure the ground below (Fig. 3). NRSC corrected missing or distorted lines in the AVHRR data and also corrected bands 1 and 2 for varying sun-illumination angle. The resolution of the original AVHRR data varies from 1.1 km directly under the satellite to as large as 2.4 by 6.9 km at the edge of a 2400-km-wide swath. NRSC resampled the image into a polar stereographic projection by means of ground control points, defined the edges of the mosaic sections, and then combined the sections into a consistent tone-matched image of the continent. They mapped the AVHRR mosaic to a polar stereographic graticule at 1:5 000 000 scale with a standard parallel of 71°S. The root-mean-square error in pixel location is estimated to be 2.5 km after the digital data were edited, rescaled, and processed by the USGS. Further information concerning the AVHRR image is provided on the Satellite Image Map of Antarctica (USGS Miscellaneous Investigations Series Map I-2284, 1991) and in Merson (1989). Bands 1

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GSA TODAY
Vol. 3, No. 5 *May 1993*

GSA TODAY (ISSN 1052-5173) is published monthly by The Geological Society of America, Inc., with offices at 3300 Penrose Place, Boulder, Colorado. Mailing address: P.O. Box 9140, Boulder, CO 80301-9140, U.S.A. Second-class postage paid at Boulder, Colorado, and at additional mailing offices. **Postmaster:** Send address changes to *GSA Today*, Membership Services, P.O. Box 9140, Boulder, CO 80301-9140.

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Antarctic Plate *continued from p. 117*

(visible), 2 (near infrared), and 4 (far infrared) of the USGS digital AVHRR image are shown in Figure 1. The original image was filtered and resampled from a 1 km to a 2 km grid (i.e., 2.066 km pixel dimension at 90°S) prior to merging with the gravity anomaly image. The gray level of the AVHRR image was modulated by the average of bands 1 and 2, and band 4 was used to modulate the hue.

TECTONICS

Our combination of the gravity and AVHRR data allows direct examination of the relation of features in the oceanic lithosphere, the continental shelf, and the ice-covered continent (see Fig. 3 for significant features). Although not all are visible in the small-scale version of the composite image that is shown in Figure 1, those discussed in the text can be distinguished in the 1:17 000 000 version (nominal scale), which can be obtained from us (see Fig. 1 caption). This scale was chosen because it corresponds to that of the recently published marine geological and geophysical atlas of the circum-Antarctic (Hayes, 1991). The lineaments on the ocean floor represent the structural fabric of the Southern Ocean as interpreted from the Geosat deflection of the vertical data (from Royer et al., 1990). They correspond to features such as fracture zones and spreading ridges. Although 98%–99% of the Antarctic continent is covered by ice, the ice surface imaged by the AVHRR data closely reflects the sub-ice structure (Drewry, 1983; Dalziel, 1992a).

Sea Floor

Prominent sea-floor features fall into four categories; fracture zones, spreading ridges, seamounts and plateaus, and continental margins. Perhaps the most striking sea-floor features in the deep ocean are the fracture-zone lineaments in the Weddell Sea region from 310°E to 005°E (longitudes are given as degrees east from 000°, the Greenwich meridian), across the Pacific-Antarctic Ridge (210°E to 160°E), and the Tasman (150°E) and Balleny (155°E) fracture zones at the bottom of the image. The major-offset fracture zones of the South Pacific, the Heezen (260°E) and Tharp (255°E) fracture zone systems, and the Udintsev Fracture Zone at 240°E are also quite prominent. There is some hint that the Udintsev Fracture Zone may trend into the eastern coast of the Amundsen Sea at Pine Island Bay, representing a major structural boundary in West Antarctica (Dalziel and Elliot, 1982; Dalziel, 1992a).

The only active spreading center within the map area appears as a series of orthogonal ridges and transform faults along the Pacific-Antarctica plate boundary between 208° and 160°E and a few sections of the Australia-Antarctica plate boundary between 160° and 150°E. Between 208° and 200°E, the spreading center appears as a single gravity ridge superimposed on a broad gravity rise. The wake of a triangular-shaped propagating rift appears at 63°S between 193° and 196°E (see Fig. 3). Farther to the south, the spreading center appears as a gravity trough superimposed on a broad gravity rise. The change from gravity ridge to gravity trough at the spreading center may be related to the decrease in spreading rate toward the southwest (Small and Sandwell, 1992). Away from the spreading center, the conjugate bends in the fracture zones (i.e., gravity troughs) reflect changes in sea-floor-spreading direction in accordance with synthetic flowlines generated from the plate-motion models (Mayes et al., 1990). This recent change in spreading direction has resulted in extension along a major-offset transform fault (between 160° and 180°E), causing the ridge to splinter into numerous short spreading centers offset by transform faults.

Other prominent sea-floor features are submarine plateaus and numerous seamounts. Maud Rise appears as a prominent gravity high at 005°. Only a small part of the the Kerguelen Plateau extends south of 60°S at 085°E, and there is a clear gravity low (i.e., deep water) between the Kerguelen Plateau and the Antarctic margin, indicating that Kerguelen was formed after India rifted from Antarctica. However, the presence of a small alkaline volcano, Gaussberg, on the margin of the Antarctic continent (089°E, Fig. 3) indicates some structural connection between the Kerguelen Plateau and the continent. The Balleny Islands at 67°S and 165°E, Scott Island at 68°S and 180°E, and Peter I Island at 69°S and 270°E are all quite prominent features. The gravity signatures of other seamounts throughout the deep ocean areas are apparent.

Perhaps the most obvious gravity feature is the prominent high that marks the edge of the continental margin. With the exception of the Gunnerus Ridge at 032°E, there are very few anomalous seafloor features contiguous to the continental margin. The Gunnerus Ridge marks the boundary between where Africa rifted from Antarctica to the west and Sri Lanka and India rifted off to the east (Lawver et al., 1992). At two places where major ice streams drain large parts of the East Antarctic Ice Sheet, 070° to 075°E off the Amery Ice Shelf, and 115°E along the East Antarctic continental margin, major postbreakup sedimentation appears to have occurred on the continental slope, obscuring the gravity signature of the basement rocks (wide orange anomaly). There appears to be a gross 120°-angle "scallop" to the edge of the East Antarctic continent, with promontories at 000°, 055°, 080°, 100°, and 135° (see below).

Terrestrial

Significant structural features on the AVHRR image of Antarctica fall into two groups: (1) mountain ranges or escarpments and (2) ice-filled rift basins. The most prominent mountain range is the Transantarctic Mountains, which extend from North Victoria Land at 72°S and 165°E near the bottom of the image of Antarctica to near the South Pole in the center. The Transantarctic Mountains define the lower left side of the roughly kidney-shaped East Antarctic Precambrian shield, which is penetrated by the

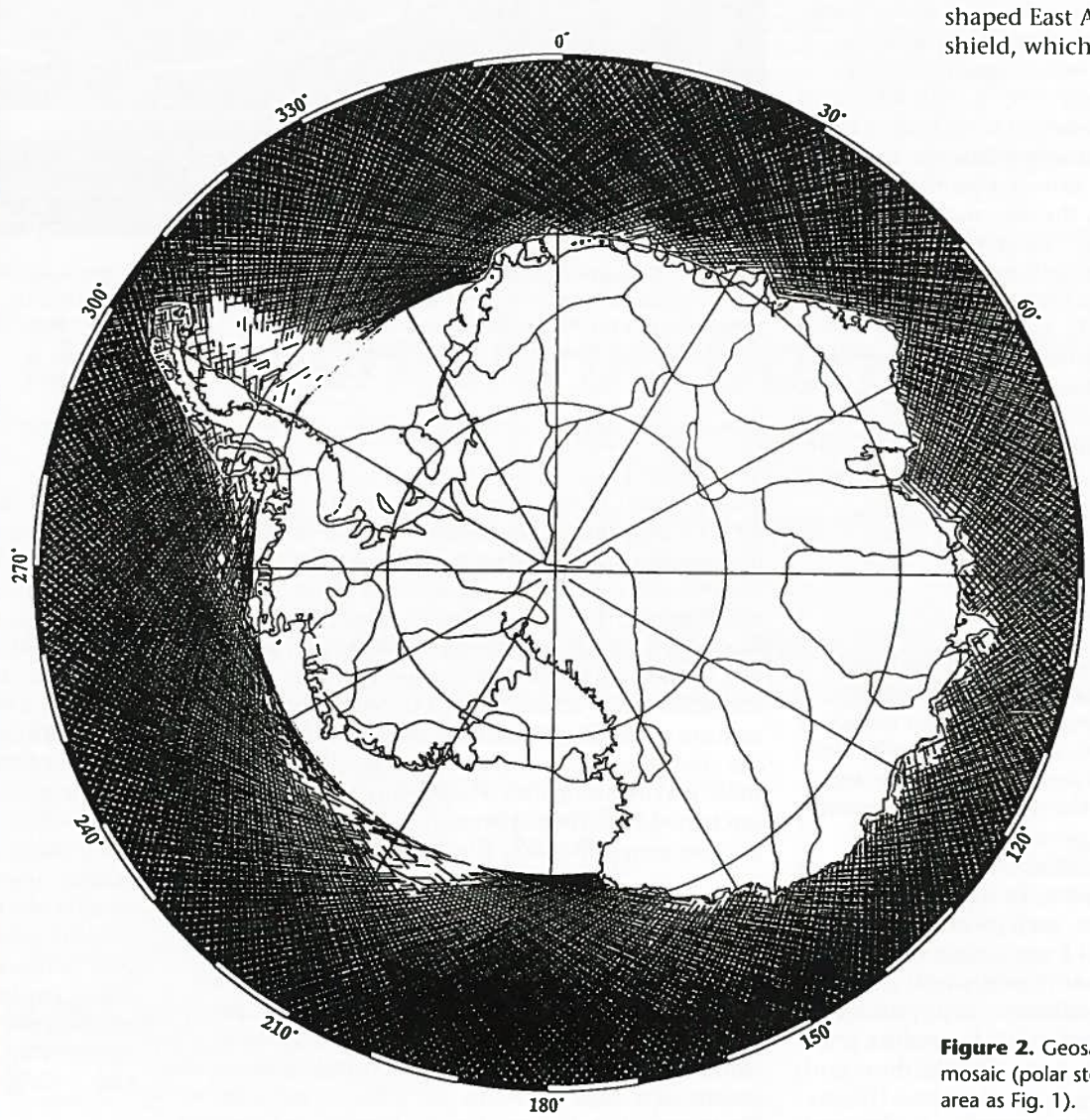
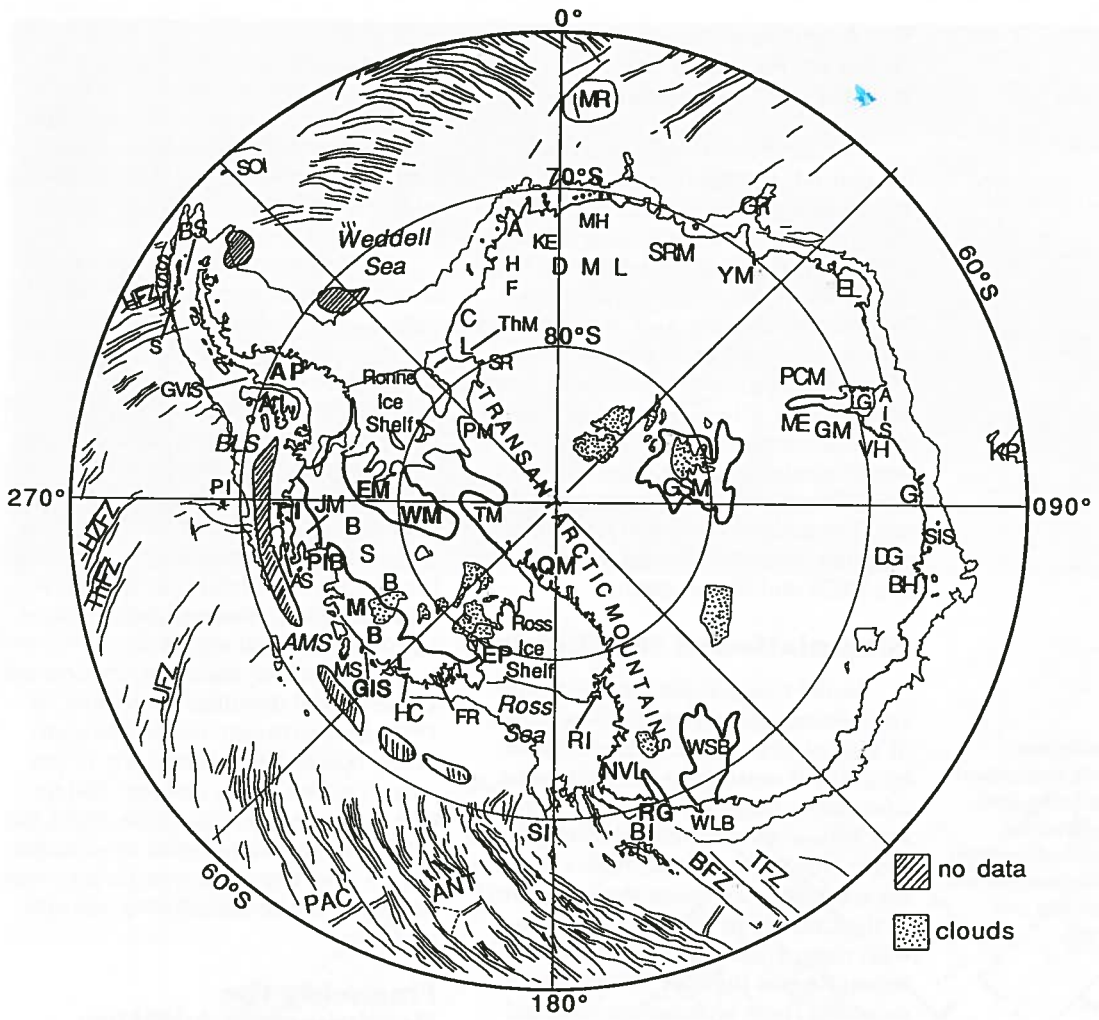


Figure 2. Geosat tracks and radiometer mosaic (polar stereographic projection, same area as Fig. 1).



A—Annandagstoppane
AI—Alexander Island
AIS—Amery Ice Shelf
AMS—Amundsen Sea
AP—Antarctic Peninsula
AS—Abbott Ice Shelf
BFZ—Balleny Fracture Zone
BH—Bunger Hills
BI—Balleny Islands
BLS—Bellingshousen Sea
BS—Bransfield Strait
BSB—Byrd Subglacial Basin
CL—Coats Land
DG—Denman Glacier
DML—Dronning Maud Land
EL—Enderby Land
EM—Ellsworth Mountains
EP—Edward VII Peninsula
FR—Ford Ranges
G—Gaussberg
GIS—Getz Ice Shelf
GM—Grove Mountains
GR—Gunnerus Ridge
GSM—Gamburtzev Subglacial Mountains
GVIS—George VI Sound
HC—Hobbs Coast
HF—Heimefrontfjella
HFZ—Hero Fracture Zone
HZFZ—Heezen Fracture Zone
JM—Jones Mountains
KE—Kirwan Escarpment
KP—Kerguelen Plateau
LG—Lambert Glacier
MBL—Marie Byrd Land
ME—Mawson Escarpment
MH—Mühlig-Hofmannfjella
MR—Maud Rise
MS—Mount Siple
NVL—North Victoria Land
PAC-ANT—Pacific-Antarctic Ridge
PCM—Prince Charles Mountains
PI—Peter I Island
PIB—Pine Island Bay
PM—Pensacola Mountains
QM—Queen Maud Range
RG—Rennick Glacier
RI—Ross Island
S—Smith Island
SI—Scott Island
SIS—Shackleton Ice Shelf
SOI—South Orkney Islands
SR—Shackleton Range
SRM—Sør Rondane Mountains
SSI—South Shetland Islands
TFZ—Tasman Fracture Zone
ThFZ—Tharp Fracture Zone
ThM—Theron Mountains
TI—Thurston Island
TM—Thiel Mountains
UFZ—Udintzev Fracture Zone
VH—Vestfold Hills
WLB—Wilkes Land Basin
WM—Whitmore Mountains
WSB—Wilkes Subglacial Basin
YM—Yamato Mountains

Figure 3. Location of features mentioned in the text (polar stereographic projection, same area as Fig. 1). The continental margin is the 2000 m bathymetric contour. Sub-ice features are delineated by the grounding line (Ross and Weddell embayments), the –500 m contour (Transantarctic Mountains front and crustal blocks of West Antarctica), the –1000 m contour (basins of East Antarctica), and the +2000 m contour (Gamburtzev Subglacial Mountains). Stippled areas are major cloud groups.

Lambert Glacier–Amery Ice Shelf rift at 070° to 075°E. The Transantarctic margin of the East Antarctic shield continues toward the top of the image and includes the Thiel and Pensacola mountains and the Theron Mountains at 79°S and 335°E. This is the margin recently suggested as having been conjugate to the late Precambrian–early Paleozoic rifted margin of western North America (Moores, 1991; Dalziel, 1991). The anomalous structural trend of the Shackleton Range at a high angle to the Transantarctic Mountains is apparent near the southeastern corner of the Weddell Sea. According to the new hypothesis suggesting that North America "broke out" from between East Antarctica–Australia and South America at the end of the Precambrian, this trend is a continuation of the Yavapai-Mazatzal and Taconic orogens of southern North America (Moores, 1991; Dalziel, 1991, 1992a, 1992b; Dalla Salda et al., 1992). The Grenville orogen would have continued into Coats Land and the Heimefrontfjella along the eastern margin of the Weddell Sea.

Northeast of the Theron Mountains, an escarpment made up of the Heimefrontfjella, Kirwan Escarpment, and Mühlig-Hofmannfjella extends around Dronning Maud Land to the Sør-Rondane Mountains at 030°E. In a reconstruction of the Gondwana supercontinent, this Antarctic escarpment mirrors the Lebombo monocline of southeast Africa and reflects the prebreakup fit of the continents (Lawver et al., 1991). The prominent north-trending Dronning Fabiolafjella (Yamato Mountains) can be seen at 72°S and 036°E. Enderby Land between 040° and 070°E can be reconstructed to India in a prebreakup fit and matches the east coast of India between 10° and 20°N. The protuberant margin of Enderby Land between 050° and 057°E comprises the Napier complex of Archean granitoid and granulite facies metamorphic rocks (Tingey, 1991). It is one of three promontories of the East Antarctic craton margin mentioned above that is underlain by a nucleus of Archean rock. The Napier complex, the ancient rocks of the Kaapval craton exposed at Annandagstoppane, and the Vestfold Hills complex appear to have controlled development of the continental margin during fragmentation of Gondwana (Dalziel, 1992a).

The Lambert-Amery graben is flanked by the Prince Charles Mountains to the west and the very prominent Mawson Escarpment to the east near the head of the graben. The Lambert Glacier, which feeds the Amery Ice Shelf, is the largest drainage system for the East Antarctic Ice Sheet (Drewry, 1983). To the south of the Lambert graben lie the Gamburtsev Subglacial Mountains (80°S, 076°E). A cloud obscures this location on the image. Air photographs indicate that these mountains, which have a sub-ice relief of over 3000 m, come close to the surface without actually being exposed (Swithinbank, 1988). The Grove Mountains appear as a dark spot at 73°S and 075°E and are one of the very few outcrops through the East Antarctic Ice Sheet.

The Shackleton Ice Shelf is the prominent feature at 097°E that extends in a hook shape from the coast. Offshore, there is a definite change in trend of the outer continental margin gravity high at 100°E. West of this point, India rifted from East Antarctica during the Neocomian Epoch of the Early Cretaceous (~135 Ma; Lawver et al., 1991); to the east, Australia rifted from East Antarctica during the Late Cretaceous (starting slowly at ca. 96 Ma; Veevers et al., 1991). The Bunger Hills, the dark area near the coast at 100°E, consist of Proterozoic and early Paleozoic age metamorphic and igneous rocks (Tingey, 1991). The Denman Glacier, which feeds the Shackleton Ice Shelf, is just west of the Bunger Hills. To the east, there are only scattered outcrops along the coast to 155°E.

Between 145° and 155°E, the Wilkes Land Basin is a major feature indicated offshore by the gravity low inboard of the continental-margin gravity high. The Wilkes Land Basin is the offshore extension of the much larger Wilkes Subglacial Basin, which lies parallel to the Transantaractic Mountains and appears to be part of a flexural downwarp extending inland beyond the South Pole (Stern and ten Brink, 1989). The Wilkes Subglacial Basin extends northward as a feature 500 m below sea level (mbsl) to 81°S and as a 1000 mbsl feature to 74°S. Its greatest depth is 1500 m. To the east, between 158°E and 160°E, the Wilson Hills on the coast and the Usarp Mountains inland form the western margin of the Rennick graben. The Rennick Glacier can be seen as far south as 73.5°S at 162°E. The Bowers Mountains form a linear eastern margin to the Rennick graben at 160°E. Tasmania rifted from the North Victoria Land margin of East Antarctica and marks the easternmost limit of the zone where Australia separated from Antarctica during Late Cretaceous time.

The western hemisphere side of the Transantarctic margin of East Antarctica is dominated by the Ross and Weddell sea embayments. The ice grounding line for the Ross Sea embayment runs roughly along 210°E from 80° to 86°S. The ice-grounding line for the Weddell Sea embayment runs from approximately 84°S and 300°E to 80°S and 285°E, and from there to 76°S and 290°E, where it connects to the base of the Antarctic Peninsula. The Ross and Weddell sea embayments are joined by a depression that lies between the Transantarctic Mountains and the Marie Byrd Land, Thurston Island, and Antarctic Peninsula crustal blocks of West Antarctica (Dalziel and Elliot, 1982). The depression includes the Byrd Subglacial Basin, which reaches oceanic depths beneath the West Antarctic Ice Sheet and appears to be part of a volcanically active rift system (Blankenship et al., 1993). The isolated Ellsworth Mountains show up prominently between 77° and 80.5°S along 275°E. They form a fourth structural unit of West Antarctica that extends beneath the ice to the Whitmore Mountains at 82°S and 255°E, separating the Weddell Sea embayment from the Ross Sea embayment. This crustal block appears to be a fragment of the Gondwana craton margin displaced from between the Transantarctic Mountains and southern Africa (Dalziel, 1992a).

Marie Byrd Land extends from 202° to 257°E and from the continental margin to 79°S. Mt. Siple is the prominent, inactive (SPRITE Group and Boyer, 1992), volcano along the continental edge at 73°S and 234°E. Between Mt. Siple and the coast of Marie Byrd Land is the Getz Ice Shelf. Inland is the Executive Committee Range parallel to the margin, and the Ford Ranges and Edward VII Peninsula forming the western end of Marie Byrd Land. Marie Byrd Land has some geologic affinities to North Victoria Land (Borg et al., 1990) and is assumed to have been closer to East Antarctica prior to Mesozoic and Cenozoic extension in the Ross Sea embayment. The Campbell Plateau and Chatham Rise, which are parts of the greater New Zealand microcontinent, rifted from Marie Byrd Land when the Pacific-Antarctic spreading center propagated between the two at around 85 Ma.

Pine Island Bay at 255°E marks the boundary between the Marie Byrd Land and Thurston Island blocks of West Antarctica. Thurston Island itself lies right along 72°S between 258° and 265°E, and is separated from the mainland by the Abbott Ice Shelf. The Jones Mountains lie to the southeast of Thurston island, and the Hudson Mountains lie due south along 76°S. Both are Tertiary volcanic centers. The Antarctic Peninsula is the prominent S-shaped peninsula that extends from 76° to 63°S between 285° and 300°E. The Thurston Island block may have originally been rotated with the Antarctic Peninsula such that they lay parallel to the Falkland Plateau prior to the breakup of Gondwana (Grunow et al., 1991). Alexander Island (69° to 72°S along 290°E) is separated from the peninsula by George VI Sound. The South Shetland Islands (63°S and 297°E to 62°S and 303°E) lie along the outer continental margin separated by the basins of Bransfield Strait. The South Shetland trench slowed or ceased subduction when spreading stopped along the remnant of the Antarctic-Aluk spreading center at 4 Ma. Volcanism and possibly active extension is occurring in Bransfield Strait.

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GSA Headquarters Expansion

Robert D. Hatcher, Jr., GSA President
F. Michael Wahl, Executive Director

GSA President Robert Hatcher (right), Foundation President Bob Fuchs (left), and Executive Director Mike Wahl (center) breaking ground for the headquarters addition in Boulder on March 17, 1993.

A new chapter in the 105-year history of the Geological Society of America began on March 17, 1993, with the ground-breaking ceremony for the addition to the headquarters building in Boulder, Colorado. The 13,200 square feet (see drawings) will be used primarily for existing programs in urgent need of additional space (Membership Services Department, Editorial and Production Departments, and the GSA Foundation), as well as for the recently created Science Awareness for Geoscience Education (SAGE) and Institute for Environmental Education (IEE) programs. The addition will almost double the available space at GSA headquarters—the present building contains approximately 17,000 square feet. Total cost of the project will be about $2.2 million, which includes all design fees and permits, site preparation and construction costs, plus furniture, fixtures, and the initial financing costs.

All present at the ceremony were aware that this event marks not just the beginning of a building addition, but both a celebration of the success of the Geological Society of America and a commitment to the future. Existing programs—publications, meetings, Penrose Conferences, research grants, Congressional Science Fellows, and the GSA Foundation—have been increasingly successful in the recent past and this event marks a major commitment to the future success of these programs, as well as to the new initiatives recently undertaken by the Society in geoscience education with SAGE and in environmental issues with the IEE.

Background on the Need to Expand the Headquarters Building

The need for the addition was recognized in early 1986, and was reaffirmed two years ago when the editorial offices of the *Bulletin* were moved to the house next door, where the GSA Foundation offices had already been located for a decade. Also, the Meetings Department has been operating in extremely overcrowded space for the past several years. The Headquarters addition and subsequent moves of other departments will allow relocation to a much larger area in the existing building. The addition will also provide adequate space for development of the SAGE and IEE programs.

Formulation of the Decision

Initial Council discussions to alleviate severe space restrictions occurred in May of 1986. After further reviews by Council during the next two years, a feasibility study for a possible addition was authorized in 1989. Following this study, three possible alternative means for acquiring new space were presented to the Council in 1991, in San Diego, with the request that this issue be an action item at the May 1992 Council meeting. These alternatives included selling the existing building and purchasing land at a new site farther east on the outskirts of Boulder (where an all-new facility could be constructed), constructing an addition to the existing building, or purchasing temporary expansion space in other buildings in the local area. The Executive Committee thoroughly explored all options, and also heard presentations by the architects and financial planners on the various alternatives and how they might be financed.

The alternative of a building addition using the same techniques and materials as in the original building proved very expensive, but it was found that it would be possible to construct an addition similar in appearance and design, and at a much lower cost, by using modern techniques and materials. Reducing the size of the proposed addition from three floors to two also helped lower the estimated cost.

The Executive Committee met in Boulder in August 1992, to hear presentations on all alternatives, on the revised building addition design, and on the projected cost. Following these presentations, the Executive Committee unanimously agreed that a building addition should be the option recommended to Council.

A briefing session was held in Cincinnati on Sunday, October 25, 1992, prior to the Wednesday Council meeting to explain the need for additional space, and to enlist discussion from councilors, councilor-nominees, several past presidents of the Society, and others. This was a very fruitful undertaking because we received many constructive comments. Members of the Executive Committee also met again with a number of councilors later that day to engage in further informal discussion, again with fruitful results.

After further discussion by Council at the official meeting on October 28, 1992, in Cincinnati, the building addition option was passed with 13 yes votes, zero no votes, and one abstention. Executive Director Mike Wahl was instructed to proceed with the completion of final drawings, contracting, and financing of the project as quickly as possible.

Financing the Headquarters Addition

The Council recognized that the timing for considering acquisition of additional space for GSA headquarters was very good, because current interest rates were the lowest in 20 years and probably would not last. Accordingly, even before the costs of different alternatives were known, the Society proceeded in late 1990 with required reviews by the City of Boulder that resulted in final Planned Unit Development approval should Council authorize the "go-ahead" at a later date.

Because the Society is a 501(c)(3) non-profit corporation, we qualify for the issuance of tax-exempt, private activity bonds to fund the project. In 1992, the Executive Committee heard presentations on the marketing of these bonds, at both variable and fixed interest rates, and recommended to Council that a variable rate be chosen,

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LETTERS TO THE EDITOR

This is with regard to "The Crisis in Scientific Publication," by John E. Costa and Arthur G. Sylvester, which appeared in the January issue of *GSA Today* [v. 3, no. 1, p. 13].

Libraries have been shrinking their subscriptions to journals, as noted by Costa and Sylvester, and shrinking subscriptions have added to costs for remaining subscriptions. This factor is an addition to inflation, increased postal rates, and the devaluation of the dollar; together, the prices rise not because the commercial firms are obtaining huge profits but because they are trying to maintain sound business enterprises. Ultimately, higher costs and shrinking subscriptions do not bring wealth to the publishers but closure to the journals. *Mining Science and Technology* (Elsevier) ceased publication last year. The journal had plenty of very good papers, but few subscriptions. The other commercial journals can fail the same way.

It is unfortunate that Costa and Sylvester brand commercial publishers as *foreign*. Properly, they are *international*, like IBM, Exxon, etc., and the material they handle is international as well. I am able to speak only for *Engineering Geology*. The provenance of the papers we receive is approximately: United States—40%, Europe—40%, Asia and Africa—18%, Latin America—2%; and the contributions from outside the United States are growing. We should expect both Asia and Latin America to figure more importantly.

Costa and Sylvester have ignored the exchanges that are essential with the rest of the world. If their recommendations were implemented and American papers together with American participation on international editorial boards were withdrawn, the result would be the demise of many avenues for international scientific communication where, inevitably, the United States is no longer the major player but is, instead, the beneficiary.

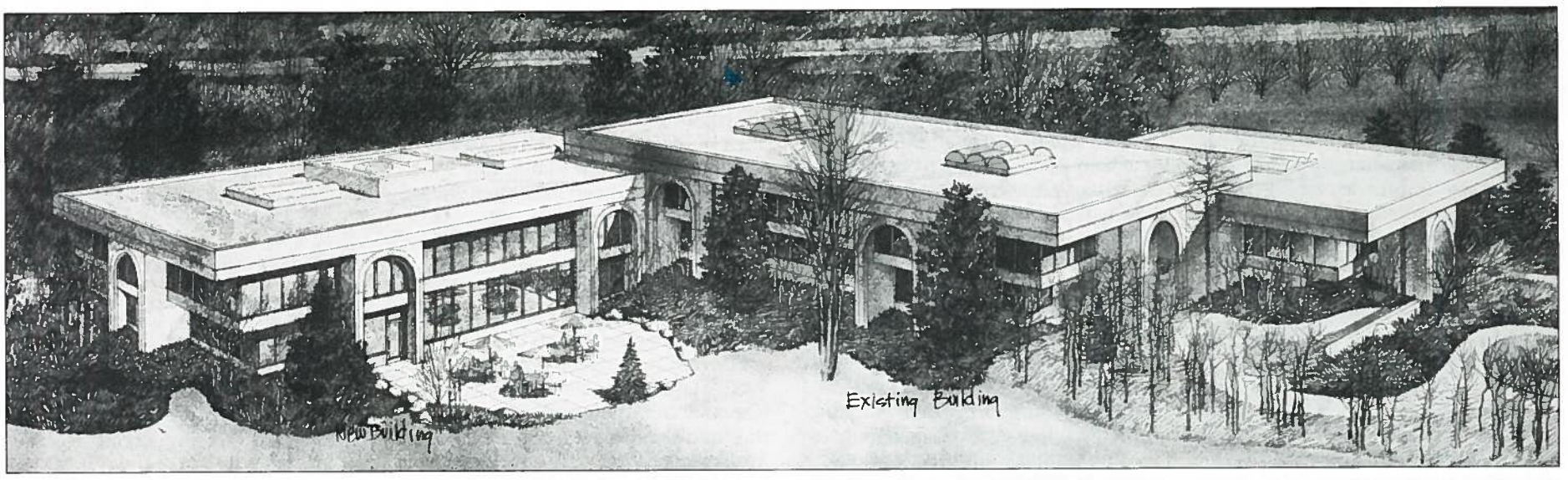
In my field of engineering geology, there are only two world-class journals: the *Bulletin of the Association of Engineering Geologists*, subsidized by subscriptions to the AEG, which by the way is an *international* society, and *Engineering Geology*, from Elsevier. Both are top quality. Neither of them are money makers. Money in publishing is where Madonna is. And speaking for *Engineering Geology*, Costa and Sylvester's recommendations would be disastrous. The engineering geology profession worldwide would be losers.

E. L. Krinitzsky
Editor-in-Chief, Engineering Geology

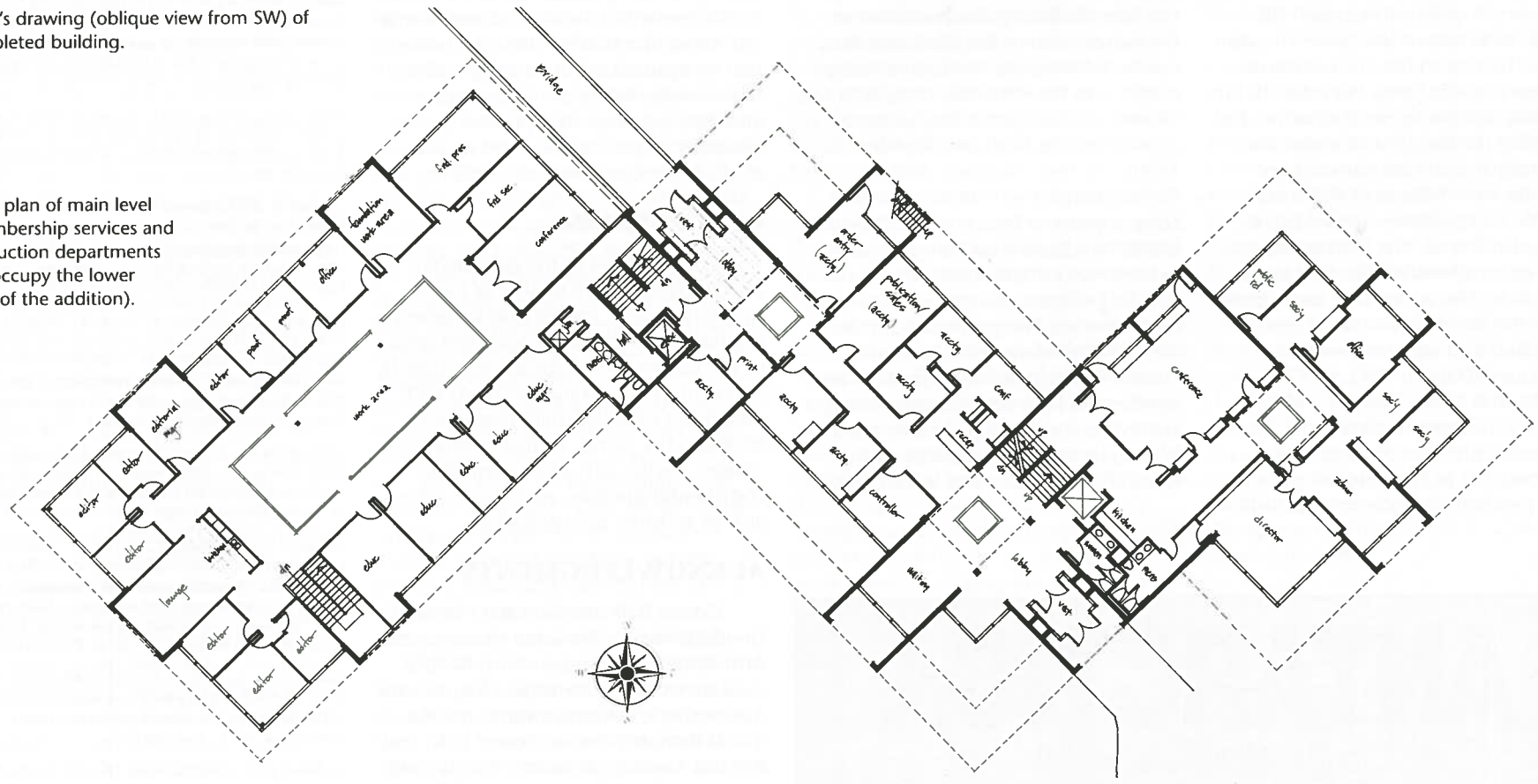
Outgoing GSA President E-an Zen's bold, worldly, and up-front thoughts regarding the citizen-geologist merit serious consideration [*GSA Today*, v. 3, no. 1, p. 2–3]. The spectrum of reaction is likely to reflect the ever-present generational struggle that seeks to locate the shifting divide between reality and ideality. My views are those of a retiree whose professional life was devoted to being a public-service geologist for the Arizona Geological Survey. Zen asks that we consider what the role of GSA and of geologists should be in the future well-being of our world.

Although I agree with much of what Zen writes, I am discomfited by the degree of subjectivism (judgment and conviction) he asks us to share with the public. I sense an assumption that we geologists, by virtue of our geological training and experience, may tend to think alike about those world affairs rooted in things geologic. Do we? How diverse might our opinions be in judging whether or not a course of action is wise, good, bad, right, wrong, important, etc.? Do basic political-economic philosophies influence views on geologically related matters? I think they do. How do we, for instance, respond to the planetary prin-

continued on p. 121



Artist's drawing (oblique view from SW) of completed building.



Floor plan of main level (membership services and production departments will occupy the lower level of the addition).

Expansion *continued*

with the option of conversion to a fixed rate if at some time in the future interest rates spiral upward. The Council concurred and authorized issuance of variable-rate, tax-exempt bonds to cover the cost of the project. Both the City and County of Boulder endorsed this request, and the bonds were sold in late December at an initial interest rate of 3%.

With the finalizing of drawings and the selection of a general contractor, all the elements were in place, thus setting the stage for the historical milestone that took place on March 17, 1993. Construction actually began the following week, and the new addition is scheduled to be occupied in January 1994.

Looking ahead to the 21st century, the Society should mark this occasion as a commitment to continued leadership in our profession, both nationally and internationally, as well as a renewed commitment to citizenship in Boulder and the State of Colorado. ■

Letters *continued*

ciple of finiteness (nonrenewability) of important global mineral-energy resources? Would we bring a common what-to-do-about-it message to the public? Some of us would be fearful, some not, etc. Is there a "politically correct" response? Might it be Zen's position that the planet is "fragile" and the ultimate goal is "sustainable global development"? In my view it is life that is fragile, not the planet, and sustainable global development seems idealistic in that it seeks equity in an inherently unequal world, especially geologically.

It is important that we seek, through science, consensus about the geological hand that nature has dealt and share this with the world. What to do about it, however, is quite another matter—our convictions may not be as unique as our science.

H. Wesley Peirce
Tucson, Arizona

I think E-an Zen is quite right, and he has been candid enough to include himself and his professional position (and those of his colleagues with similar responsibilities in geoscience and education) in the category of scientists whose main interest, given their knowledge of Earth and its fragile systems, should be care of that Earth. This consideration affects everyone involved in the earth sciences, at whatever level, as well as nonscientists. No one should be allowed to forget his/her knowledge and intelligence or to reject his/her role.

In my opinion, much of the problem lies in ignorance (and the desire for it!).... Although I speak from my perspective as an Italian, I have heard about and seen the same behavior in other places in the world. If you ask someone, "Why do you drop a piece of paper on the street, when there's a trashcan nearby?" or ... "Why, when building a house atop a hill, do you move or drop earth down the hill with no thought for possible risk to persons and buildings downslope, rock slides, or water drainage problems?," the answer ... may well be, "Why should I care about that? If there is damage, it won't affect me; Earth's a big planet!" Such responses indicate lack of common sense and good manners, but they also show a lack of education, from the very first years of school. Ask a kid of 13 or 14, "What exactly is pollution? What is the environment you live in?" and you might get no answer at all.

People need to have love for and interest in Earth, as a planet on which many live and as the place where *they* live, a place they want to conserve. But most people need help in understanding how to preserve their world, and this could be the geoscientists' task.

... As a geoscience student, I cannot ignore the carelessness that some who have important responsibilities, in academia and in other areas, sometimes show. Even worse is that some students don't think of geology as a challenge to obtain better knowledge of problems still to be solved, but only as a subject in which to take exams.... Some geologists lack commitment, don't see their work as a means of personal growth, and therefore cannot teach others or act as a good example. Some students ... give little thought to declining energy and mineral resources (estimates indicate that we have about 30 years' worth of oil and some 50 years' worth of gas—what happens after that?), to oceanographic issues (e.g., use of tidal waves for hydroelectric energy), or to soil conservation....

These are the reasons why I hope that geoscientists will teach us something more. As a student, I'm trying to do my best on my own, but I could use some help, and so could many of my fellow students all over the world.

Umberto Fracassi
University of Urbino, Urbino, Italy ■

Antarctic Plate *continued from p. 119*

Continental Margins

Unfortunately, Geosat data do not exist for the Ross Sea or the Weddell Sea region south of 72°S. The principal regions where there are clear-cut continuations of features across the continental margin are the major glacier-fed ice shelves and deep (>1000 m) continental shelf basins. The best example is the Lambert Glacier–Amery Ice Shelf–Prydz Bay region. Less spectacular on this image but possibly a larger feature is the Wilkes Land Basin offshore and the Wilkes Subglacial Basin onshore.

There is an obvious relation between the pattern of fracture zones that reflect the fragmentation of the Gondwana supercontinent and the internal structure of the Antarctic continent. The reason for this relation is not clear in most cases. We infer that in some way the continental structure has controlled the location of major fracture zones and/or that the onshore structures were formed at the same time and by the same mechanism as the fracture zones. The fracture zones in the eastern Weddell Sea that mark the track of Africa generally trend parallel to the Neoproterozoic orogen of Coats Land and western Dronning Maud Land (Dalziel, 1991, 1992b). Likewise, the South Tasman and Balleny fracture zones, which show the northward direction of motion of Australia, trend in to the Rennick graben, which parallels the Paleozoic tectonic fabric of North Victoria Land (Tingey, 1991). In Marie Byrd Land there seems to be a close geometric relation between the fracture zones that reflect the northwestward motion of New Zealand and the older continental basement unconformably overlain by Cenozoic volcanic rocks. A horst and graben–type topography predating the Cenozoic volcanic rocks has a west-northwest structural trend in the Ford Ranges–Fosdick Mountains area at 215°E, and a northward trend just 300 km to the east on the Hobbs Coast at 226°E. The difference reflects the change in the orientation of the fracture zones at the continental margin in the two closely spaced locations.

The Udintsev Fracture Zone, which trends toward the eastern extremity of the New Zealand microcontinent at the eastern end of the Chatham Rise, can be followed on the Geosat image nearly into the Antarctic margin in the vicinity of Pine Island Bay, as noted elsewhere (Sandwell and McAdoo, 1990). On the combined AVHRR-Geosat image, the Udintsev Fracture Zone appears to be constrained by the trends of adjacent fracture zones and to be directly aligned with the north-trending eastern margin of Pine Island Bay. However, the geologic boundary between the Marie Byrd Land and Thurston Island blocks appears to be represented by a deep trough eroded across the continental shelf by the Pine Island glacier slightly farther to the west (SPRITE Group and Boyer, 1992).

Finally, there are two striking margin-parallel features along the southern rim of the Pacific. One is the almost continuous grabenlike feature along the coast which includes the Getz Ice Shelf of Marie Byrd Land, the Abbott Ice Shelf of Thurston Island, and George VI Sound and Bransfield Strait of the Antarctic Peninsula. This may be related to the extent of Cenozoic alkaline basaltic volcanism along the margin (LeMasurier and Thomson, 1990) and to the sequential cessation of subduction along the margin during Late Cretaceous to Neogene time (Barker, 1982; Mayes et al., 1990). The second feature of note along this margin is the "mid-shelf" gravity high along the Antarctic Peninsula. This trends into Smith Island, southernmost of the South Shetland Islands, and into northern Alexander Island. These are underlain by uplifted subduction complexes that contain fossils as old as Jurassic and that were metamorphosed during Mesozoic and Cenozoic time (Barker et al., 1992; Grunow et al., 1992).

CONCLUSIONS

Combination of the radiometer and satellite gravity images of the Antarctic region reveals many interesting features of the large-scale tectonics of the region. Although the ice cover in Antarctica perhaps makes the AVHRR data more valuable there than elsewhere in the world, similar composite images, particularly from conjugate continental margins, may prove valuable in tectonic interpretation.

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ACKNOWLEDGMENTS

Geosat data are from the National Geodetic Survey, National Oceanic and Atmospheric Administration. AVHRR data are from the National Oceanic and Atmospheric Administration, the National Remote Sensing Center (UK) and the U.S. Geological Survey. Funds used in preparation of the image and this article came from the National Aeronautics and Space Administration Solid Earth Sciences Program (NAG 5-1226), the National Science Foundation Division of Polar Programs (DPP 90-19247 and DPP 89-17127), Scripps Institution of Oceanography, and the Institute for Geophysics, University of Texas, Austin. Walter Smith, Mark Wiederspahn, and Lisa Gahagan gave technical assistance. Institute for Geophysics contribution 992.

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Manuscript received January 25, 1993; accepted March 11, 1993. ■

Penrose Conference Report

Fluid-Volcano Interactions

Conveners
Steve Ingebritsen, U.S. Geological Survey, Menlo Park, California
Bruce Christenson, Institute for Geological and Nuclear Sciences, Taupo, New Zealand
Craig Forster, University of Utah, Salt Lake City
Grant Heiken, Los Alamos National Laboratory, Los Alamos, New Mexico
Craig Manning, University of California, Los Angeles

A Penrose Conference, "Fluid-Volcano Interactions," held October 4–9, 1992, at Kahneeta Resort, Warm Springs, Oregon, attracted 86 researchers representing 10 countries. Disciplines of attendees included volcanology, geochemistry, hydrogeology, geophysics, economic geology, and metamorphic petrology. Nearly all of the attendees study some aspect of the role of fluids in volcanic processes, and all wished to learn more about how other disciplines approach problems of mutual interest. The conference logo illustrates some of the relevant fluid-flow–related processes schematically; it borrows liberally from conceptual models of volcanic hydrothermal systems developed by R. W. Henley and W. E. Giggenbach, among others.

The conference opened with a half-day tutorial session in which representatives of several disciplines gave talks addressed to the other disciplines of the others in attendance. The goal was to create a framework for later interdisciplinary discussions. An effort was also made to mix disciplines in the subsequent topical sessions, which included lessons from fossil systems, sources of fluids and solutes, physical aspects of magma-water interaction, time-series observations, evolution of composite cones and their associated hydrothermal systems, history of hydrothermal systems in rift systems and calderas and their relation to eruptive history, and rapid transient processes. More than 35 papers on related topics were presented at a lively mid-week session. The conference concluded with a summary panel discussion.

Optional pre- and post-conference field trips took some of the attendees to Mount St. Helens (led by Bob Symonds, Bruce Christenson, and Don Swanson), the central Oregon Cascade Range (led by Dave Sherrod, Steve Ingebritsen, Terry Keith, and John Curless), and Christmas Lake Valley via Newberry volcano (led by Grant Heiken and Sherrod). Swanson and Sherrod also led an impromptu afternoon field trip in the Warm Springs area.

Prior to the conference, the conveners framed a preliminary list of questions to address. (1) What are the modes of heat and mass transfer from magma to the land surface? (2) What are the pressure, temperature, and fluid-saturation conditions between magma and the land surface? (3) What are the sources of fluids and solutes in volcanic systems? How can we distinguish their origins? (4) Can temporal variations in the discharge of "magmatic" components be related to eruptive cycles, and are there consistent precursory indicators? (5) How important is the role of meteoric water in eruption processes? Can we infer the volume and location of water sources through the study of deposits from explosive eruptions? How dependable is accelerated phreatic activity as an eruption precursor? (6) What controls the permeability of volcanoes? How does it vary in space and time? What role do temporal variations in permeability play in the evolution of volcanogenic hydrothermal systems? How important is intrusive-explosive eruptive activity to the creation of fracture permeability within a volcano? (7) How well coupled are various fluid flow, transport, and mechanical deformation processes? (8) Current numerical models cannot rigorously simulate the coupled problem of heat and fluid flow, solute transport, and deformation within a volcano. Do relatively simple models that simulate a subset of these processes provide useful insight into transport processes? (9) At what stage of model development, if any, will we be able to make useful predictions of eruptive behavior? What are the most important parameters to consider toward this end? (10) How can we evaluate hydrothermal systems in composite cones dominated near the surface by cold-water recharge?

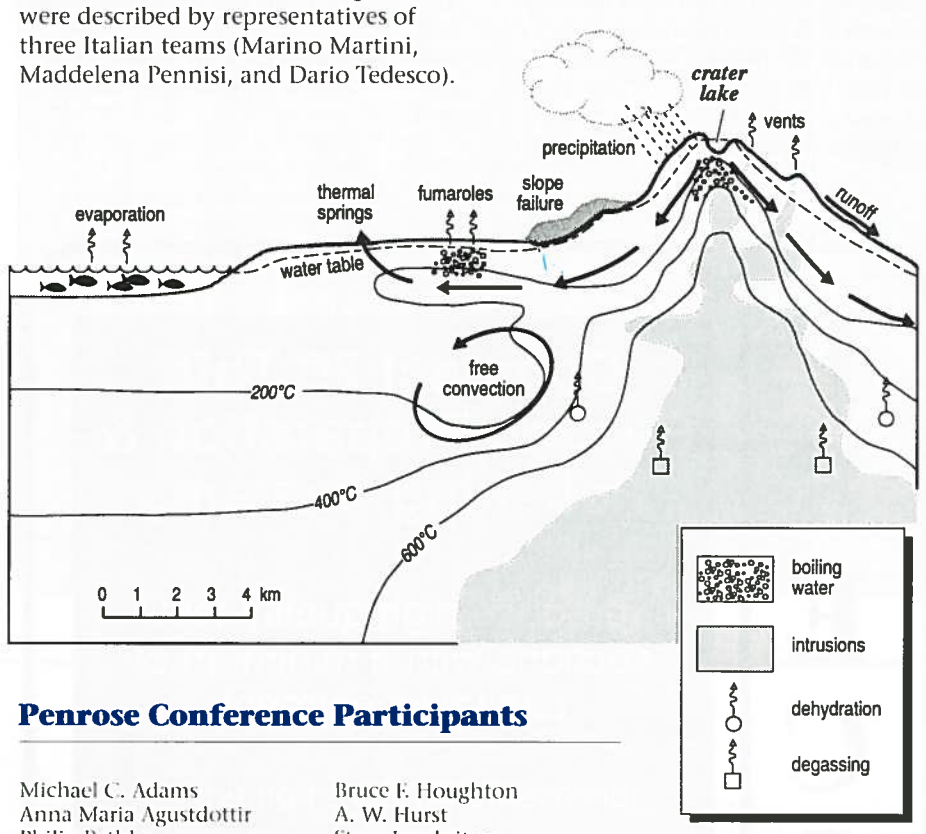
As might be expected, none of these broad questions was answered conclusively. However, some progress was made toward developing better defined, more tractable research questions. For instance, the first two questions deal with (1) modes of heat and mass transfer and (2) *P-T-x* conditions between magma and the land surface. Papers on the crater-lake systems at Poas (Gary Rowe, Geoff Brown, and David Stevenson) and Ruapehu (Tony Hurst and Bruce Christenson) were particularly relevant to these issues. For these systems, *rates* of heat and mass transfer are well constrained, but *modes* and thermodynamic conditions remain conjectural. it became apparent that heat and mass transfer across the magma–ground-water interface is quite poorly understood, in comparison to transport within the magma and ground-water systems proper. Claude Jaupart, as part of the last-day summary panel, noted that magma bodies are commonly invoked to supply heat and mass to hydrothermal systems, but that the actual mechanisms are poorly understood. (In his words: "Hydrothermal systems need magma bodies. But do magma bodies need hydrothermal systems?") Jaupart identified two research challenges: first, understanding the small-scale mechanisms for gas release, and second, determining the relative importance of continuous vs. intermittent processes.

Premeeting questions 7–9 dealt with the coupling of fluid flow and related processes, and the utility of numerical flow and transport models that simulate only a subset of the coupled processes. During the opening tutorial session, Craig Forster and Ingebritsen noted that, in practice, flow modelers generally use models describing two-phase pure-water systems at temperatures of 0–350 °C *or* single-phase pure-water systems at 0–1000 °C. Clearly, neither set of models is adequate to simulate a complete volcanic system, which would generally include multiphase flow in addition to extreme ranges in temperature (perhaps 0–1200 °C) and salinity (0–20 wt% NaCl). Some studies suggest that simulating a subset of coupled processes can be heuristically useful and can show qualitative agreement between simulated results and thermal or chemical data. However, the importance of the neglected processes is hard to estimate. In general, flow modelers do not incorporate realistic spatial and temporal variations in permeability into their models, and this creates something of a credibility gap between modelers-hydrogeologists and other groups that attempt to characterize subsurface flow—for example, the economic geologists and metamorphic petrologists. All groups recognize permeability as a primary parameter and are aware of the difficulty of quantifying permeability at any point in time, let alone the variation in permeability through time.

Some of the more contentious discussions were related to questions 3 and 4, regarding sources of fluid and solutes and the feasibility of monitoring for pre-eruption changes in fumarole or spring chemistry. Much discussion of fluid sources was initiated by Werner Giggenbach's evidence for a magmatic water component (∂D –20‰ ±10‰) in many circum-Pacific hydrothermal systems. Giggenbach suggested that some geothermal waters previously described as "oxygen-shifted" local meteoric waters should be reinterpreted as containing this magmatic component. Geochemical-monitoring efforts were described by representatives of three Italian teams (Marino Martini, Maddelena Pennisi, and Dario Tedesco). They presented unusually complete long-term time-series data from springs and fumaroles. Despite interesting correlations with magmatic activity, logistical problems seem formidable. It is expensive to acquire sufficient data and process it rapidly enough to be useful in a hazards-monitoring context, and it is difficult to separate magma-related changes from changes caused by climatic variables, fluctuations in ground-water levels, and other factors.

A primary goal of the conference was to increase interchange among the various disciplines, and there were indications of progress. During the summary panel presentation, geophysicist Roger Denlinger related Stan Williams's geochemically based estimates of clay-formation rates to models for large-scale deformation of volcanoes. Jeff Hedenquist emphasized the importance of integrating volcanic-gas and porphyry-copper fluid-inclusion data, to determine whether the high-temperature gas samples are representative of the magma. Bruce Taylor also emphasized the integration of data sets, for example by comparing glass inclusions, fumaroles, and deep fluids, or by using three-dimensional oxygen-isotope data and water-rock ratios to constrain flow models. Finally, Mike Sorey presented an explicit list of what flow modelers currently *can* do, *could* do (with help), and *cannot* do with respect to volcano problems.

Partial support for this conference was provided by the Geothermal Division of the U.S. Department of Energy and by the National Science Foundation. ■



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WASHINGTON REPORT

Bruce F. Molnia

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

Solid Earth Sciences and Society—What the Keck?

> The goal of the solid-earth sciences is to understand the past, present, and future behavior of the whole earth system. From the environments where life evolves on the surface to the interaction between the crust and its fluid envelopes (atmosphere and hydrosphere), this interest extends through the mantle and the outer core to the inner core. A major challenge is to use this understanding to maintain an environment in which the biosphere and humankind will continue to flourish.
>
> (Prologue of *Solid Earth Sciences and Society*, p. v and Executive Summary, p. 2)

Question: What do GSA, the American Association of Petroleum Geologists (AAPG), the Association of Earth Science Editors (AESE), the American Geological Institute (AGI), the American Institute of Professional Geologists (AIPG), the Society of Economic Geologists (SEG), the Society for Sedimentary Geology (SEPM), and the Society of Vertebrate Paleontology (SVP) have in common? Answer: Along with the W. M. Keck Foundation of Los Angeles, all are listed as having provided support for a National Research Council (NRC) comprehensive and critical review of the solid earth sciences entitled, *Solid Earth Sciences and Society,* released in late February. That's not a misprint! The last two words of the title are "and Society." That's correct: from its inception this review focused on societal concerns!

Other sources of support for the review, often called "the Keck report" by those involved in its preparation, were grants from the G. Unger Vetlesen Foundation, and the National Academy of Sciences Arthur L. Day and Maurice Ewing Earth and Planetary Science Funds. Unlike most NRC studies, no funds were provided by federal agencies for the completion of this study. The report "covers the workings of the whole Earth, concentrating on solid-earth processes and their influence on and interactions with human society" (p. xix).

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LOGITECH
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Solid Earth Sciences and Society (346 pages, $49.95) was prepared by the Committee on Status and Research Objectives in the Solid-Earth Sciences of the NRC Board on Earth Sciences and Resources. The committee, which consisted of 31 earth scientists, was chaired by Peter J. Wyllie of the California Institute of Technology. Considering the committee's composition, the report could have been prepared by GSA; 24 of the committee members are GSA Fellows and four are GSA Members. Only three members of the Committee have no affiliation with GSA. Thomas M. Usselman and Kevin C. Burke, both GSA Fellows, were the NRC staff representatives who directed the preparation of the report. Burke is the president of GSA's International Division.

The committee was charged with "preparing a comprehensive and critical review of the current state of the science, to identify opportunities for research during the coming decades, and to consider the issue of establishing priorities" (p. xvii). *Solid Earth Sciences and Society* is based on the assumption that "human societies face momentous decisions concerning their control of many future activities that require understanding the Earth.... Attaining that fundamental understanding is the primary objective of the solid-earth sciences. There are many major challenges facing solid-earth scientists as they serve societal needs" (p. 1–2).

To synthesize the vast body of earth science knowledge on specific societal issues, the committee formed 21 panels. Each prepared draft materials that served as input to the report. The panels, with their chairs (all committee members) were: Active Tectonics (Robert E. Wallace); Data Bases and Data Management (William J. Hinze); Dynamics and Evolution of the Core and Mantle (Raymond Jeanloz); Earth Surface Processes (Stanley A. Schumm); Energy Resources (John D. Haun); Geochemical Cycles (Robert A. Berner); Geochronology and Chronostratigraphy (Robert E. Zartman); Geologic Hazards (Clarence R. Allen); Global Collaboration (G. Arthur Barber); History of Life (Steven M. Stanley); Hydrology (John D. Bredehoeft); Instrumentation and Facilities (Larry W. Finger); Land Use and Geological Engineering (Allen W. Hatheway); Mineral Resources (Samuel S. Adams); Modeling (Donald L. Turcotte); Paleooceanography, Paleoclimatology, and Paleogeography (Judith T. Parrish); Physics and Chemistry of Earth Materials (Charles T. Prewitt); Professional Community (Marvin E. Kauffman); Remote Sensing (Alexander F. H. Goetz); Sedimentary Basins and Basin Analysis (Lee R. Russell); and Structure, Dynamics, and Evolution of the Lithosphere (Bruce R. Doe).

Solid Earth Sciences and Society has seven chapters, preceded by an "Executive Summary." Chapters 1 through 6, each beginning with a short, introductory, scientific essay, summarize different components of the solid earth.

Each chapter concludes with a presentation identifying research opportunities or recommendations. Facilities, equipment, and data-base needs are included as an integral part of each chapter. Chapter 1, "Global Overview," describes the present status of the solid-earth sciences. Chapter 2, "Understanding Our Active Planet," focuses on earth processes driven by internal heat. Chapter 3, "The Global Environment and Its Evolution," concentrates on erosion and deposition and the evolution of life on Earth. Chapter 4, "Resources of the Solid Earth," presents descriptions of water, energy, and mineral resources, and addresses the question of resource dependency. Chapter 5, "Hazards, Land Use, and Environmental Change," may have the most societal relevance, presenting information on geomorphic, tectonic, and extraterrestrial hazards, problems related to population dynamics, and concerns about global change. Chapter 6, "Ensuring Excellence and the National Well-Being," pulls together presentations on how solid-earth science is practiced, education, research, data gathering and handling, and international cooperation. Chapter 7, "Research Priorities and Recommendations," presents a summary of priorities, recommendations, research opportunities, facility requirements, and goals presented in the other chapters of the report.

Four *objectives* and five *research areas* are repeatedly presented throughout the report. The objectives are: "A. Understand ... the processes involved in the global earth system, with particular attention to the linkages and interactions between its parts (the geosphere); B. Sustain sufficient supplies of natural resources; C. Mitigate geologic hazards; D. Minimize and adjust to the effects of global and environmental change" (p. 3).

The five research areas furnish the "understanding needed to address" the objectives. They are: "I. Global paleoenvironments and biological evolution; II. Global geochemical and biogeochemical cycles; III. Fluids in and on the Earth; IV. Dynamics of the crust (oceanic and continental); and V. Dynamics of the core and mantle" (p. 3).

Solid Earth Sciences and Society combines the "objectives" and "research areas" in two ways: (1) in a 4 x 5 matrix to examine solid-earth science research; and (2) in a series of eight "priority themes" derived by "understanding the processes (Objective A) in each of the five research areas, plus the other three objectives" (p. 3).

Nineteen recommendations, grouped in three separate categories, are summarized in Chapter 7. There are eight research recommendations (each being a "priority theme"), eight general recommendations, and three education recommendations. Each recommendation is accompanied by text that provides background and additional rationale to support the recommendation. Each research recommendation is accompanied by a minimum of two additional high-priority topics. Only the primary recommendations in each category are presented below.

Research Recommendations

1 (Priority Theme A-I). There should be a coordinated thrust at understanding how Earth's environment and biology have changed in the past 2.5 million years.

2 (Priority Theme A-II). The earth sciences need to establish how global geochemical cycles have operated through time.

3 (Priority Theme A-III). The earth sciences need to take up the challenge of investigating the three-dimensional distribution of fluid pressure and fluid composition in Earth's crust.

4 (Priority Theme A-IV). There should be coordinated and intensified efforts to understand active crustal deformation.

5 (Priority Theme A-V). An integrated attack on solving the problem of understanding mantle convection is needed.

6 (Priority Theme B). A dense network of water quality and quantity measurements, including resampling at appropriate intervals, should be established as a basis for scientific advances.

Washington Report *continued on p. 125*

Washington Report *continued from p. 124*

7 (Priority Theme C). There should be an effort to define and characterize regions of seismic hazard.

8 (Priority Theme D). The earth sciences need to develop the ability to remediate polluted ground water on both local and regional scales, emphasizing microbial methods.

General Recommendations

1. There should be a major commitment to earth system science, emphasizing interrelations among all parts of Earth.

2. High priority should continue to be given to the best proposals from individual investigators.

3. The newest tools for data acquisition need to be made available for use in earth science research.

4. Opportunities for integration and use of observations and measurements from advanced space-borne instruments in solid-earth geophysics and geology should continue to be made available.

5. There is an essential need for the production and availability of interactive data banks on a national level within the earth sciences.

6. Efforts are needed to expand earth science education to all.

7. Research partnerships involving industry, academia, and government are encouraged to maximize our understanding of Earth.

8. Increased U.S. involvement in international cooperative projects in the solid-earth sciences and data exchange is essential.

Education Recommendations

1. Conventional discipline courses should be supplemented with more comprehensive courses in earth system science.

2. New courses need to be developed to prepare students for growth in both employment and research opportunities in areas such as hydrology, land use, engineering geology, environmental and urban geology, and waste disposal.

3. Colleges and universities should explore new educational opportunities (at both the undergraduate and graduate levels) that bridge the needs of the earth science and engineering departments.

Solid Earth Sciences and Society presents an excellent summary of the solid-earth sciences. It succeeds in bridging the enormous void between what geologists and geophysicists traditionally have done (frequently in an information vacuum) and what we must do now, not only to be relevant, but to survive as a profession in times of declining budgets and increasing competition for resources.

The NRC isn't the only group attempting to establish relevance for its discipline or its products. The U.S. Geological Survey (USGS) has just released "Societal Value of Geologic Maps" (Circular 1111), prepared by seven authors, which attempts to present a bridge between traditional geologic mapping and the information needed for informed public-policy decision making. Unlike most USGS publications, this one, which is available at no cost from the Survey (Map Distribution, Box 25286, Building 810, Denver Federal Center, Denver, CO 80225) is not aimed at a geological audience. Rather, by describing what geologic maps are, what scientific information they contain, why they are needed, and how they can be used, the USGS has targeted this circular at urban planners, public-sector officials, financial decision makers, and engineers.

Principal author Richard L. Bernknopf and his six coauthors present two case studies conducted for Loudoun County, Virginia, where benefits and costs of using geologic map information in site-selection procedures were evaluated. The two case studies, siting a large landfill and locating a new interstate-type highway route around Washington, D.C., both relied on an analytical geographic information system to evaluate potential locations and to derive a measure of resulting benefits.

The teaser on the title page of Circular 1111 describes its contents as "an economic analysis by the U.S. Geological Survey's National Geologic Mapping Program that describes (1) geologic maps and their use as a fundamental data base, (2) a rigorous benefit-cost model for valuing geologic map information, and (3) the economic issues associated with determining whether or not a geologic map is a public good." My analysis of the circular is that it, in itself, is most definitely a "public good" and that it is unquestionably good for the public! ■

Earth Sciences History Is Subject of Penrose Conference

A GSA Penrose Conference, From the Inside and the Outside: Interdisciplinary Perspectives on the History of the Earth Sciences, will be held in San Diego, California, March 19–21, 1994. The goal of the conference is to bring together people who write on the history of the earth sciences to discuss key methodological issues arising out of the different approaches taken in this field. A basic premise of the conference is that a deep schism separates the "insider" and "outsider" perspectives in the history of the earth sciences. The scientist-historian finds it difficult to comprehend how anyone who is not an earth scientist can grasp the history of the discipline without mastering it, or understand the internal dynamics of earth science research without taking part in it. Conversely, the historian of science is inclined to believe that scientists lack an appropriately historical outlook and have not learned how to frame historical questions or use historical materials. Scholars in other disciplines (e.g., sociology, philosophy) are also critical of earth scientists' efforts at humanistic interpretation of their own discipline.

Although there is some recognition of basic common interests between "insiders" and "outsiders," most observers realize that these constitute two distinct communities. The earth scientist–historians write primarily for other scientists, using the language and analytical forms of the sciences, and prefer to publish in scientific journals. Historians, sociologists, and philosophers use assumptions, methods, and terminology that may be unfamiliar to scientists, and they usually publish in their own professional journals. These divisions, while perhaps somewhat unavoidable, are currently deeper in the writing of history of the earth sciences than in the writing of the history of physics or of biology. This "insider-outsider" dichotomy is ironic, given that one of the primary purposes of historical investigation is precisely to bridge this gap. One recent authoritative restatement of this purpose, the National Academy of Sciences publication "On Being a Scientist" (1989), called for renewed attention to historical examination of science as a way of integrating social and personal values with the scientific process.

This Penrose Conference aims to assemble "insiders" and "outsiders" for robust and candid exchange on central issues in advancing historical understanding of the earth sciences. Emphasis will be placed on such issues as the purposes, methods, and analytical processes of research and presentation in the history of earth sciences, with participants from both sides gaining insight and appreciation of viewpoints different from their own. Prospective participants should include, of course, not only persons already actively engaged in research in the history of the earth sciences, but also others thinking of entering the field. Thus, graduate students and persons with recent Ph.D.s in the earth sciences or in history, philosophy, sociology, or other disciplines are particularly invited to apply (some financial support may be available to defray expenses).

If you would like to attend, please contact one of the co-conveners, who will send more detailed information and application materials. *The application deadline is November 1, 1993.* The co-conveners are: Léo F. Laporte, Earth Sciences Dept., University of California, Santa Cruz, CA 95064, (408) 459-2248, fax 408-459-3074, E-mail: laporte@cats.ucsc.edu; Naomi Oreskes, Earth Sciences Dept., Dartmouth College, Hanover, NH 03755, (603) 646-1420, fax 603-646-3922, E-mail: naomi.oreskes@mac.dartmouth.edu; and Kenneth L. Taylor, History of Science Dept., University of Oklahoma, Norman, OK 73019-0315, (405) 325-2213, fax 405-325-2363, E-mail: aa0214@uokmvsa.bitnet.

ODP Sets Sights on 1994 Science Plan

At the December 1992 meeting of the Ocean Drilling Program (ODP) Planning Committee, the science and engineering objectives for 1994 drilling were established.

The science plan was the result of a review process involving an international network of scientists. The program is focused thematically and driven by proposals from individual scientists and multidisciplinary groups of scientists. "The most successful proposals are ones that address high-priority scientific questions which can realistically be studied using the JOIDES Resolution," says Brian Lewis, chairman of the ODP Planning Committee. "Proposals must also show that the geographic area chosen to address the science theme is globally representative."

Expressions of interest or proposals for drilling are accepted at all times of the year and will be reviewed following January 1 and July 1 deadlines. Opportunities exist for shipboard participation and postleg data acquisition. ODP is a consortium of countries, led by the United States, with a broad mandate to drill in the world oceans. For more information or a free subscription to ODP's newsmagazine, the *JOIDES Journal,* contact JOIDES Office HA-30, University of Washington, Seattle, WA 98195, (206) 543-2203; Internet joides@ocean.washington.edu

Leg 153, MARK
November 29, 1993–January 24, 1994

To sample lower crust and upper mantle created at a slow-spreading ridge. Specific drilling targets include an exposed gabbro massif and a residual mantle section along strike to the south of the Gabbro.

Leg 154, Ceara Rise
January 29–March 26, 1994

To study the Cenozoic history of Atlantic deep-water circulation and southern-source deep water in an area where the two water masses converge. Study of carbonate dissolution along a bathymetric transect will provide information on the mixing of these water masses. The mixing influences the initial chemical and physical characteristics of the deep water that flows into the Indian and Pacific oceans.

Leg 155, Amazon Fan
March 31–May 26, 1994

To determine the lithology, facies, and age of several acoustic units comprising the Amazon Fan and their relation to sea-level change. The data will provide information on the terrestrial paleoclimate, western equatorial Atlantic paleocurrents, and regional tectonic influences, such as Andean uplift, on fan sedimentation.

Leg 156, North Barbados Ridge
May 31–July 26, 1994

To drill and log five holes along a transect. The holes will be cased and sealed, using a special borehole seal, in order to measure fluid flow along the decollement. This will yield information on the dynamics of deep-source fluids, tectonic features, and geochemical signatures in the decollement zone.

Leg 157, Engineering
July 31–September 25, 1994

To test the diamond coring system and in particular the secondary heave compensation system. The test will take place on the Vema Fracture Zone. Drilling is expected to take place on the median ridge, starting in the limestone cap.

Leg 158, TAG
September 30–November 25, 1994

To characterize the fluid flow, geochemical fluxes, and associated alteration and mineralization and to investigate the subsurface nature of an active hydrothermal system at a slow-spreading ridge. The data should provide an analogy for modern land-based mineral deposits of similar sea-floor origin. ■

Call for Committee Service—1994

The GSA Committee on Committees wants your help. The committee is looking for potential candidates to serve on committees of the Society or as GSA representatives to other organizations. You can help by volunteering yourself or suggesting the names of others you think should be considered for any of the openings and submitting your nomination on the form on page 127. Younger members are especially encouraged to become involved in Society activities.

Listed below are the number of vacancies and a brief summary of what each committee does and what qualifications are desirable. If you volunteer or make recommendations, please give serious consideration to the special qualifications for serving on a particular committee. *Please be sure that your candidates are Members or Fellows of the Society and that they meet fully the requested qualifications.*

Volunteering or Making a Recommendation

All nominations received at headquarters by **July 15, 1993,** on the official one-page form will be forwarded to the Committee on Committees. *Council requires that the form be complete.* Information requested on the form will assist the committee members with their recommendations for the 1994 committee vacancies. Please use one form per candidate (additional forms may be copied). The committee will present at least two nominations for each open position to the Council at its October 27 meeting in Boston, Massachusetts. Appointees will then be contacted and asked to serve, thus completing the process of bringing new expertise into Society affairs.

Committee on Committees

The 1993 committee consists of the following people: Chairman **Gordon P. Eaton,** Lamont-Doherty Geological Observatory, Columbia University, Palisades, NY 10964-1090, (914) 365-8348; **David M. Cruden,** Department of Civil Engineering, University of Alberta, Edmonton, Alberta, Canada T6G 2G7, (403) 492-5923; **Richard H. Groshong, Jr.,** Department of Geology, Box 870338, University of Alabama, Tuscaloosa, AL 35487-0338, (205) 348-1882; **Mary J. Kraus,** Department of Geological Sciences, Campus Box 250, University of Colorado, Boulder, CO 80309-0250, (303) 492-7251; **Richard J. Moiola,** Mobil E & P Technical Center, P.O. Box 650232, Dallas, TX 75265-0232, (214) 951-3252; **Stephen G. Wells,** Department of Earth Sciences, University of California, Riverside, CA 92521, (909) 787-4367.

Council wishes to acknowledge the many member-volunteers who, over the years, have stimulated growth and change through their involvement in the affairs of the Society.

Each year GSA also asks for volunteers to serve on committees, and many highly qualified candidates express their willingness to serve. Not everyone can be appointed to the limited number of vacancies; however, members are reminded that there are also opportunities to serve in the activities and initiatives of the sections and divisions. Annually, Council asks sections and divisions to convey the names of potential candidates for committee service to the Committee on Committees. The Southeastern and South-Central Sections have diligently responded to this call.

Committees and Qualifications

Continuing Education **(2 vacancies)**
Will direct, advise, and monitor the Society's continuing education program, review and approve proposals, recommend and implement guideline

continued on p. 127

GSA Sections and Divisions—1993

SECTIONS

GSA has six regional North American sections, generally including GSA members who live within the geographical limits of each section. (Members who live in one section but have a professional interest in another section can become members of the section of interest.) Each section holds annual technical and business meetings. The number of voting members shown for each section is as of December 31, 1992.

Cordilleran Voting members: 3812
Geographic area: Alaska, Arizona south of lat 35°N, California, Hawaii, Nevada, Oregon, Washington, British Columbia, Yukon, Northwest Territories.
Officers: [To be elected], chairman; [To be elected], vice-chairman; [To be elected], secretary; Richard A. Schweickert, past chairman.

Rocky Mountain Voting members: 1836
Geographic area: Arizona north of lat 35°N, Colorado, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming, Alberta, Saskatchewan.
Officers: Douglas C. Brew, chairman; Robert W. Blair, Jr., vice-chairman; Kenneth E. Kolm, secretary; Walter S. Snyder, past chairman; Craig M. White, past vice-chairman.

North-Central Voting members: 1294
Geographic area: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, Ohio, Wisconsin, Manitoba, Ontario west of 89th meridian.
Officers: Alan E. Kehew, chairman; Ronald B. Chase, vice-chairman; George R. Hallberg, secretary; Richard D. Hagni, past chairman; Eva B. Kisvarsanyi, past vice-chairman.

South-Central Voting members: 1338
Geographic area: Arkansas, Kansas, Oklahoma, Texas.
Officers: John A. Breyer, chairman; Philip L. Kehler, vice-chairman; Rena M. Bonem, secretary-treasurer; Hans G. Avé Lallemant, past chairman.

Northeastern Voting members: 2150
Geographic area: Connecticut, Deleware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, New Brunswick, Newfoundland, Nova Scotia, Prince Edward Island, Quebec, Ontario east of 89th meridian.
Officers: Sandra M. Barr, chairman; Stephen G. Pollock, vice-chairman; Kenneth N. Weaver, secretary; James M. McLelland, past chairman.

Southeastern Voting members: 1578
Geographic area: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia.
Officers: Molly Fritz Miller, chairman; Lynn Glover, III, vice-chairman; Michael J. Neilson, secretary-treasurer; William A. Thomas, past chairman; James F. Tull, past vice-chairman.

DIVISIONS

GSA's twelve specialty divisions provide a focus for members interested in a particular discipline. The divisions hold annual business meetings in conjuction with the Society's Annual Meeting, and each division publishes a newsletter periodically. Division membership totals are as of December 31, 1992.

Archaeological Geology Members: 425
Officers: Bonnie A. Blackwell, chairman; Henry P. Schwarcz, first vice-chairman; Margaret J. Guccione, second vice-chairman; C. Reid Ferring, secretary-treasurer; E. Arthur Bettis III, past chairman.
Newsletter editor: Vance T. Holliday.

Coal Geology Members: 302
Officers: Robert A. Gastaldo, chairman; Alan Davis, first vice-chairman; James C. Hower, second vice-chairman; Cortland F. Eble, secretary; Timothy A. Cross, past chairman.
Newsletter editor: Cortland F. Eble.

Engineering Geology Members: 1028
Officers: Jerome V. DeGraff, chairman; Rhea L. Graham, chairman-elect; John D. Rockaway, secretary; Charles W. Welby, past chairman.
Newsletter editor: John R. Giardino.

Geophysics Members: 453
Officers: Richard G. Gordon, chairman; Lawrence L. Malinconico, Jr., first vice-chairman; John W. Geissman, second vice-chairman; G. Randy Keller, secretary-treasurer; Laura F. Serpa, past chairman.
Newsletter editor: Laura F. Serpa.

Geoscience Education Members: 386
Officers: Dorothy L. Stout, acting chairman and first vice-chairman; Whitman Cross II, second vice-chairman; Stephen H. Stow, secretary-treasurer.
Newsletter editor: Dorothy L. Stout.

History of Geology Members: 284
Officers: Samuel T. Pees, chairman; Joanne Bourgeois, first vice-chairman; Robert N. Ginsburg, second vice-chairman; William M. Jordan, secretary-treasurer; Donald M. Hoskins, past chairman.
Newsletter editor: William M. Jordan.

Hydrogeology Members: 1846
Officers: Franklin W. Schwartz, chairman; Leonard F. Konikow, first vice-chairman; Donald I. Siegel, second vice-chairman; John F. Harsh, secretary-treasurer; John A. Cherry, past chairman.
Newsletter editor: Alan R. Dutton.

International Members: 302
Officers: Kevin Burke, president; Bruce Molnia, first vice-President; Pinar Oya Yilmaz, second vice-president; John S. Oldow, secretary-treasurer; Brian J. Skinner, past president.

Planetary Geology Members: 368
Officers: Harry Y. McSween, Jr., chairman; George E. McGill, first vice-chairman; Odette B. James, second vice-chairman; Larry S. Crumpler, secretary-treasurer; Baerbel K. Lucchitta, past chairman.
Newsletter editor: Larry S. Crumpler.

Quaternary Geology and Geomorphology Members: 1317
Officers: Stephen G. Wells, chairman; Parker E. Calkin, first vice-chairman; Steven M. Colman, second vice-chairman; Deborah R. Harden, secretary-treasurer; David M. Mickelson, past chairman.
Newsletter editor: Richard B. Waitt.

Sedimentary Geology Members: 939
Officers: Cathy J. Busby, chairman; Norman D. Smith, first vice-chairman; Rudy L. Slingerland, second vice-chairman; Gordon S. Fraser, secretary-treasurer; Timothy F. Lawton, past chairman.
Newsletter editor: Robert K. Suchecki.

Structural Geology and Tectonics Members: 1825
Officers: Jan A. Tullis, chairman; Richard H. Groshong, Jr., first vice-chairman; Edward C. Beutner, second vice-chairman; Donald T. Secor, Jr., secretary-treasurer; Darrel S. Cowan, past chairman.
Newsletter editors: Gregory A. Davis, Scott R. Paterson. ■

Service *continued*

changes, and monitor the scientific quality of courses offered.

Committee members should be familiar with continuing education programs or have adult education teaching experience.

Day Medal (2 vacancies)
Selects candidates for the Arthur L. Day Medal.

Committee members should have knowledge of those who have made "distinct contributions to geologic knowledge through the application of physics and chemistry to the solution of geologic problems."

Education (1 vacancy)
Stimulates interest in the importance and acquisition of basic knowledge in the earth sciences at all levels of education.

Committee members work with other interested scientific organizations and science teachers' groups to develop precollege earth-science education objectives and initiatives. The committee also promotes the importance of earth-science education to the general public.

Geology and Public Policy (3 vacancies)
Translates knowledge of the earth sciences into forms most useful for public discussion and decision making.

Committee members should have an awareness of public policy and decisions involving the science of geology. They should also be able to develop, disseminate, and translate information from the geologic sciences into useful forms for the general public and for the Society membership; they should be familiar with appropriate techniques for the dissemination of information.

Honorary Fellows (2 vacancies)
Selects candidates for Honorary Fellows, usually non–North Americans.

Committee members should have knowledge of geologists throughout the world who have distinguished themselves through their contributions to the science.

Membership (2 vacancies)
Screens Member and Fellow applications; evaluates membership benefits and makes recommendations to the Council about them.

Committee members must be GSA Fellows and must be able to attend one meeting a year. Previous experience in recruitment programs and in the evaluation of professional qualifications is desired.

Minorities and Women in the Geosciences (Vacancies to be determined)
Stimulates recruitment and promotes positive career development of minorities and women in the geoscience professions.

Committee members should be familiar with minority and female education and employment issues and have expertise and leadership in such areas as human resources and education. Membership shall include representation of minorities and women and representatives from government, industry, and academia.

Nominations (5 vacancies; one position for a member from Canada or Mexico)
Recommends to the Council nominees for the positions of GSA officers and councilors.

Committee members should be familiar with a broad range of well-known and highly respected geological scientists.

Penrose Conferences (1 vacancy)
Reviews and approves Penrose Conference proposals; recommends and implements guidelines for the success of the conferences.

Committee members must either be past conveners or have attended two or more Penrose Conferences.

Penrose Medal (2 vacancies)
Selects candidates for the Penrose Medal.

Committee members should be familiar with outstanding achievements in the geological community that are worthy of consideration for the honor. Emphasis is placed on "eminent research in pure geology which marks a major advance in the science of geology."

Research Grants (3 vacancies)
Evaluates research grant applications and selects grant recipients.

Committee members must be able to attend the spring meeting and should have experience in directing research projects and in evaluating research grant applications.

Young Scientist Award (Donath Medal) (1 vacancy)
Selects candidates for the Donath Medal.

Committee to have members covering a broad range of disciplines, i.e., geophysics, economic geology, stratigraphy, etc.

Committee members should have knowledge of young scientists with "outstanding achievement(s) in contributing to geologic knowledge through original research which marks a major advance in the earth sciences."

Joint Technical Program Committee GSA Representatives-at-Large (2 vacancies)
Supervises the review of abstracts for papers to be presented at the GSA annual meeting.

Representatives-at-large should be specialists in either petroleum geology or marine geology, and must be able to attend a meeting in August. These subdisciplines are not represented by any of the associated societies or GSA divisions.

GSA Representative to the North American Commission on Stratigraphic Nomenclature (1 vacancy)
Must be familiar with and have expertise in stratigraphic nomenclature.

GSA Representative to the American Association for the Advancement of Science (AAAS) (2 vacancies)
Section E, Geology and Geography, and Section W, Atmospheric and Hydrospheric Sciences

Must be members of AAAS who will be attending the AAAS meetings under other auspices; term February 23, 1994 to February 23, 1997. ■

NOMINATION FOR GSA COMMITTEES FOR 1994

(One form per candidate, please. Additional forms may be copied.)

(Please print)

Name of candidate _____

Address _____

_____

Phone ( ) _____

COMMITTEE(S) BEING ☐ VOLUNTEERED OR ☐ NOMINATED FOR (please check):

Committee(s):

Comment on special qualifications:

☐ GSA Fellow
☐ GSA Member

Section affiliation:
Division affiliation(s):

Brief summary of eduction:

Brief summary of work experience (include scientific discipline, principal employer—e.g., mining industry, academic, USGS, etc.):

If you are VOLUNTEERING to serve GSA, please give the name of 2 referees/references (please print):

Name: _____

Phone: ( ) _____

Name: _____

Phone: ( ) _____

If you are NOMINATING SOMEONE other than yourself to serve GSA, please give your name, address, and phone number (please print):

Name: _____

Address: _____

_____

Phone: ( ) _____

DEADLINE: Please return this form to headquarters by July 15, 1993. Form must be complete to be considered. Mail to GSA Executive Director, P.O. Box 9140, Boulder, CO 80301.

"What Happened to My Abstract?"

Sue Beggs, GSA Meetings Manager

Did you ever wonder what happens to your abstract after you submit it to GSA? Most authors are satisfied with the confirmation of a date, time, and place, and they know the system works for them. Other authors are puzzled about the results. "Why did I get Thursday afternoon—again?" "Why am I in an engineering session when I submitted my abstract to geophysics?" "Why is my paper separate from the theme session to which it was submitted?" "Why did I get a poster session?" "Why was my abstract rejected?"

Especially in these times of theme sessions and other changes within the technical program, this explanation might help you clear the hurdles and avoid going in the wrong direction.

INVITED ABSTRACTS

When an abstract enters the GSA system as an invited paper for a symposium, the paper is reviewed by the convener, and 99% of the time it is accepted as submitted. The convener puts the paper in an order within the time allotted for the symposium and sends the list to GSA. The time, date, and place of the symposium have been determined by the convener, the sponsoring organization, and the technical program chairs.

VOLUNTEERED ABSTRACTS

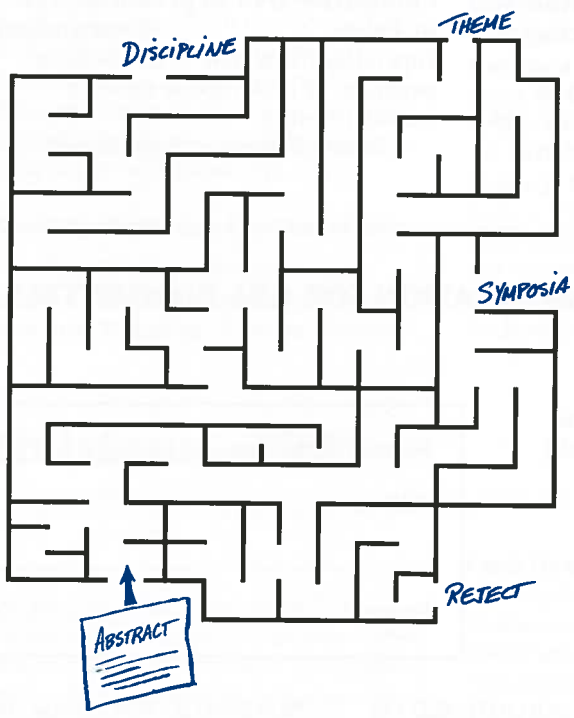
For Theme Sessions

When an abstract enters the GSA system as a volunteered abstract, its destination and disposition are not as predictable. This is usually the place where authors lose contact with the process. In GSA's system, there are only two kinds of abstracts: invited and volunteered. *All abstracts not submitted as invited papers are volunteered, including those papers submitted for theme sessions.* Their disposition and final destination are determined by reviewers (3 or 4 per abstract), the Joint Technical Program Committee (JTPC) representative handling that discipline, the technical program chairs, and possibly a theme advocate.

Reviewers' ratings and comments are given to the JTPC representative. She/he has a stack of ratings and abstracts—sometimes as many as 150 in a discipline. If the abstract was submitted to a theme session, the abstract, together with all other abstracts for that theme session, are grouped together—regardless of scientific discipline.

Then the abstracts are assembled into a coherent session by someone from the JTPC who has been appointed to coordinate the session. NOTE: The theme advocate is NOT this person. Contrary to popular perception, the theme advocate is hundreds of miles away at home or in the field—or on vacation. Unlike a symposium convener, the theme advocate does NOT control the final selection or order of papers. In fact, the theme session process was set up to avoid such control. The advocate does have a lot of influence, however. In the theme session process, the advocate's cover letter with preferences regarding abstract order is given considerable weight.

Sometimes, however, an abstract shows up that is a perfect fit with a theme session. One of the representatives brings this to the attention of the JTPC theme coordinator, and presto!, there is a new paper in the session. This may mean that another paper with less enthusiastic reviews or less ideal fit is not included in the theme session. The theme coordinator is supposed to inform the advocate when changes happen, but the theme coordinator has the final word.



For Discipline Sessions

Once the theme abstracts are settled in the right place, the rest of the abstracts continue on the road to their destinations. This includes abstracts that started out as theme abstracts but were eliminated from the theme for one reason or another. The good news is that this theme abstract gets a *second chance,* in another session—provided, of course, that on the basis of the ratings it was an acceptable abstract from the beginning.

With the abstract in the hands of the representative responsible for its discipline, the abstract is assembled with others on a similar topic. Although it may not seem like it sometimes, every effort is made to develop coherency within the program. Abstracts assembled this way are usually given a title. The theme abstracts start out with a title *before* the JTPC meets, whereas the discipline abstracts acquire a title *during* the selection process.

REASONS FOR REJECTION

So now we know the path the abstracts take as they move from symposia, theme, and discipline destinations, but some abstracts never make it at all. Why not? Aside from negative reviews, which could be the obvious reason, there are some administrative reasons that are not so obvious. The first—and primary—reason is that authors forget that they can submit only ONE volunteered paper as the speaker. The rule is on the abstract form, but not everyone reads it. The reason for the rule is that scheduling 2000 papers is a formidable task, and avoiding conflicts in a single author's schedule is just one step too many.

Currently GSA policy is that if an author submits more than one paper on which she/he is the speaker—and this includes theme sessions—only one will be considered. The other(s) will be rejected. In the future, it may be decided that only one volunteered OR one invited abstract will be accepted. Another scenario under consideration is that any authors as speakers submitting more than one abstract of *any format* will find that ALL of those abstracts have been rejected automatically.

Another reason an abstract doesn't make it is that the author elects to withdraw the paper if it cannot be accepted in the author's preferred mode—oral or poster. This, of course, is the author's option. The abstract might have been accepted as grouped in a poster session, but is not, because of author preference.

POSTER MODE

"Why did my paper become a poster?" Poster papers go through the same selection process as all other abstracts. There are the same review and selection standards. It is a fact, however, that it is easier to add more poster booths than it is to add meeting rooms. Anyone who has worked on section meetings or annual meetings understands this issue very well. If there are many abstracts submitted for a given year, the technical program chairs may put all the papers for which the author has indicated "either Oral or Poster" into the Poster category in order to maximize the opportunity to accept abstracts. The goal is to *accept* abstracts, not to reject them.

In other cases, the paper just fits best with the group of abstracts being presented as posters—or, conversely, has no fit with an oral session, and is more of a loner—a unique creature that needs a place of its own.

DATE, TIME, PLACE

The final question is usually, "Why is my abstract scheduled at this particular time?" The mysteries surrounding the technical program schedule are manifold to the outside person who has not been involved with a JTPC. Once you have been involved, however, you know that the schedule is the best blend possible, given the participation of 22 organizations. Yes! Twenty-two organizations hold their annual meetings and technical sessions at a GSA Annual Meeting. That's what a GSA program is. Only through GSA's divisions and associated societies does the program take shape.

Because most of the 22 groups want their programs on Monday and Tuesday, which is clearly impossible, some accommodation must take place to meet the needs of these groups and the number of abstracts submitted. This is the primary job of the technical program chairs. They do not review, select, nor order abstracts. In fact, they do not usually see the abstracts at all. They could, but they have no role relative to individual abstracts. Their main role is to pull together sessions in an acceptable way without unacceptable overlap—a very tough hurdle indeed.

The first part of the schedule is established for symposia because they are the most predictable. The GSA divisions and associated societies are given two opportunities in the spring to assist the technical program chairs in determining the symposia schedule. After that, theme sessions are *tentatively* scheduled around the symposia—*tentatively* because some theme sessions do not receive enough abstracts to make a two-hour session (eight papers), and are, therefore, eliminated. The abstracts, however, continue on to discipline sessions.

This way of scheduling makes sense because the *topics* for symposia and theme sessions are *known in advance,* whereas other session topics are developed only during the JTPC meeting. After these two session types are in place, the discipline sessions are roughed in on the basis of a ten-year history of the number of abstracts submitted for each of the scientific categories. After the abstracts deadline, this schedule is adjusted for reality and used as the starting schedule for the JTPC.

During the JTPC meeting, sessions come and go. Some conflicts are identified. Some abstracts are located in sessions other than the one to which they were submitted. Trades of dates and rooms take place among the representatives. Several iterations of the schedule are developed. Finally, by Saturday afternoon, after two days of deliberation, a final schedule is produced.

After the schedule is set, it takes close to ten working days to input the results, to print, to proof, and to mail the acceptance cards (and rejection letters). From this point the author index and speaker and title reports are produced and proofed. At last, the abstracts are pasted up in chronological order and sent to the printer.

By this time, an author has received an acceptance (or rejection) card and calls to ask if a change can be made. As much as all of us would like to accommodate the author at this point, the program has been cast in concrete—a monument to ten months of work on the part of the technical program chairs, who have done their best to represent the interests of all the organizations in a fair and balanced way.

If you have a question about the system and how it works, please contact Sue Beggs, Meetings Manager. Remember that the abstract deadline for 1993 is July 7. We sincerely hope the system works for you this year. ■

ABSTRACT DEADLINE: JULY 7

BOSTON

1993
GSA ANNUAL MEETING
OCTOBER 25–28
BOSTON, MASSACHUSETTS

Come to Boston

James E. MacNeil

Boston is a city built on history. It was established in 1630, after the Pilgrims arrived and settled at Plymouth, Massachusetts, in 1620. Eventually, it grew to become the capital of Massachusetts, as well as the largest city in New England.

From dining and arts to shopping and the sights, Boston is a world in itself. Each section of this renowned city is easily accessible by the T, Boston's rapid transit system, which connects all major areas of interest. All sections of Boston have their own unique characteristics, which make them attractive to visitors and residents alike. If shopping is your goal, try Faneuil Hall, Copley Place (near the convention hotels), or Newbury Street for a variety of shopping experiences. Hungry? There are eating establishments in Boston to suit all tastes. Visitors from around the world discover Boston's history, culture, and beauty and take back with them some of the most educational and rewarding experiences of their lives.

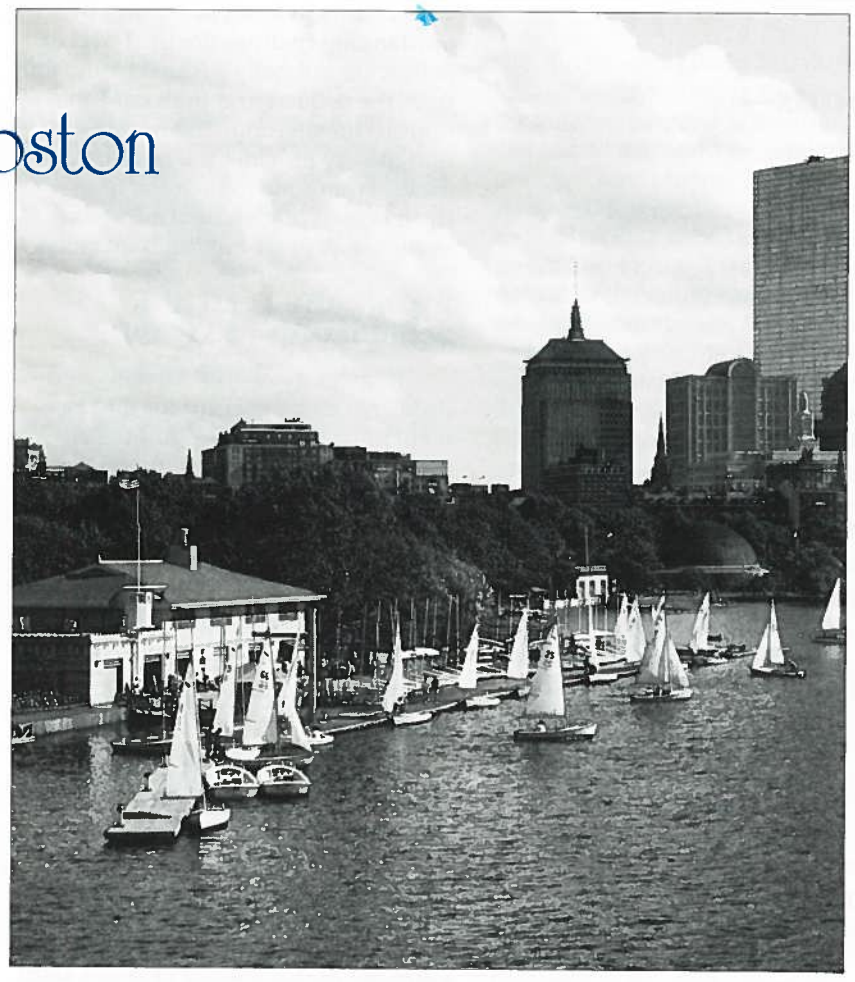


Photo courtesy of Boston Convention and Visitors Bureau, Inc.

Boston is separated into sections, known for their distinctive attributes:

Beacon Hill is a slant of red brick townhouses and cobblestone streets nestled together on a hill. It was originally 60 feet higher then it is now, and it took its name from a beacon constructed by residents to warn colonists of enemy approach.

Back Bay was originally under water, part of the Charles River. Gradually filled in, Back Bay boasts a variety of shopping areas, including Newbury Street and Copley Place, which house high-fashion designer shops as well as other specialty stores. Both the John Hancock Building and Prudential Tower offer a breathtaking panorama of Boston.

The **Cultural District** provides entertainment galore, including drama, comedy, ballet, opera, and Broadway shows in its many theaters and auditoriums.

The Fenway is home to the Boston Red Sox, the Museum of Fine Arts, Symphony Hall, and Harvard Medical School.

Chinatown is the third largest Chinese neighborhood in the United States. Fine restaurants and exotic shops are located here.

The Waterfront is a wonderful place to get a wide-angle view of the harbor, as well as to visit its restaurants and museums. The New England Aquarium, Children's Museum, and the Boston Tea Party Ship are here.

The **North End** is famous for homemade pizza, pasta, bread, and other delicacies reminiscent of Old Italy. The North End is also known for Paul Revere's house and the Old North Church, landmarks on the Freedom Trail.

Nightlife

There is much to offer in terms of nightlife in Boston. Whether you are in the mood to laugh, cry, dance, or socialize, there are plenty of places to satisfy every mood. There are performances in music, comedy, dance, and theater.

Laugh yourself silly at any one of the comedy clubs in town: Catch a Rising Star, the Comedy Connection, Dick Doherty's Comedy Vault, or Nick's Comedy Stop.

Dance the night away at Nightstage, the Roxy, Zanzibar, the Gallery, or the Hub Club, to name a few.

Musical cravings can be satisfied by listening to the Boston Symphony Orchestra, which performs at Symphony Hall. Other forms of listening enjoyment are the Opera Company of Boston, the Boston Concert Opera, and the Handel and Haydn Society, the oldest choral group in the country.

Dance and theater, integral parts of Boston's culture, are performed at many halls and theaters around the city. The world-famous Boston Ballet performs modern choreography as well as favorite classics. There are also many modern dance companies in the city. Popular long-running theater performances in Boston include "forbidden Broadway," which satirizes Broadway hits, and "Shear Madness," a comedy who-dun-it and Boston's longest running play, now in its 12th year.

Bravo Boston GSA Chorale

Tuesday, October 26

This year one of the special events for the GSA Annual Meeting is indeed very special. Many of you may recall the performance by the 1988 GSA Centennial Orchestra of geologists in Denver, heard on National Public Radio. A past president of GSA wrote these words about the performance: "...the audience 'exploded' as the last chord of the final march died away. Around me, people leaped onto chairs, cheering, many saying 'quite incredible' and 'unbelievable,' sentiments that I shared to the full." Well, once again musical geologists will have the opportunity to come together, this time in a dazzling choral performance in Boston, where the musical arts are a thriving part of the city's culture. Don't miss the excitement on Tuesday evening!

The performance will take place in the acoustically renowned Jordan Recital Hall, an intimate and cherished hall, treasured for its turn-of-the-century architecture and widely used by recording companies and famous artists. The hall is on the campus of the New England Conservatory of Music, an easy 10-minute walk from the Hynes Convention Center. The Bravo Boston GSA Chorale will perform the melodic and moving Mozart Requiem, popularized in the film *Amadeus*, with a professional orchestra and conductor. In addition, the performance will include two double concertos by Vivaldi, featuring your musical colleagues as soloists. This is an evening not to be missed!

For those wishing to sing with the Bravo Boston GSA Chorale, contact Holly Stein, U.S. Geological Survey, MS 981, National Center, 12201 Sunrise Valley Drive, Reston, VA 22092, (703) 648-5326. You must be an active accomplished singer who reads music. Spouses and guests are also welcome.

For those wishing to attend this very special performance, ticket purchase in advance is highly recommended. Seating is limited, and given the sell-out performance by the GSA Centennial Orchestra, a ticket purchase with your meeting preregistration assures you a seat. You won't want to miss the excitement!

Win a FREE TRIP

Make your Boston reservations through **Cain Travel Group** and become eligible to win one round-trip ticket on United Airlines anywhere within the contiguous United States. The drawing will be held November 15, 1993. **Cain Travel Group,** GSA's official travel agent, guarantees the lowest possible fares for the Boston Annual Meeting. For discounts, convenience, and fast service, call:

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CORRECTION: In the April issue of *GSA Today,* we incorrectly stated that *Boston College* evolved from Weston College Seismological Laboratory. The correct statement is that ***Weston Observatory*** evolved from the Weston Seismological Laboratory.

Our apologies to our friends at Boston College and the Weston Observatory.

GSAF UPDATE

Robert L. Fuchs

The Foundation's Special Funds—Is There One for You?

The GSA Foundation is the keeper of money that is used in support of GSA programs. These dollars reside in 37 funds, which can be broadly grouped into four categories. There are seven funds that support major activities of the Foundation and the Society—GEOSTAR, IEE, SAGE, Publications, Research Grants, Operating, and Unrestricted. Two funds have been important in the past, but the goal of each has been achieved and the funds are in the liquidation mode. These are Century Challenge and DNAG. Five funds are restricted as to purpose and categorized as fully funded and closed to further contributions. These are the Gladys and Storrs Cole Funds, 28th IGC, Rocky Mountain Coal Symposium, and Young Scientist Award.

Finally, the Foundation's endowment has 23 restricted or special-purpose funds that are open to receive contributions and from which disbursements are made out of income (and in some cases principal) to finance GSA programs. A few of these funds are described in the following paragraphs along with an approximate current fund balance. Perhaps one of these funds has particular appeal to you, as a contributor or an award recipient.

Birdsall Award—$34,000

A $10,000 bequest from the estate of John Birdsall in 1976 was the basis for this fund, which is under the supervision of the Hydrogeology Division. Birdsall was the donor of the Birdsall Bowl, which travels each year with the current O. E. Meinzer Award. The fund supports the purchase of a smaller replica of the bowl which is given to each recipient to keep. Recurrent expenses—engraving, refurbishing, transportation, and replicas—are paid from bequest income. The Birdsall Distinguished Lecturer Series was established to provide an annual series of lectures by an outstanding hydrogeologist. Travel expenses are normally covered by income from the bequest and from contributions to the division. The host institution usually provides the housing and meals. From time to time the fund is the recipient of memorial gifts given in the name of past division members.

Antoinette L. Medlin Scholarship—$31,000

In memory of Toni Medlin, who dedicated many years to the advancement of coal geoscience and the encouragement of students of coal geology. Currently awarded each year at the $1500 level, with possible follow-on stipends, the Medlin Scholarship money can be used to pay expenses essential to the successful completion of the awardee's research project.

Allan V. Cox Award—$10,000

Established by GSA's Geophysics Division in 1988, this fund is named after the 1975 Day medalist whose career work in geophysics, particularly in paleomagnetics, had an important effect upon the concepts of plate tectonics. The award is given annually, currently in the amount of about $600, as part of a grant in response to an outstanding research proposal from a graduate student.

Cady Award—$28,000

The Gilbert H. Cady Memorial Fund, set up in 1971, supports an award presented yearly for an outstanding contribution to coal geology. The awardee receives an inscribed sterling silver tray and a certificate. Granting of this award is under the auspices of the Coal Geology Division, of which Gilbert Cady was a key founder.

Claude C. Albritton, Jr., Memorial—$5000

Newer than the preceding funds, the Albritton Memorial was created in 1991 by friends, family, and close associates of Claude C. Albritton, Jr. The fund will provide scholarships and fellowships for graduate students in earth sciences and archaeology. Awardees can be at either the M.S. or Ph.D. level, and must have an interest in pursuing a career in teaching or research. The funds are to be spent in support of thesis or dissertation research, particularly on field or laboratory work. ■

Donors to the Foundation, February 1993

History of Geology Award Fund
Kennard B. Bork
Robert H. Dott, Jr.

Hydrogeology Division Award Fund
John M. Sharp, Jr.

GEOSTAR FUNDS

Allan V. Cox Student Research Fund
Scott C. Reeve

Doris M. Curtis Memorial
Janet M. Aitken
Robert H. Dott, Jr.
Ranaye Dreier
Robert N. Ginsburg
Scott C. Reeve

John T. Dillon Alaska Scholarship
Stephen E. Box
David J. Harding
Andrew J. Meigs

Stephen E. Dwornik Planetary Geoscience Student Paper Award
Joseph M. Boyce

Geostar
Robert M. Cassie
Ronald K. DeFord
Ross L. Kinnaman
Joseph L. Weitz

Institute for Environmental Education
Peter Robinson

Antoinette Lierman Medlin Scholarship
Bruce R. Doe
E. A. Noble

Minority
Neely H. Bostick
Michael L. Fellows
Robert B. MacNaughton
Jeffrey K. Miller
Jay F. Piper

Operating
Eugene Cameron

Research
Thomas L. Annaratone
M. F. Bickford
Charles V. Fulmer
William T. Holser
Y. W. Isachsen
G. Duncan Johnson
Maureen P. Leshendok
Karen M. Love
Harmon D. Maher, Jr.
Peter Robinson
David A. Seeland
Jesse W. Whitlow

SAGE
Lois J. Campbell
Whitman Cross II
Ranaye Dreier
Ross L. Kinnaman
Nancy L. Kiser
Marathon Oil Company*
William A. Ranson
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Lee R. Russell

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Mortimer H. Staatz
Edward A. Steiner
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Myron T. Sturgeon
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A. L. Washburn
Kenzo Yagi
Leland W. Younker

Women In Science
Helen M. Lang
Scott R. Paterson

*Century Plus Roster (gifts of $150 or more)

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☐ Enclosed is my contribution in the amount of $_____.

☐ Please add my name to the Century Plus Roster (gifts of $150 or more).

☐ Please credit my gift to the _____ Fund.

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If you have a hand lens, rock hammer, or compass, common rock, mineral, and fossil samples, or quality photographic slides of geologic features and processes that you no longer use or need, please consider donating these items to the SAGE program. If your department or business is replacing old but still usable computer equipment, microscopes, or other laboratory or field equipment, your donation will help K–12 school teachers and students.

For further information please contact Ed Geary, Coordinator for Educational Programs, GSA, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020.

In Memoriam

William S. Benninghoff
Ann Arbor, Michigan
January 1993

Felix Chayes
Kensington, Maryland
February 28, 1993

Theodore A. Dodge
Tucson, Arizona
November 7, 1992

Richard P. Fischer
Grand Junction, Colorado

John A. Hageman
Nashville, Tennessee

Edward T. Heck
Waukesha, Wisconsin
February 2, 1993

John B. Hersey
Springfield, Virginia
November 4, 1992

Wendell B. Johnson
Jackson, Mississippi
August 30, 1992

Frederick J. Kuellmer
Socorro, New Mexico

Lowell R. Laudon
Madison, Wisconsin
March 13, 1993

Edwin T. McKnight
Falls Church, Virginia
December 26, 1992

Robert C. Riecker
Los Alamos, New Mexico

Robert V. Ruhe
Bloomington, Indiana

Robert B. Wing
Carthage, Missouri
December 28, 1992

Memorial Preprints

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

George D'Aumale DeBuchananne
Alfred Clebsch

Josep-Maria Fontboté i Mussolas
Michel Durand-Delga

Walter Francis Gouin
Sherman A. Wengerd

Meredith Esrey Johnson
Frank J. Markewicz

Vincent Cooper Kelley
Wolfgang E. Elston

Arthur H. Lang
R. W. Boyle

Thomas Seward Lovering
Hal T. Morris

Alfred O. Woodford
Douglas M. Morton, Rollin Eckis, Mason L. Hill, Ivan P. Colburn, Vincent S. Cronin, H. Stanton Hill, Thane H. McCulloch, John S. Shelton, Jack G. Vedder, Robert F. Yerkes

BOOK REVIEWS

Trilobites. *H. B. Whittington, Boydell Press, Woodbridge, Suffolk, England, (Fossils Illustrated, Volume 2) 1992, $79.*

As Steve Gould says in his delightful short preface to this excellent book, "Every field needs a primary symbol.... Invertebrate paleontology has trilobites." Among young enthusiasts and amateur paleontologists, trilobites may be the most popular fossils. Harry Whittington has provided a profusely illustrated review (120 photographic plates) of just about everything any amateur or professional, young or old, might want to know about trilobites.

Whittington's photographs are superb, and key morphologic features are unobtrusively labeled on most of them. In addition to the photographs, there are clear text figures illustrating some of the anatomical features or functional activities of trilobites.

This book brings together a diverse body of information of value to both generalist and specialist. Seven chapters, averaging about 11 pages each, cover morphological terminology and nomenclature, appendages, anatomy, growth processes, functional morphology, preservation and occurrence, and evolution and classification. Each chapter is accompanied by a list of relevant references, for deeper understanding. A summary classification to the family level is cross-referenced to the photographic illustrations.

Although the price is not immodest for a book only 2 cm thick (excluding covers) this volume will be a rewarding purchase and a valuable addition to the library of anyone with a serious interest in trilobites. The most knowledgeable living expert on trilobites has produced a quality review which should stand for some time to come as a primary reference to the elegance and complexity of this marvelous group of extinct organisms out of our past.

A. R. Palmer
Boulder, CO

Radioactive Waste Disposal and Geology *(Topics in the Earth Sciences, Volume 1). Konrad B. Krauskopf. Chapman and Hall, New York, 1988, 141 p.*

In many nations, nuclear energy is now a significant part of the total energy supply (United States, France, Japan, Canada). Every day, the mass of high-level nuclear waste that must be kept away from the biosphere and hydrosphere increases. While in terms of our total wastes it is quite a trivial mass, it is nontrivial in terms of potential environmental impact.

Krauskopf presents a brief summary of the state of ideas on permanent disposal from various nations. He starts with a brief description of the nature of radioactive wastes and effects of radioactivity on life. There is a general description of present systems for interim storage. He appears to favor reprocessing spent fuel, but he recognizes the political-social issues. He raises the ethical issue of leaving wastes to future generations.

There is a brief review of options for disposal sites, from space to ice sheets, the ocean floor, and mined cavities. (I very much agree with Krauskopf that marine disposal is worth more serious consideration.) The generally accepted multi-barrier concepts are reviewed, followed by a discussion of models of release and leakage from cavities. Finally, a large section of the book considers the critical problem of disposal-site selection.

Krauskopf is fully aware of the various types of real and perceived problems: "It is important that we plan well, so that the menace will be as small as we can make it." This short book presents a good introduction to the approaches to this difficult problem. It could be suitable for a wide range of readers, including undergraduates in several fields. One thing is certain: this global problem with its important input from the geosciences, must be solved to the best of our knowledge, and final decisions must have international approval.

William S. Fyfe
London, Ont., Canada

Quaternary Landscapes. *Edited by Linda C. K. Shane and Edward J. Cushing. University of Minnesota Press, Minneapolis, 1991, 229 p., $29.95.*

Herbert E. Wright, Jr., in whose honor *Quaternary Landscapes* is published, received the Distinguished Career Award from GSA's Quaternary Geology and Geomorphology Division last year. Both the quality of the six chapters in this book and the breadth of disciplines that they represent are testimony to Herb Wright's leadership of and impact upon Quaternary research. Thanks go to the authors and editors, for they have achieved their respective goals: authors were charged with presenting "a paper reflecting on the state of the art" in their fields, and editors hoped to "open ... doors ... to graduate and undergraduate students" and to "help established researchers expand their horizons...."

In Chapter 1, "Origins of Food Production in Western Asia and Eastern North America," Patty Jo Watson stresses the importance of an interdisciplinary and paleoecological approach to archaeology and anthropology, and she illustrates this approach by tracing the archeobotanical evidence for cultigens within the frameworks of climate, biota, and landscape. A major theme of the book, the issue of spatial scale and its representation in Quaternary deposits, emerges in her discussion of optimal resource zones, which are small pieces of the landscape mosaic containing abundant resources.

Jan Mangerud's Chapter 2, "The Last Interglacial/Glacial Cycle in Northern Europe," stresses the importance of making the land-sea connection by correlating the glacial record of northern Europe with the deep-sea oxygen-isotope stages. He sets the record straight on the status of the Eemian as the last interglacial in northern Europe and correlates it with oxygen-isotope substage 5e. Subsequent phases

Book Reviews *continued on p. 132*

ESSENTIAL GEOLOGY FROM CAMBRIDGE

Understanding the Earth
Edited by Geoff Brown, Chris Hawkesworth, and Chris Wilson
Starting with the exploration of the solar system and the study of planet formation, this text includes contributions on the earth's interior and dynamic evolution that reflect the increasingly integrated and multi-disciplinary current research trends.
1992 551 pp. 37020-5 Hardcover $135.00
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Book Reviews *continued from p. 131*

of expansion and contraction of the Scandinavian Ice Sheet are also correlated to the isotope stages.

Chapter 3, "Peat Growth," by Richard Clymo, provides a review of peat-forming environments and processes and then focuses on raised bogs for examples. We are reminded that paleoecologic study of peat must allow for differing degrees of decay (preservation), which are determined not only by depth (age), but also by nutrient content of phytomass, hydrology, and climate.

James C. Ritchie highlights recent progress in pollen and plant macrofossil analysis in Chapter 4, "Paleoecology: Status and Prospect." He emphasizes the need for multiple paleoenvironmental data sets in order to better understand paleo-ecosystems. Ritchie concludes that while paleoecology has been a successful geologic and paleoclimatic tool, it has great, unrealized potential in the biologic areas of community ecology and evolution.

Richard W. Battarbee's focus in Chapter 5, "Recent Paleolimnology and Diatom-Based Environmental Reconstruction," is the use of diatoms in studies of recent acidification of lakes. He emphasizes the important role played by modern analogues and numerical techniques for interpreting fossil data.

John E. Kutzbach and Thompson Webb III summarize the results of the Cooperative Holocene Mapping Project (COHMAP) in Chapter 6, "Late Quaternary Climatic and Vegetational Change in Eastern North America: Concepts, Models, and Data." The historical background that they provide on the Milankovitch theory and CLIMAP is helpful. COHMAP's global data base of land– sea–ice sheet paleoclimatic proxy data has been used to reconstruct general circulation patterns; however, Kutzbach and Webb also emphasize that circulation patterns lead to paleoclimatic hypotheses that can be tested at a variety of scales.

Quaternary Landscapes is well written and edited, far better reading than most symposium volumes. It is on reserve for my senior seminar.

William N. Mode
University of Wisconsin
Oshkosh, WI

Geomorphic Responses to Climatic Change. *W. B. Bull. Oxford University Press, New York, 1991, 326 p., $59.95*

Geomorphic Responses to Climatic Change provides an ambitious and timely examination of alterations in earth surface processes, landforms, and sedimentary deposits, as well as major, long-term (glacial-interglacial) climatic shifts. Bull's text, written for graduate-level students and professionals, is relavant not only to academicians studying geomorphic systems or interpreting the sedimentary rock record, but also to geologists and engineers dealing with societal concerns such as the design of bridge structures or the suitability of landforms for waste disposal.

Following a brief introduction of process geomorphology in Chapter 1, climate-related responses in earth surface processes and landforms are discussed in chapters 2–5 for four study areas with different climatic, tectonic, and lithologic characteristics. Chapter 2 focuses on fluvial, hillslope, and piedmont response(s) to changing climate within the southwestern deserts of California and Arizona. This chapter (and to a lesser extent, Chapter 4) includes an in-depth review of geomorphic surface and deposit dating and correlation techniques that is particularly valuable. Chapter 3 primarily examines the influence of climate and lithology on hillslope sediment production, accumulation, and erosion within multilithologic basins located primarily in the Middle East. Attempts are made to separate the geomorphic effects of tectonic activity from climatic change for the currently semiarid to subhumid watersheds of the San Gabriel Mountains, California (Chapter 4) and the humid, Charwell River basin of New Zealand (Chapter 5). The final chapter discusses the similarities and differences in geomorphic response to shifting climate within the four study areas.

Perhaps the book's most important contribution is its example of using an interdisciplinary approach to solve complex geomorphic problems. For example, the types, magnitude, and timing of landscape modification are determined using paleobotanic, geochronologic, pedologic, geomorphic, and sedimentologic data. Bull clearly illustrates that scientists concerned with geomorphic impacts of changing climate can no longer isolate their efforts. In addition, *Geomorphic Responses to Climatic Change* reveals the necessity of understanding *both* geomorphic processes and the evolutionary history of geomorphic systems.

The book does have some minor shortcomings. The text, especially the introductory chapter, is difficult to understand in places, partly because a few of the terms and concepts are not consistent with those of the formal literature. Second, the compression of such a diverse topic as the effects of long-term climatic change on geomorphic systems into 285 pages of text has led to some overgeneralizations. Suggested process-response models are significantly affected, because they tend to be speculative. Finally, the explosion of information concerning paleoclimates and geomorphic systems during the past several years has already left the book somewhat dated.

Despite these minor problems, *Geomorphic Responses to Climatic Change* provides (1) a good review of the long-term climate-induced geomorphic responses to be expected in moderate- to high-relief, arid to humid, fluvial and hillslope environments, and (2) a sound methodological approach for assessing the effects of climatic change on geomorphic systems. Bull's book represents a good starting point for graduate-level students and professionals interested in the relation between climate flux and landscape modification.

Jerry R. Miller
Desert Research Institute
Reno, NV

Progress in Metamorphic and Magmatic Petrology. *A memorial volume in honor of D. S. Korzhinskiy. Edited by L. L. Perchuk. Cambridge University Press, Cambridge, 1991. 503 p., $105.*

This book is a collection of research articles dedicated to the memory of the Russian petrologist D. S. Korzhinskiy, who is best known for his pioneering work in theoretical petrology. The 1959 translation of Korzhinskiy's book *Physiochemical Basis of the Analysis of the Paragenesis of Minerals* introduced many of us to the quantitative thermodynamic description of perfectly mobile components in open geologic systems.

This volume is divided into three parts, each reflecting a primary area of Korzhinskiy's own research: (1) general thermodynamics and mineral equilibria including geothermobarometry, (2) metasomatic and metamorphic processes, and (3) the mantle and magmatic processes. The authors include people who knew Korzhinskiy personally or were well acquainted with his work. On careful reading of the chapters, one is struck by the great diversity of topics and approach. This is as much a tribute to Korzhinskiy as it is a bit confusing. Some of the chapters are review articles geared for the novice, others are written for the expert, and still others are research papers, very specific in topic, that one might find in a scientific periodical. The theme that ties this array of 18 articles together is, presumably, that the topics build on Korzhinskiy's earlier pioneering studies. Unfortunately, this includes virtually all aspects of metamorphic and igneous petrology (a testament to Korzhinskiy's vast influence) and so the unifying theme is not so unifying. The topics represented in this volume seem to have been pulled together somewhat randomly. Authors were chosen, rather than topics. As a consequence, however, the papers are generally of high quality. It is disappointing only in trying to fix on a theme for the book.

For example, the first part includes seven different papers that range in topic from an introduction to mineral thermodynamics and equilibria, to an experimental study exploring the stability of hydrous, magnesian phases at high pressure, to a description of vector representation of the lithium component in micas, and finally to a series of critiques of various thermobarometers (three different chapters). The second part includes five papers on metasomatic and metamorphic processes. The first is a computationally intensive study of bimetasomatism; the second is an experimental study of this phenomenon; the third is a very specific study of the paragenesis of serendibite (a Ca-Mg-Al borosilicate); the fourth is a field paper examining the evolution of orthogneisses within the Adirondacks; and the fifth is an essay on pressure-temperature-time paths. The third section is focused on igneous problems and includes six chapters. Again, the topics range widely: an experimental study of fusion curves for various silicates, a review paper focused on the evolution of the lithosphere over geologic time, a theoretical study of temperatures in and around crystallizing magma bodies, taking rigorous account of the enthalpic heat released, an experimental study of condensation and vaporization processes relevant to the early solar nebula, a review article on volatiles in magmatic liquids, and a summary of the magmatic consequences of volatile fluxes in the mantle.

The danger in compiling such a broad cross section of petrologic papers is that it can never be complete with only 18 chapters. It is impossible in one volume (503 pages) to deal comprehensively with all aspects of modern petrology. And so, because one is tantalized with this volume's breadth of coverage, one is also left feeling that so much was left out. As an example, one might wonder that since there is a field paper on orthogneisses, why not one on amphibolites?

For any given petrologist, there will be several articles of key interest

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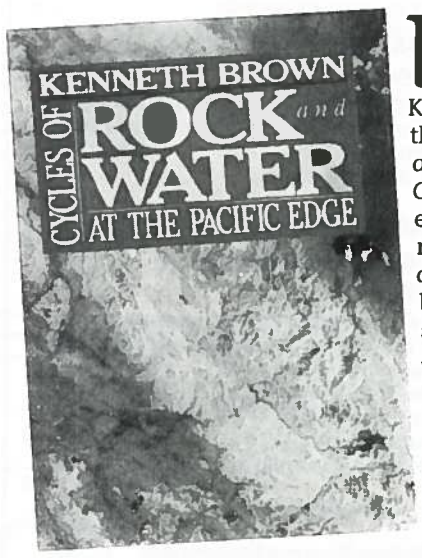

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in this volume, but even more of only peripheral interest. Perhaps that indicates that few of us are as broad in our research as Korzhinskiy himself. As a consequence, given the cost of the book, the volume is probably not appropriate for the personal bookshelf; I do recommend that petrologists encourage its purchase by their library, for there are at least a few choice chapters in this book for every petrologist.

R. A. Lange
University of Michigan
Ann Arbor, MI

Living Ice: Understanding Glaciers and Glaciation. *Robert F. Sharp. Cambridge University Press, Cambridge, England, 1988, 225 p.*

There is a growing interest, among members of the public, in glaciers. One reason is their grandeur—apart from the dazzling beauty of pictures of tidewater glaciers in Alaska, the idea of an ice mass kilometres thick situated over most of North America is fascinating and compelling. But there is another reason as well—the public is attempting to grasp the effects our activities are having on Earth, and to learn for themselves the implications of continued production of greenhouse gases. Will the polar glaciers melt and flood our coastal cities? Or will glaciers grow, leaving our coastal cities high and dry?

Living Ice has been written for the lay individual with an interest in science. The reader is assumed to have little or no science background. All important technical terms are defined in a glossary at the back of the book: even the terms "geology" and "glaciology" can be found there.

Living Ice starts off by explaining what a glacier is, and how an "imaginary governmental commission" might go about creating one (the bureaucratic inefficiencies are left to the imagination of the reader). The book describes the importance of snowfall and melt in determining whether a glacier advances or retreats, and describes the gradual conversion of snow to glacial ice. In subsequent chapters, a description is given of the different kinds of glaciers, the way in which glaciers move, erode, and deposit sediments, and the geomorphological forms that result. A short summary at the end of each chapter reiterates the most important points.

The final chapter discusses climate change, starting with the geological evidence for past ice ages and their causes. This chapter also discusses the lines of reasoning that have led to the conflicting predictions of future changes in sea level in response to continued global warming. The arguments are illustrated with an amusing line drawing of Florida as it appears at present, after a 70 metre rise in sea level, and after a 120 metre fall in sea level.

The photographs used in this volume are excellent. They have been carefully chosen from a vast store of photographs taken over many years of field work. If there is any complaint that casual readers of this volume will have, it will be that too few of the photographs are in color. However, the photographs all clearly show the features that they were chosen to illustrate, and this more than makes up for the lack of color. This book provides a clear introduction to the topic of glaciers and glaciation for the nonspecialist, and should be of particular interest to geography teachers in both high schools and public schools.

Michael R. Gipp
University of Toronto
Scarborough, Ont., Canada

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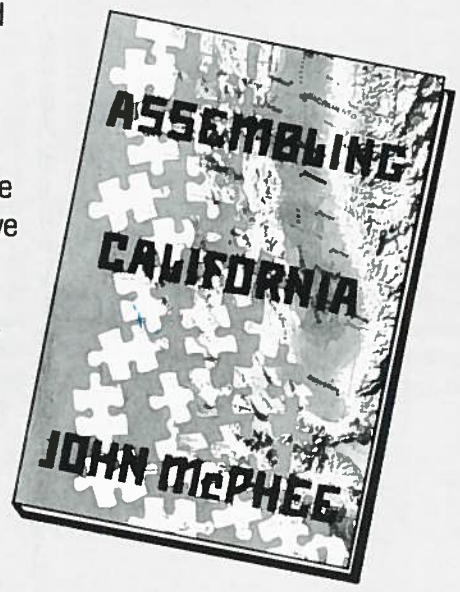

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Paleoclimatology. *T. J. Crowley and G. R. North. Oxford University Press, New York, 1991, 339 p.*

In the first paragraph of their introduction, T. J. Crowley and G. R. North state that the goal of *Paleoclimatology* is to link recent paleoclimate data analyses with progress in climate modeling. the outcome is a comprehensive synthesis of results and paleoclimatic interpretations derived from both observational and modeling studies on the subject. After introducing climate modeling and the strengths and weaknesses of different approaches, Crowley and North examine atmosphere-ocean–coupled general circulation models and the results of simulation experiments. This introductory section is clearly presented in a way that enables the reader to understand how the models are constructed and to evaluate the reliability of the results.

Approximately 40% of the text focuses on paleoclimatic fluctuations during the Quaternary. Results from studies on marine and terrestrial sequences and ice cores provide the foundation for an in-depth review of global paleoclimatic fluctuations during the Pleistocene. These data are compared at length to ocean and atmosphere model results. A more historical data base is used to evaluate climatic change during the Holocene on decadal to millennial time scales. Milankovich theory and time series analysis are clearly discussed, and an appendix explains time series terminology and gives illustrative examples for individuals interested in delving further into the mathematics of the procedure.

The latter half of the text compresses the paleoclimatology of the Pre-Cambrian through Tertiary time into approximately 100 pages. Crowley and North combine available data and modeling results to leave the reader with an image of shifting paleocontinents and an understanding of the processes leading to changing oceanic current systems and continental climate patterns over the past billion years. The success of this effort is in part due to the extensive series of citations included with each subject, for further reading. The resulting bibliographic section is in itself an invaluable resource.

As a summary of the current status of the field, *Paleoclimatology* fills a critical gap in the scientific literature. Researchers and educators will find the text is comprehensive and easily read. It should serve as a valuable desk reference and a text suitable for graduate or upper-undergraduate-level courses.

Howard Spero
University of California
Davis, CA ■

A Digital Landform Map of Italy

The shaded-relief portrait of Italy shown here, much reduced from a new map (87 cm x 120 cm) by Reichenbach et al. (1992), is the most detailed image of an entire nation state yet made by computer from a digital elevation model (DEM). Created by Paola Reichenbach of Italy's National Research Council (CNR, Perugia) in cooperation with William Acevedo, Robert Mark, and Richard Pike of the U.S. Geological Survey (Menlo Park), the map has a ground resolution of only 230 m, 3.5x better than that of the shaded-relief map of the United States (Thelin and Pike, 1991). Landforms as small as 0.5 km across can be distinguished on the published map. Such features as the Anzio-Ancona lineament, moraines of the Alpine piedmont, Etna and other volcanoes bordering the Tyrrhenian microplate, and the limestone Ragusa plateau in southeast Sicily appear accurately and in their true complexity.

The DEM was assembled and processed at the USGS from data provided to CNR by the Italian Geological Service (Reichenbach et al., 1993). The elevations had been digitized in Italy from all 1:25 000-scale quadrangles of the Italian Geographic Military Institute (IGMI); values were assigned to grid locations every 7.5" of latitude and 10" of longitude by averaging nearby contour lines and point elevations. The mean heights were furnished to us in 280 large blocks corresponding to the 1:00 000-scale IGMI maps of Italy. We assembled these matrices into one array of nearly 27 000 000 cells (4546 east-west x 5886 north-south), of which about 8 000 000 are land-surface elevations. Each rectangular cell or picture element (pixel) measures 230 m across on the ground, corresponding to 0.19 mm on the published 1:1 200 000-scale map.

As in other shaded-relief maps (e.g., Thelin and Pike, 1991), each pixel represents a theoretical reflected-light intensity computed from a relation between position of a simulated sun, local ground slope and slope direction, and location of the observer (here, overhead). Steep slopes are black or white depending on the sun-facing direction; gentle slopes are shades of gray. We obtained the best portrait for Italy in both low- and high-relief topography by illuminating the image from the west at 30° above the horizon. To avoid distorting the appearance of the Alps, we applied no vertical exaggeration. Neither a national boundary nor a coastline mask was fitted.

Unique to the new Italian map is an inset (omitted here) showing regional divisions that are roughly equivalent to U.S. physiographic provinces. We divided Italy into 28 units of internally similar topography by mathematically combining digital maps of terrain measures. The six maps—of average elevation, local relief, skewness of elevation, slope angle, angle of slope curvature, and frequency of slope reversal—were calculated on 600-m cells from the same DEM as the shaded relief. A composite image displaying the varied character of terrain as different colors was made from the six maps by clustering techniques adapted from LANDSAT image processing. We drew the division boundaries provisionally, by inspection, on the composite image to best separate the most dissimilar patterns.

The new shaded-relief map was published as a special product (Reichenbach et al., 1992) and is not distributed as part of a regular series; inquiries into its availability should be directed to Paola Reichenbach, CNR/IRPI, 126 via Madonna Alta, 06100 Perugia, Italy. The Italian DEM is the property of the Italian government and has not been released. The 280 constituent DEMs, however, are available individually from the Italian Geological Service.

REFERENCES CITED

Reichenbach, Paola, Acevedo, William, Mark, R. K., and Pike, R. J., 1992, Landforms of Italy: Perugia, Italy, Consiglio Nazionale delle Ricerche, Instituto di Ricerca per la Protezione Idrogeologica nell'Italia Centrale, *in collaboration with* U.S. Geological Survey, one sheet, scale 1:1 200 000.

Reichenbach, Paola, Pike, R. J., Acevedo, William, and Mark, R. K., 1993, A new landform map of Italy in computer-shaded relief: Geodesia e Scienze Affini (Instituto Geografico Militare, Florence Italy), Bolletino, v. 52, no. 1, p. 21–44, foldout 1:2 000 000-scale map (in English).

Thelin, G. P., and Pike, R. J., 1991, Landforms of the conterminous United States—A digital shaded-relief portrayal: U.S. Geological Survey Miscellaneous Investigations Map I-2206, scale 1:3,500,000 (reprinted 1992).

Richard J. Pike
U.S. Geological Survey
Menlo Park, California 94305

Earthwatch Offers Grants for Labor-intensive Field Research

Earthwatch, a private nonprofit organization, fosters scholarly research by offering capital, labor, and greater visibility to the scientific community. The membership consists of individuals who want to learn more about scientific problems and to share in the excitement of solving them, thereby providing a bridge between scholarly research and public education. The Center for Field Research receives, reviews, and recommends research proposals for Earthwatch support.

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Examples of the labor-intensive geoscience field research that Earthwatch is supporting in 1993 include: submarine ground-water discharge into the Gulf of Mexico; air pollution in the Russian Arctic; catastrophic volcanic blasts on Kanchatka, Russia; and floods in the southern Negev Desert, Israel.

Preliminary proposals may be made by telephone or by a detailed letter or fax to the Center for Field Research. Upon favorable review, full proposals will be invited for submittal at least 12 months before the proposed start date of the project. Full proposals will be peer-reviewed. Proposals will be considered from scholars of any nationality, for research in any geographic region.

For further information contact: Andrew Hudson, Program Director, Center for Field Research, 680 Mt. Auburn Street, P.O. Box 403, Watertown, MA 02272; (617) 926-8200; fax 617-926-8532.

MEETINGS

■ Indicates new or changed information

GSA Penrose Conferences

March 1994

From the Inside and the Outside: Interdisciplinary Perspectives on the History of Earth Sciences, March 19–21, 1994, San Diego, California. Information: Léo F. Laporte, Dept. of Earth Sciences, University of California, Santa Cruz, CA 95064, (408) 459-2248, fax 408-459-3074; Naomi Oreskes, Dept. of Earth Sciences, Dartmouth College, Hanover, NH 03755, (603) 646-1420, fax 603-646-3922; Kenneth L. Taylor, Dept. of the History of Science, University of Oklahoma, Norman, OK 73019-0315, (405) 325-2213, fax 405-325-2363.

1993 Meetings

May

National Earthquake Conference, May 3–5, 1993, Memphis, Tennessee. Information: 1993 NEQC, c/o CUSEC, 2630 E. Holmes Rd., Memphis, TN 38118-8001, (901) 345-0932, fax 901-345-0998.

Pacific Sections 1993 Convention, American Association of Petroleum Geologists, SEPM, 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 Properties, 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 49-2 21/821-0, fax 49-2 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.

GSA Cordilleran–Rocky Mountain Section Meeting, May 19–21, 1993, Reno, Nevada. Information: Richard A. Schweickert, Dept. of Geological Sciences, Mackay School of Mines, University of Nevada, Reno, NV 89557-0138, (702) 784-6050; or Walter S. Snyder, Dept. of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061.

Midwest Friends of the Pleistocene, May 21–23, 1993, Sturgeon Bay, Wisconsin. Information: Allan F. Schneider, Dept. of Geology, University of Wisconsin—Parkside, Box 2000, Wood Road, Kenosha, WI 53141, (414) 595-2439.

■ **Eastern Friends of the Pleistocene,** May 22–23, 1993. Concord, New Hampshire. Information: Carol T. Hildreth, 135 Washington Street, Holliston, MA 01746, (508) 429-5085; or Richard B. Moore, U.S. Geological Survey, 525 Clinton St., Bow, NH 03304, (603) 225-4681.

American Geophysical Union Spring Meeting, May 24–28, 1993, Baltimore, Maryland. Information: AGU–Meetings Department, 2000 Florida Avenue, N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: dsolomon@kosmos.agu.org.

International Basin Tectonics and Hydrocarbon 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.

American Society of Limnology and Oceanology, Society of Wetland Scientists, Society of Canadian Limnologists, Joint Annual Meeting, May 30–June 3, 1993, Edmonton, Alberta, Canada. Information: Marcel Ouellet, Institut National de la Recherche Scientifique, 2700 rue Einstein, P. Box 7500, Sainte-Foy, Québec, (418) 654-2631, fax 418-654-2562.

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, 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.

Society for the Preservation of Natural History Collections Conference, June 7–12, 1993, Victoria, British Columbia, Canada. Information: Liz Taylor, Royal British Columbia Museum, (604) 387-3701 or (604) 356-8791.

Geology and Confinement of Toxic Wastes International Symposium, June 8–11, 1993, Montpellier, France. Information: Michel Barrès, BRGM—Département "Environnement," BP 6009, 45060 Orléans Cedex, France, phone 33-38 64 34 14, fax 33-38 64 30 13, Telex BRGM 780 258 F.

Maine Mineral and Geological Society 10th Annual Gem, Mineral and Fossil Show, June 12–13, 1993, Portland, Maine. Information: Gerry Bates, P.O. Box 2333, South Portland, ME 04116-2333.

Rapid Excavation and Tunneling 11th Conference, June 13–17, 1993, Boston, Massachusetts. Information: Meetings Department, SME P.O. Box 625002, Littleton, CO 80162, (303) 973-9550, fax 303-979-3461.

■ **AAPG Hedberg Research Conference—Seals and Traps: A Multidisciplinary Approach,** June 21–23, 1993, Crested Butte, Colorado. Information: AAPG Continuing Education Department, P.O. Box 979, Tulsa, OK 74101, (918) 584-2555, fax 918-584-0469.

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

International Mining Geology Conference, July 5–8, 1993, Kalgoorlie-Boulder, Australia. Information: The Chairman, International Mining Conference, c/-Kalgoorlie Consolidated Gold Mines Pty Ltd., PMB 27, Kalgoorlie, 6430, Australia, phone 61-90-22 1229, fax 61-90-93 2315.

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

Society for Industrial and Applied Mathematics, Annual Meeting, July 12–16, 1993, Philadelphia, Pennsylvania. Information: SIAM Conference Coordinator, 3600 University City Science Center, Philadelphia, PA 19104-2688, (215) 382-9800, fax 215-386-7999, E-mail: meetings@siam.org.

■ **AAPG Hedberg Research Conference—Unconformities and Porosity Development in Carbonate Strata,** July 13–16, 1993, Vail, Colorado. Information: AAPG Continuing Education Department, P.O. Box 979, Tulsa, OK 74101, (918) 584-2555, fax 918-584-0469.

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 44-733-62626, fax 44-733-893 971.

10th International Clay Conference, July 18–23, 1993, Adelaide, Australia. Information: Conference Secretariat, Elliservice Convention Management, P.O. Box 753, Norwood, 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.

Hydrometallurgy—Milton E. Wadsworth International Symposium, August 1–5, 1993, Salt Lake City, Utah. Information: Meetings Department, SME, P.O. Box 625002, Littleton, CO 80162, (303) 973-9550, fax 303-979-3461.

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.

Carboniferous to Jurassic Pangea: A Global View of Environments and Resources, August 15–19, 1993, Calgary, Alberta, Canada. Cosponsored by the Canadian Society of Petroleum Geologists and the Global Sedimentary Geology Program. Information: Benoit Beauchamp or Ashton Embry, Geological Survey of Canada, 3303 33rd St. NW, Calgary, Alberta T2L 2A7, Canada, (403) 292-7126, fax 403-292-4961.

Mine Design International Congress, Mining into the 21st Century, August 23–26, 1993, Kingston, Ontario, Canada. Information: Peter Scott, Public Relations,

Meetings *continued on p. 136*

Short-Course Series

Fundamentals of Stochastic Modeling of Flow and Transport in Porous Formations

June 28 - July 2, 1993

Instructors: **Drs. G. Dagan (University of Tel Aviv) and Y. Rubin (University of Berkeley)**

Foundation of stochastic theory and stochastic modeling and application in solving field problems; includes exercise-solving, use of a computer codes, analysis of field applications, and discussion of the most recent and future developments.

For more information contact the IGWMC.

international ground water modeling center

igwmc

Institute for Ground-Water Research and Education
Colorado School of Mines
Golden, Colorado 80401-1887
Phone: (303) 273-3103
FAX: (303) 273-3278

Meetings *continued from p. 135*

ICMD/Relations publiques, CICM, Department of Mining Engineering/Département de génie minier, Queen's University/Université Queen's, Kingston, Ontario K7L 3N6, Canada, (613) 545-2212, fax 613-545-6597.

Hydrothermal Reactions Fourth International Symposium, August 31–September 3, 1993, Nancy, France. Information: 4th ISHR, CREGU, BP-23, 54501-Vandoeuvre-lès-Nancy Cedex, France, telex: 960934, fax 33-83-44-00-29, E-mail: internet CREGU ciril.fr, or FRciiL71.bitnet.

September

■ **Mineralization Related to Mafic and Ultramafic Rocks, International Symposium,** September 1–3, 1993, Orléans, France. Information: Daniel Ohnenstetter, Symposium Secretary, CRSCM-CNRS, 1a, rue de la Férollerie, 45071 Orléans Cedex 2, France, phone (33) 38 51 54 01, fax (33) 38 63 64 88.

Rocky Mountain Friends of the Pleistocene, September 10–12, 1993, Mission Valley–Flathead Lake area, northwest Montana. Information: Dan Levish, Bureau of Reclamation, P.O. Box 25007, D-3611, Denver, CO 80225-0007, (303) 236-8532.

Coal Science 7th International Conference, September 12–17, 1993, Banff, Alberta, Canada. Information: David Brown, P.O. Bag 1280, Devon, Alberta T0C 1E0, Canada, (403) 450-5200, fax 403-987-3430.

Fractography, Geological Society of London Thematic Meeting, September 13–14, 1993, London, United Kingdom. Information: M. S. Ameen, GeoScience Limited, Silwood Park, Buckhurst Road, Ascot SL5 7QW, UK, phone 44-344-872220, fax 0344 872438.

■ **AAPG Hedberg Research Conference—Salt Tectonics,** September 13–17, 1993, Bath, England. Information: AAPG Continuing Education Department, P.O. Box 979, Tulsa, OK 74101, (918) 584-2555, fax 918-584-0469.

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.

■ **American Association of Petroleum Geologists Eastern Section Meeting,** September 19–21, 1993, Williamsburg, Virginia. Information: Arthur D. Cohen, Dept. of Geological Sciences, University of South Carolina, Columbia, SC, fax 803-777-6610.

10th Annual International Pittsburgh Coal Conference, September 20–24, 1993, Pittsburgh, Pennsylvania. Information: Ann McDonald, Conference Secretary, Pittsburgh Coal Conference, University of Pittsburgh, 1140 Benedum Hall, Pittsburgh, PA 15261, (412) 624-7440, fax 412-624-1480.

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.

■ **Clay Minerals Society Annual Meeting,** September 25–30, 1993, San Diego, California. Information: Richard Berry, Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182-0337, (619) 594-6394, fax 619-594-4372.

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) General Assembly, Ancient Volcanism and Modern Analogues, September 25–October 1, 1993, Canberra, Australia. Information: IAVCEI General Assembly, Acts, GPO Box 2200, Canberra, ACT 2601, Australia, phone 61-6-2573299, fax 61-6-2573256.

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 48-22-217-391, fax 48-22-297-497; or Helmut H.J. Geldsetzer, Geological Survey of Canada, 3303 33rd St. N.W., Calgary, Alberta T2L 2A7, Canada, (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.

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.

Geothermal Resources Council Annual Meeting, October 10–13, 1993, Burlingame, California. Information: Geothermal Resources Council, P.O. Box 1350, Davis, CA 95617-1350, (916) 758-2360, fax 916-758-2839.

International Association for Mathematical Geology, October 10–15, 1993, Prague, Czechoslovakia. Local Chairman: Vaclav Nemec, K. Rybinickum 17, Praha 1–Strasnice, Czechoslovakia; Technical Program Committee cochairmen—North and South America: John C. Davis, Kansas Geological Survey, University of Kansas, Lawrence, KS 66047, (913) 864-3965, fax 913-864-5317, E-mail: john_davis.moore_hall@-msmail.kgs.ukans.edu; Europe, Africa, and Asia: Jan Harff, Institute for Baltic Sea Research, Seestr. 15, 0-2530 Warnemuende, Germany, phone 49-381-58-261, fax 49-381-58-336, E-mail: harff@-geologie.io-warnemuende.dbp.de.

■ **Seismological Society of America, Eastern Section Meeting,** October 13–15, 1993, Weston, Massachusetts. Information: John E. Ebel, Weston Observatory, Dept. of Geology & Geophysics, Boston College, 381 Concord Road, Weston, MA 02193-1340, (617) 899-0950, fax 617-552-8388, E-mail: EBEL@-BCVMS.BC.EDU. *(Abstract deadline: September 10, 1993.)*

Federation of Analytical Chemistry and Spectroscopy Societies 20th Annual Meeting, October 17–22, 1993, Detroit, Michigan. Information: FACSS, P.O. Box 278, Manhattan, KS 66502, (301) 846-4797.

GSA ANNUAL MEETINGS

■ 1993

Boston, Massachusetts
Hynes Convention Center
October 25–28

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

Abstract Deadline: July 7
Preregistration Deadline: September 24

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

New for '93

Registration Materials will be in JUNE *GSA Today*—REGISTER EARLY

■ 1994

Seattle, Washington
Washington State Convention and Trade Center
October 24–27

Chairman: Darrel S. Cowan, University of Washington

Call for Field Trip Proposals: Please contact the field trip chairman—Donald A. Swanson, Department of Geosciences, University of Washington, Seattle, WA 98195, (206) 543-1190. *Deadline: May 15, 1993.*

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

NEW NEW NEW

PROPOSALS DUE BY OCTOBER 1

Call for Continuing Education Course Proposals

The GSA Committee on Continuing Education *(formerly the Short Course Committee)* invites those interested in proposing a GSA-sponsored or cosponsored course or workshop to contact GSA headquarters for proposal guidelines.

Continuing Education courses may be conducted in conjunction with all GSA annual or section meetings. We are particularly interested in receiving proposals for the 1994 Seattle Annual Meeting OR 1995 New Orleans Annual Meeting.

NEW DEADLINE—Proposals must be received by **October 1, 1993.** Selection of courses for 1994 will be made by February 1, 1994. For those planning ahead, we will also consider courses for 1995 at that time.

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

■ FUTURE

Boston	October 25–28	1993
Seattle	October 24–27	1994
New Orleans	November 6–9	1995
Denver	October 28–31	1996
Salt Lake City	October 20–23	1997

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

New Developments in Geothermal Measurements in Boreholes, October 18–23, 1993, Klein Köris, Germany. Information: E. Hurtig, GFZ Potsdam, Talegrafenberg A45, 0-1561 Potsdam, Germany, phone 49-331-310-347, fax 49-331-310-610, E-mail: gth@gfz-potsdam.dbp.de.

Gulf Coast Association of Geological Societies and Gulf Coast Section of SEPM 43rd Annual Convention, October 20–22, 1993, Shreveport, Louisiana. Information: Roger Berg, Arkla Exploration Co., P.O. Box 21734, Shreveport, LA 71151, (318) 429-2713.

■ **Overthrusting into Foreland Basins: Sedimentological Consequences,** October 20–22, 1993, Troy, New York. Information: Gerald M. Friedman, Northeastern Science Foundation, Rensselaer Center of Applied Geology, 15 Third Street, P.O. Box 746, Troy, NY 12181-0746.

Geological Society of America Annual Meeting, October 25–28, 1993, Boston, Massachusetts. Information: GSA Meetings Department, P.O. Box 9140, Boulder, CO 80301,

continued on p. 137

GSA SECTION MEETINGS

1993

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. Snyder, Department of Geosciences, Boise State University, Boise, ID 83725, (208) 385-3645, fax 208-385-4061. *Preregistration Deadline: April 23, 1993.*

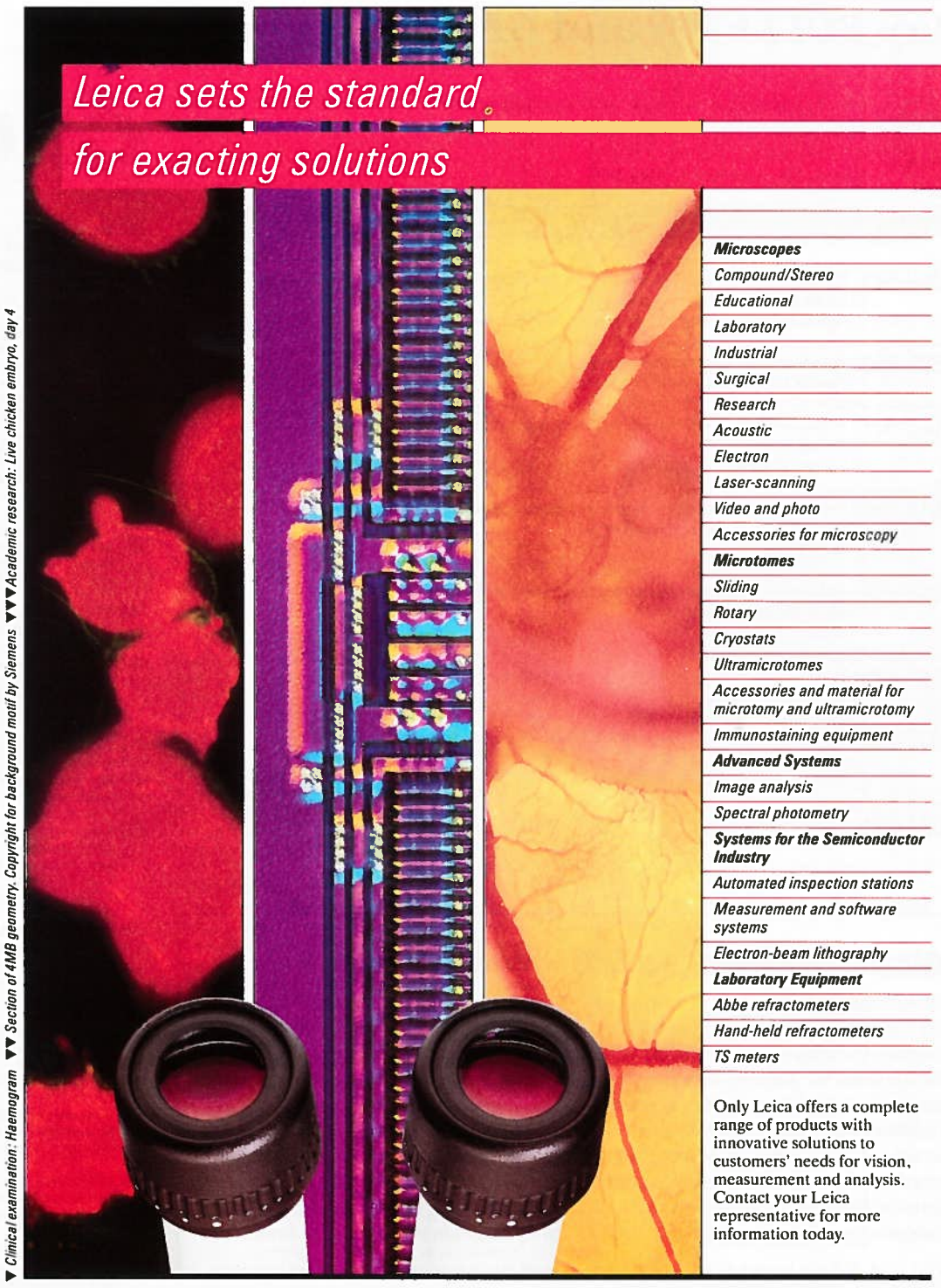
1994

South-Central March 21–22	University of Arkansas Little Rock, Arkansas	
Cordilleran March 21–23	California State University San Bernardino, California	
Northeastern March 28–30	SUNY at Binghamton Binghamton, New York	} tentative
Southeastern April 7–8	Virginia Polytechnic Institute and State University, Blacksburg, Virginia	
North-Central April 28–29	Western Michigan University Kalamazoo, Michigan	
Rocky Mountain May 4–6	Fort Lewis College Durango, Colorado	

GSA
GEOVENTURES 1993

LAST CHANCE **to register!**

For information call the Meetings Department at 1-800-472-1988



Meetings *continued*

(303) 447-2020, fax 303-447-1133. *(Abstract deadline: July 7, 1993.)*

World Energy Engineering 16th Congress, October 26–28, 1993, Atlanta, Georgia. Information: Ruth M. Bennett, 4025 Pleasantdale Road, Suite 420, Atlanta, GA 30340, (404) 447-5083, fax 404-446-3969.

■ **Rocky Mountain Ground Water Conference,** October 27–29, 1993, Albuquerque, New Mexico. Information: Michael E. Campana, Dept. of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131-1116, (505) 277-3269, fax 505-277-8843. *(Abstract deadline: May 28, 1993.)*

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.

■ **Geological Association of New Jersey, Precambrian Traverse of Northern New Jersey,** October 29–30, 1993. Information: John Marchisin, P.O. Box 5145, Trenton, NJ 08638, (201) 200-3162, fax 201-200-2298.

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.

24th Annual Underwater Mining Institute, November 7–9, 1993, Estes Park, Colorado. Information: Karynne Chong Morgan, UMI Conference Coordinator, 811 Olomehani Street, Honolulu, HI 96813-5513, (808) 522-5611, fax 808-522-5618, Internet: morgan@uhunix.uhcc.hawaii.edu, Compuserve: MMTC, 70673,534.

■ **Mineral Resources of Russia, Internatinal Symposium and Exhibition,** November 9–13, 1993, St. Petersburg, Russia. Information in the USA: (505) 291-9812. Information in Russia: Organizing Committee, P.O. Box 215, 199004, St. Petersburg, Russia, E-mail: vsg@sovamsu.sovusa.com., phone 7-812-218-9224, fax 7-812-355-7952.

■ **Eastern Oil Shale Symposium,** November 17–19, 1993, Lexington, Kentucky. Information: Geaunita H. Caylor, University of Kentucky/OISTL, 643 Maxwelton Court, Lexington, KY 40506-0350, (606) 257-2820, fax 606-258-1049.

December

American Geophysical Union Fall Meeting, December 6–10, 1993, San Francisco, California. Information: AGU—Meetings Department, 2000 Florida Avenue, N.W., Washington, DC 20009, (202) 462-6900, fax 202-328-0566, E-mail: dsolomon@kosmos.agu.org. *(Abstract deadline: September 9, 1993.)*

1994 Meetings

January

Remote Sensing for Marine and Coastal Environments, 2nd Thematic Conference, January 31–February 2, 1994, New Orleans, Louisiana. Information: Robert Rogers, ERIM, Box 134001, Ann Arbor, MI 48113-4001, (313) 994-1200, ext. 3234, fax 313-994-5123.

February

■ **Breakthroughs in Karst Geomicrobiology and Redox Geochemistry,** February 16–19, 1994, Colorado Springs, Colorado. Information: Arthur Palmer, Earth Sciences Dept., SUNY Oneonto, Oneonto, NY 13820-4015, (607) 436-3064, fax 607-436-2107.

April

Transport and Reactive Processes in Aquifers IAHR Symposium, April 11–15, 1994, ETH-Zürich, Switzerland. Information: Th. Dracos or F. Stauffer, Institute of Hydromechanics and Water Resources Management (IHW), ETH-Hönggerberg, CH-8093 Zürich, Switzerland, phone 41-1-377 30 66 or 41-1-377 30 79, fax 41-1-371 22 83.

■ **European Association of Science Editors 5th General Assembly and Conference,** April 24–28, 1994, Budapest, Hungary. Information: EASE Secretariat, 49 Rossendale Way, London, NW1 0XB, UK, phone 44-71-388 9668, fax 44-71-383 3092.

May

Geological Association of Canada and Mineralogical Association of Canada Annual Meeting, May 15–18, 1994, Waterloo, Ontario, Canada. Information: Alan V. Morgan, Department of Earth Sciences, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada, (519) 885-1211 (ext. 3231), fax 519-746-7484.

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May *BULLETIN* and *GEOLOGY* Contents

The Geological Society of America
BULLETIN
Volume 105, Number 5, May 1993

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GEOLOGY
VOLUME 21
NO. 5
P. 385–480
MAY 1993

Forum

GSA Bulletin Managing Editor Position Open

Qualifications: (1) Excellent command of grammar and the English language. (2) Experience in managing all editorial aspects of publishing a monthly scientific journal. Includes communicating with scientist-authors; copy editing; appraising illustrations for papers; working in cooperation with remote-location science editors to schedule papers for publication; preparing papers for journal's printer; checking page proofs and bluelines (final proofs). (3) Background in science; preferably at least a B.S. in geology. (4) Computer experience sufficient to perform word-processing, edit scientific papers on screen, and prepare disks for journal's printer. Experience with Microsoft Windows preferred. (5) Interpersonal skills: cooperation, discretion, tact. (6) Ability to track details in many areas at once.

The *GSA Bulletin* is widely recognized as one of the premier general geology journals. Copy editing and production work for the *Bulletin* are done at GSA headquarters in Boulder, Colorado. The Managing Editor position will be open in late 1993. Salary: $32,000–$35,000. Application deadline: *August 1, 1993*. Send applications to: Faith Rogers, Managing Editor, Geological Society of America, P.O. Box 9140, Boulder, CO 80301, (303) 447-2020, fax 303-447-1133.

Meetings *continued from p. 137*

June

1st North American Rock Mechanics Symposium, June 1–3, 1994, Austin, Texas. Information: Priscilla Nelson, (512) 471-4929, or Stephen Laubach, fax 512-471-0140.

Geochronology, Cosmochronology, and Isotope Geology Eighth International Conference (ICOG-8), June 5–11, 1994, Berkeley, California. Information: Garniss H. Curtis, Institute of Human Origins–Geochronology Center, 2453 Ridge Road, Berkeley, CA 94709, (415) 845-4003, fax 415-845-9453.

July

FORAMS '94: International Symposium on Foraminifera, July 5–9, 1994, Berkeley, California. Information: FORAMS '94, Museum of Paleontology, University of California, Berkeley, CA 94720, (510) 642-1821, fax 510-642-1822.

Earthquake Engineering Fifth U.S. National Conference, July 10–14, 1994, Chicago, Illinois. Information: Claudia Cook, Newmark Civil Engineering Laboratory, University of Illinois, 205 N. Mathews, Urbana, IL 61801-2397, (217) 333-0498.

Basement Tectonics 11th International Conference, July 25–29, 1994, Potsdam, Germany. Information: Onno Oncken, Conference Chairman, GeoForschungsZentrum, Telegrafenberg, D-0-1561 Potsdam, Germany, phone 49-331-310601, fax 49-331-310306. *(Abstracts deadline: March 1, 1994.)*

August

V.M. Goldschmidt Conference, August 29–September 2, 1994, Edinburgh, Scotland. Information: B. Harte or P. Symms, V.M. Goldschmidt Conference 1994, Department of Geology and Geophysics, University of Edinburgh, Grant Institute, West Mains Road, Edinburgh EH9 3JW, Scotland, UK.

September

Cyclicity in Global Geology, Australian Geological Convention Symposium, September 1994, Perth, Australia. Information: Bryan Krapez, C.McA. Powell, Department of Geology, University of Western Australia, Nedlands, 6009, Australia.

October

German Geological Society (DGG) Annual Meeting, October 4–7, 1994, Heidelberg, Germany. Information: Th. Bechstädt and R.O. Greiling, Geologisch-Paläontologisches Institut, Ruprecht-Karls-Universität, Im Neuenheimer Feld 234, D-6900 Heidelberg, Germany.

November

Geology and Resources of the Eastern Frontal Belt, Ouachita Mountains, Oklahoma, November 15–17, 1994, Poteau, Oklahoma. Information: Neil H. Suneson, Oklahoma Geological Survey, Sarkeys Energy Center Room N-131, 100 East Boyd St., Norman, OK 73019-0628, (405) 325-3031.

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

"Living Benefit" Added to GSA Term Life Plan

A new feature of the GSA Group Insurance Plan is designed to provide insured members or insured spouses who have a terminal illness the option to use part of their life benefit while they are still alive. This feature is available when the insured has a life expectancy of twelve months or less. This life expectancy must be verified in writing by a physician.

The insured can select an amount ranging from 25% to 75% of the death benefit for payment. The choice may be made only once. The benefit will be paid in a lump sum. All payments will be made to the insured individual.

Certificate Riders reflecting this benefit enhancement were mailed to insured GSA members participating in the Term Life Plan with the March 1 renewals. If you would like further information about this benefit or any of the insurance coverage available from the GSA Group Insurance Program, contact the office of the administrator at 800-424-9883 or (202) 457-6820.

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.

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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.

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Positions Open

ENVIRONMENTAL GEOSCIENCES

The Department of Geological Sciences, Indiana University, Bloomington, invites applications for a tenure-track faculty position (rank and salary open). We seek individuals who can establish a competitively funded research program focused on quantitative evaluation of chemical physical or biological processes and mechanisms insurface and near-surface systems. Preference will be given to scientists who possess research interests that complement and enhance existing departmental strengths, and who can further develop and coordinate our environmentally related programs. Support for a senior scientist may include signficant start-up funds, laboratory facilities and an affiliated research personnel position. Submit letter of application and vitae by June 15 to: Professor Simon C. Brassell; Chairman, Faculty Search Committee; Department of Geological Sciences; Indiana University; Bloomington, IN 47405-5101.

Indiana University is an equal opportunity/affirmative action employer.

UNIVERSITY OF PITTSBURGH
Planetary Science

Department of Geology and Planetary Science invites applications for a full-time tenure-track faculty position at the assistant professor level in planetary science with emphasis upon surficial morphology and processes. Experience in remote sensing capabilities is also desirable. This position is available in September, 1993. We seek an individual with a completed Ph.D. who has a strong commitment to teaching and research and can develop a successful research program that is competitive for external funding. Responsibilities will include teaching introductory level geology courses (both for majors and non-majors) as well as upper level and graduate offerings in the individual's area of expertise. Salary is negotiable dependent upon qualifications and experience.

Applicants should submit a statement of research interests, curriculum vitae, reprints of recently published articles, and names of at least three references to Thomas H. Anderson, Chairman, Department of Geology and Planetary Science, University of Pittsburgh, Pittsburgh, PA 15260.

In order to ensure full consideration applications must be received by June 10, 1993.

University of Pittsburgh is an equal opportunity/affirmative action employer. Applicants are especially encouraged from qualified women and minority candidates.

RESIDENT MANAGER
BAHAMIAN FIELD STATION, SAN SALVADOR ISLAND, BAHAMAS

BS degree in Natural Sciences required, MS degree preferred. Mechanical aptitute ("a do-it-yourself junkie") and organization skills a must in order to direct and supervise maintenance staff and mechanics. Limited lecturing and leading of natural science field trips. SCUBA Diving Certification helpful. For de tailed information, write: Dr. Daniel R. Suchy, Executive Director, Bahamian Field Station, c/o Red Aircraft, 270 SW. 34th St., Ft. Lauderdale, Florida 33315.

POSTDOCTORAL POSITIONS

The Geologic Division of the U.S. Geological Survey is soliciting applications for postdoctoral positions as temporary Guest Researchers, beginning in the fall of 1993, in the following areas of research: Geologic Mapping and Isotopic Studies in Metamorphic Terranes; Quaternary Geology—Analysis of Late Cenozoic Deposits; Application of Accelerator Mass Spectrometric Techniques Utilizing Cosmogenic Isotopes; Application of Theories of Seismic Wave Propagation to the Study of the Earth's Interior; Seismic Studies of Earthquake Sources and Wave Propagation in Intraplate Settings; Seismological Studies of Volcano-Tectonic and Magmatic Processes; Economic Geology of Sediment-Hosted Copper Deposits; Economic Geology as Applied to Gold Mineralization; Marine Sonar Image Processing, Modeling, and Analysis; Well-Log Analysis in Fractured Reservoirs; and Offshore Pacific Northwest Microseismicity Study. Possible locations may be: Menlo Park, CA; Denver, CO; Hawaiian Volcano Observatory, HI; Woods Hole, MA; Memphis, TN; and Reston, VA.

Applicants should be outstanding scientists who have recently completed doctoral-level research and have a record of demonstrated ability or outstanding potential for basic and applied research. Positions will be at the GS-12 ($40,298) level. Appointments will be limited to 1 year and upon management recommendation, may be extended for 1 year. For specific information and Application for Federal Employment, SF-171, call 703-648-6131, or send application to Mr. Reginald Mervine, Office of Personnel, Att: Announcement 93-T-29, 215 National Center, Reston, VA 22092. Applications accepted through June 30, 1993. The U.S. Geological Survey is an equal opportunity employer. U.S. citizenship is required.

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We seek applicants for the following positions at Lecturer/Senior Lecturer level: *Mineral Deposits & Geochemistry*. Skills in ore microscopy, XRD and fluid inclusions; background in porphyry and epithermal mineralization preferred. Position available July '93. *Engineering Geology, Geotechnics, Hydrogeology*. We seek a generalist with expertise in these fields and ability to teach general geology also. Position available January '94.

Both are 3-year contract appointments. For further information contact Prof. Hugh Davies, Geology, University PO, NCD, Papua New Guinea, fax 675-267187, phone 675-267395 or 260268.

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Opportunities for Students

Visiting Fellows and Students/Institute for Rock Magnetism. Applications are invited for visiting fellowships (regular and student) lasting between 1 and 3 weeks during the period from September 1, 1993 through February 28, 1994.

Topics for research are open, although fellows are encouraged to take advantage of the chosen focus for cooperative research in a given year. During 1993–4, the focus for research will be the connections between the fundamentals of rock magnetism and paleomagnetic observations.

Short proposals (two pages, single-spaced text plus necessary figures and tables) are due by June 11, 1993 for consideration by the Institute's Review and Advisory Committee (Richard Reynolds, Chair).

Successful applicants will be notified in early August, 1993.

A limited number of travel grants of $500 are available to researchers who can demonstrate no existing financial resources. No funds are available for per diem expenses.

The Institute Staff (Bruce Moskowitz, Associate Director, and Christopher Hunt, Facilities Manager) will be happy to provide applications forms and information necessary for proposal preparation.

Deadline for submission is June 11, 1993 at the following address: Chris Hunt, Facilities Manager, Institute for Rock Magnetism, University of Minnesota, 293 Shepherd Laboratories, 100 Union St. SE, Minneapolis, MN 55455-0128, (612) 624-5274; fax: 612-625-7502; E-mail: chunt@staff.tc.umn.edu.

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).

California Institute of Technology. The O.K. Earl Postdoctoral Fellowship in Earth and Planetary Sciences. The California Institute of Technology announces a fellowship award from a fund endowed by Orrin K. Earl, Jr. This fellowship carries an annual stipend of $34,000 and offers a research expense fund of $1,000 per year and one-way travel to Pasadena. The duration of the appointment will normally be for two years, contingent upon good progress in the first year, and beginning with the 1993–94 academic year. Fellows are eligible to participate in Caltech's health and dental program.

The O.K. Earl Postdoctoral Fellowship has been established to support the research of scientists, typically within two years of receipt of the Ph.D. It is the intent of this program to identify and support innovative and creative work in the earth and planetary sciences, with particular emphasis on interdisciplinary work. Applicants with training in physics, chemistry, biology or computer sciences are urged to apply. The Caltech faculty is currently active in Geology, Geochemistry, Geobiology, Petrology, Geophysics, and Atmospheric and Planetary Sciences. It is expected that the fellowship holder will be hosted by a Division professor who will contribute to the fellowship support both financially and by providing intellectual guidance.

Application forms may be obtained by writing to Prof. D. J. Stevenson, Chairman, Division of Geological and Planetary Sciences, Mail Code 170-25, California Institute of Technology, Pasadena, California 91125.

Completed applications with references should arrive at Caltech by Friday, May 21, 1993.

Fellowship candidates will automatically be considered for other available postdoctoral positions at Caltech in their fields of interest.

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Astronaut Candidate Program Opportunities

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Basic Qualification Requirements

Pilot Astronaut Candidate: (1) Bachelor's degree from an accredited institution in engineering, biological science, physical science, or mathematics. (2) At least 1000 hours pilot-in-command time in jet aircraft. (3) Ability to pass a NASA Class I space physical (similar to a military or civilian Class I flight physical).

Mission Specialist Astronaut Candidate: (1) Bachelor's degree from an accredited institution in engineering, biological science, physical science, or mathematics, followed by at least three years of related professional experience. (2) Ability to pass a NASA Class II space physical (similar to a military or civilian Class II flight physical).

Further information or application materials may be obtained by writing to: NASA, Johnson Space Center, Astronaut Selection Office, ATTN: AHX, Houston, TX 77058.

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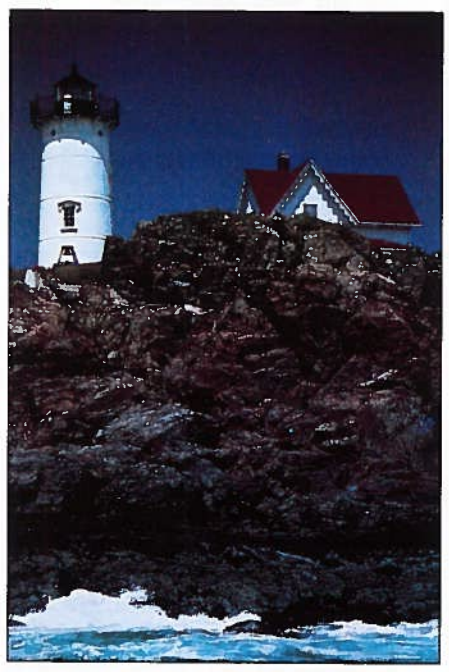

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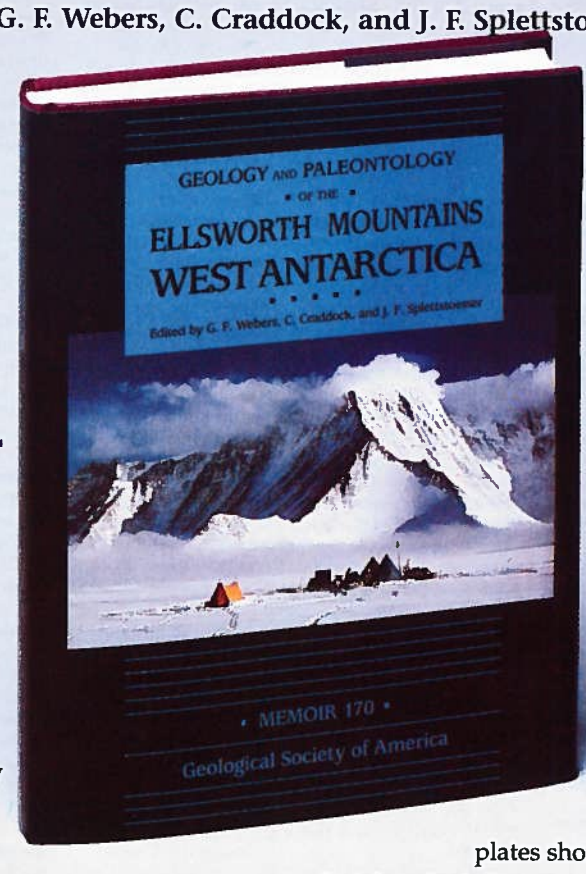

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ISSN 1052-5173

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