GSA news & information

SUPPLEMENT TO GEOLOGY MAGAZINE

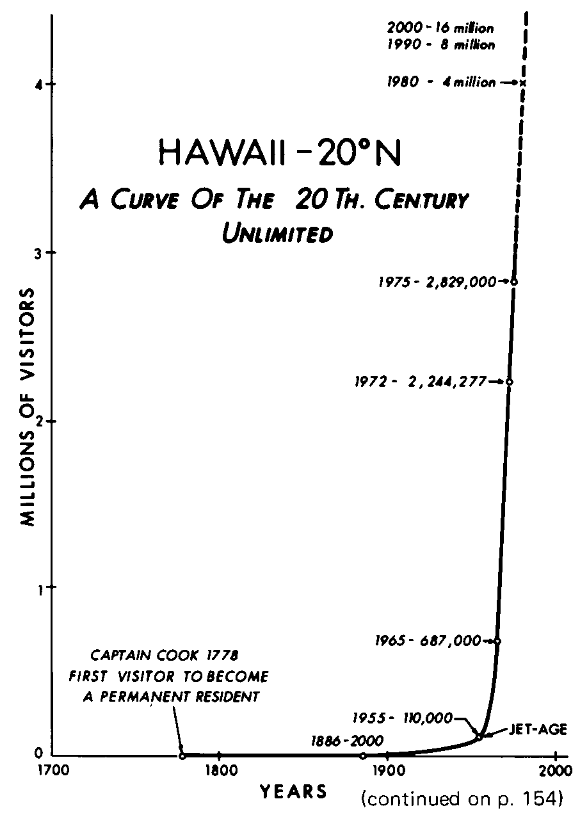
MARCH 1977

Report of the President

To the Council and Membership of The Geological Society of America, Inc.:

This report was drafted on a year-end flight from winter to the islands in the sun, Hawaii—one of the pleasanter places for the direct utilization of solar energy. For a Canadian this involves traversing some 30 degrees of latitude; however, 210,000 or 1% of us made the trip in 1976, joining 500,000 Japanese visitors (½ of 1% of the population of the Japanese islands) and 2,500,000 mainland American (1%). The graph of numbers of Hawaiian visitors is a typical 20th-century curve of rising expectations. There is a considerable energy trade-off in such a trip, for traveling in the middle class mode, packed 400 in a chartered Boeing 747, while we consumed moderate amounts of ethanol, the engines gulped 360 kilograms (2.81 barrels) of kerosene per passenger during the 12 hours of a return flight. Assuming the average plane carrying visitors was utilized at 60% efficiency, some 15,000,000 barrels of jet fuel disappeared forever from the Earth during Hawaiian visits. Extrapolating the curve to the end of the century, the number of visitors to Hawaii will approach 16,000,000 only to find that world fuel supplies have reached the point of no return.

Turning to the affairs of the Geological Society of America, we find a rather different set of curves, qualifying us for membership in the Flat Earth Society. We are no longer flat broke; the operating deficit has been turned, with great effort, into a modest surplus. The additional burden this has placed on the membership is well known to you; the sacrifices in reasonable expectations and increased workload for the headquarters' staff may not be as apparent, but they are very real. It is with regret that I accepted the resignation of Steve Hoskin, a senior member of headquarters' staff, who has served the Society well. It is disappointing that we have not been able to confirm the appointment of a new Science



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Editor; the Society is greatly indebted to Warren Hobbs and Henry Spall of the U.S.G.S. for their assistance in the interim editorial arrangements that have worked so well; the publications of GSA continue at their high level of excellence.

Requests to the Society for assistance for research projects at the graduate school level continue to be of exceptional quality. Income from the Penrose endowment, supplemented by grants from industry and individuals, have enabled us to maintain a modest level of funding, meeting some, but by no means all, of the needs in this field. We recently were informed that the Society would eventually be beneficiaries of a residual legacy from the estate of Ruby S. Pardee, late of Philipsburg, Montana. Mrs. Pardee directed that this legacy be used to set up the Joseph T. Pardee Memorial Fund for research, study, and educational advancement in the field of geology and science to be administered by the Council of the Society. Joseph Thomas Pardee (1871–1960) of the U.S.G.S. was a distinguished Fellow (1932) of GSA who did noteworthy work on the Permian phosphate deposits of the Phosphoria Sea and contributed to the engineering geology on the Hungry Horse Dam of Montana. It has become increasingly clear that the present endowment of the Geological Society of America, though well invested, will not in these inflationary times and flat stock markets provide for the needs of the Society in supporting research and education in the science of geology, our principal *raison d'etre*. We are happy to see that there will be a substantial addition to the discretionary funds available for such high purposes, and I commend to you the action of the Pardee family.

The meetings of the Council of the Society in 1976 benefited from Section representation; there was much give and take in information and debate. Pungent comment and good advice from the Sections were useful to the Council in resolving certain financial frictions and resulted in a 1977 budget item supporting student participation on sectional field trips. The Section meetings that I attended in 1976 were of high quality; the Annual Meeting was not only the largest in our history, but of high calibre. The presence of a vigorous group of research-minded young geologists bodes well for a science engaged in resolving the dilemma between the resource demands of rising expectations (the Hawaiian curve) and the increasing pressures that these impose on a fragile world ecology. My thanks go the Executive Committee and Council, the headquarters' staff, the Associated Societies, the Sections, and our numerous committees for their devoted efforts on behalf of the Society and the science of geology. They have made this year, in which I have had the honor of being your President, a memorable one for me, cementing warm friendships that I shall forever cherish.

Respectfully submitted,
ROBERT E. FOLINSBEE, President

Report of the Executive Director

To the Council and Membership of The Geological Society of America, Inc.:

The year 1976 was one of relative stability after the rather severe adjustments that were required during 1975 in order to meet the financial crisis. Fortunately, the adjustments and "belt tightening" carried out during 1975 served their purpose and, although the final audit has not yet been completed at time of writing, it seems certain that total income (including interest and dividends from investments) will somewhat more than equal the total expenditures during the year. However, little rebuilding of the general reserve fund will be possible.

The system of five dues options, with several supplemental provisions, was initiated during 1976 and is being continued for 1977. So far it appears that the optional system has served the needs of the membership reasonably well. Of the approximately 12,000 members during 1976, 46% selected an option providing the *Bulletin*, 38% selected an option that provided for separates from the *Bulletin*, and 65% selected an option that provided *Geology*; 84% received the Annual Meeting *Abstracts with Programs* and at least one section ab-

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stracts with programs; 16% of the membership elected the basic dues option and received only monthly *News & Information*. All members receive *News & Information* and it continues to be the medium for distribution of notices for all meetings and for pre-registration forms, as well as for distribution of the sequential Annual Report, general news items, *Bulletin* briefs, book briefs, and other items.

The headquarters staff was shrunk still more during the year and at year's end was 16½% below the level of two years earlier. Stephen C. Hoskin resigned as business manager and Richard F. Drozda was employed as controller. S. Warren Hobbs served as interim science editor, terminating that relationship at the end of the year. Paul Averitt, who assumed the position of interim science editor on January 1, 1977, worked with Warren Hobbs during December. Henry Spall continued as editor of *Geology*.

The Annual Meeting in Denver during November was the largest meeting ever held and had a total registration of 5,351. The Denver meeting also was the first annual meeting to run for four days. A total of 825 papers was presented and there were 65 poster presentations. The employment interview service at the Annual Meeting also was the largest, with 525 job applicants and 81 employers taking part in the program. All six of the sections also conducted successful annual meetings during the year, and nine Penrose Conferences were held.

Although financial constraints required the continuance of the research grants allotment at $50,000, this sum was significantly augmented by the contributions from industry and individuals. The flow of manuscripts to the *Bulletin* and to *Geology* continued at a high level; the number of pages published in the Memoir series slightly increased above 1975, but the pages of Special Papers sharply decreased. During the year five items were published in the Maps and Charts series and four in the Microform series. Standing orders for these two new series have now increased to 249 for Maps and Charts and 124 for the Microform series.

This was the second year for production of the *Bibliography* by GeoRef under the terms of the contract between GSA and AGI. The total subscriptions for 1976 held approximately even with 1975, and the total operation financially appears to be on a break-even basis. Modifications in the method of publishing for 1977 were made during 1976 in order to avoid the necessity of increasing the subscription price for 1977. However, it is already apparent that the subscription price for 1978 must be increased as operating costs are continuing to increase.

During the year the roster of Honorary Fellows, Fellows, Members, and Student Associates stayed approximately even, hovering around 12,000.

Respectfully submitted,
JOHN C. FRYE, Executive Director

Critical readers of manuscripts

Warren Addicott
J. M. Ade-Hall
Tom Ahlbrandt
Thomas W. Amsden
Roger N. Anderson
James E. Andrews
John T. Andrews
John Antoine
Walter J. Arabasz
Richard L. Armstrong
Tanya Atwater
Hans Avé Lallemant

Edgar H. Bailey
George Bain
Victor R. Baker
Daniel S. Barker
Fred Barker
John J. Barnes
Myrl E. Beck
Myron Best
Shawn Biehler
Marland Billings
John M. Bird
Peter Birkeland
Robert F. Black
M. C. Blake, Jr.
Harvey Blatt
Arthur L. Bloom
J. M. Botbal
Wallace A. Bothner
Carl O. Bowin
John Platt Bradbury
William J. Breed
George E. Brogan
Wilfred B. Bryan
Bruce H. Bryant
Robert C. Bucknam
Colin Bull
William B. Bull
Elizabeth T. Bunce
Kevin Burke
John Bursnall
John C. Butler
Frank M. Byers, Jr.

Wallace M. Cady
Parker E. Calkin
Wilfred J. Carr
James E. Case
Sambhudas Chaudhuri
Alfred H. Chidester
Nikolas I. Christensen
Stan Church
Sam Clarke
Donald R. Coates
Robert Coleman
James W. Collinson
Kent Condie
Peter K. Coney
Gordon Connally
John Conolly
Kenneth L. Cook
Lindrith E. Cordell
John Costa
Max D. Crittenden
Charles G. Cunningham

G. Brent Dalrymple
Paul Damon
Raymond Daniels
D. K. Davies
George H. Davis
Jelle deBoer
Edward R. Decker
Stephen E. DeLong
Michael Dence
Gabriel Dengo
Don DePaolo
James Dewey
William R. Dickinson
Robert Dietrich
Frank Dodge
Tom Donnelly
Erling Dorf
Leroy M. Dorman
James T. Drever
Jules R. Dubar
David E. Dunn
Jack Dymond

Donald J. Easterbrook
Dennis Eberl
John C. Eichelberger
M. T. El-Ashry
David Elliott
James E. Elliott
Wolfgang Elston

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REPORT OF THE EXECUTIVE DIRECTOR (continued)

Kenneth O. Emery
William W. Emmett
Bernard W. Evans
John Ewing

Robert K. Fahnestock
Henry Faul
George Faust
A. T. Fernald
Alfred G. Fischer
Robert L. Fisher
Ronald C. Flemal
Robert W. Fleming
R. C. Fletcher
Kenneth F. Fox, Jr.
William T. Fox
Robert W. Frey

N. R. Gadd
A. J. Gancarz
A. Gansser
Louis E. Garrison
R. E. Garrison
Richard P. George, Jr.
Edward Ghent
Lynn Glover III
H. D. Goode
Richard E. Grant
Arthur Grantz
Wallace R. Griffitts
Andrew Griscom
L. Trowbridge Grose
Richard Groshong
Grant Gross
Charles V. Guidotti
Robert A. Gulbrandsen

John T. Hack
Robert B. Hall
Henry Halls
Edwin Hamilton
Warren B. Hamilton
R. B. Hargraves
Christopher Harrison
Joseph H. Hartshorn
James W. Hawkins
James D. Hays
Robert Heck

Hollis D. Hedberg
Bruce C. Heezen
F. Allan Hills
Peter R. Hoover
David M. Hopkins
Clifford A. Hopson
Richard K. Hose
Patrick M. Hurley

John Imbrie
William P. Irwin
Bryan Isacks

E. D. Jackson
Roscoe Jackson II
Richard H. Jahns
David James
Arvid M. Johnson
David A. Johnson
William B. Joyner
Sheldon Judson

Martin Kane
Stephen P. Kanizay
Erle Kauffman
Robert Kay
George H. Keller
Walter D. Keller
Derrill M. Kerrick
W. Kidd
Ronald W. Kistler
Gilbert Klapper
James Knox
Ron L. Kolpack
T. E. Krogh
W. C. Krumbein
William D. Kuhn
John Kutzbach

Robert LaFleur
Walter Langbein
Marcus Langseth
Marvin Lanphere
Edwin E. Larson
Roger L. Larson
Robert Laurence
Michael Ledbetter
William P. Leeman

Robert A. Loney
Wallace Lowry
Ivo Lucchitta

D. B. MacLachlan
Norman S. MacLeod
Louis J. Maher, Jr.
Douglas M. Mahr
Robert J. Malcuit
Mike Marlow
Harold Masursky
J. C. Maxwell
A. R. McBirney
John F. McCauley
George E. McGill
B. A. McGregor
Edwin H. McKee
W. D. Means
Bill Melson
Daniel F. Merriam
Robert Milici
John D. Milliman
Daniel Milton
Peter Misch
Akiho Miyashiro
P. A. Mohr
James W.H. Monger
Wilson Monroe
David G. Moore
James G. Moore
Eldridge M. Moores
W. Jason Morgan
John D. Mudie

Charles W. Naeser
Alan E. Nairn
R. S. Naylor
Donald Noble
Warren J. Nokleberg
Carl Nordin
William R. Normark
Otto W. Nuttli

Gerhard F.M. Oertel
Hiroshi Ohmoto
William A. Oliver
Keith O'Nions
William C. Overstreet

R. S. Parker
D. K. Parrish
Dallas Peck
William J. Perry
George Peter
Donald W. Peterson
Robert E. Peterson
K. L. Pierce
Edward D. Pittman
Steven C. Porter
J. Dan Powell

Rolland R. Reid
John Reinemund
Richard Reynolds
Dale F. Ritter
Paul T. Robinson
Peter Robinson
Kelvin S. Rodolfo
Perry Roehl
Samuel I. Root
William I. Rose, Jr.
David A. Ross
Douglas Rumble
Robert O. Rye

Peter A. Scholl
James M. Schopf
C. B. Schultz
Richard A. Schweickert
Donald T. Secor
Kenneth Segerstrom
Celar Sengor
Michael F. Sheridan
Robert E. Sheridan
Toshihiko Shimamoto
Duncan Sibley
Eli Silver
Saul Silverman
M. Gene Simmons
Paul K. Sims
Norman H. Sleep
Norman D. Smith
Norman Sohl
Ronald K. Sorem
Henry Spall
William Spence
John Splettstoesser

Robert K. Springer
Randolph P. Steinen
John S. Stevenson
G. Stewart
John Stewart
Richard E. Stoiber
John C. Stormer
D. E. Sugden
C. A. Swanberg
Vernon E. Swanson
Walter C. Sweet
Don Swift
David Symons

R. W. Tabor
James Tanner
J. Thiede
George A. Thompson
Bennie W. Troxel
James F. Tull
Jan A. Tullis

Peter Vail
L. H. Van Dyke
Earl L. Verbeek
Glenn Visher

H. D. Wagener
Bruce R. Wardlaw
Norman D. Watkins
K. D. Watson
Lionel E. Weiss
John W. Wells
Hans-Rudolf Wenk
John Wheeler
I. M. Whillans
George W. White
Donald Whitehead
Philip Whitney
David Williams
Donald U. Wise
Lee A. Woodward
H. R. Wynne-Edwards

Robert Young

Publications Completed in 1976

The following publications, totaling 19,975 pages, were issued by the Society during 1976:
Periodicals: *Abstracts with Programs* for the national meeting in Denver and *Abstracts with Programs* for meetings of the Northeastern, South-Central, Cordilleran, Southeastern, Rocky Mountain, and North-Central Sections of the Society; 12 issues of the *Bibliography and Index of Geology*, Volume 40, and the cumulative *Bibliography and Index of Geology*, Volume 39; 12 issues of the monthly *Bulletin*; 12 issues of *Geology* with "GSA News & Information" sections.
Series: Maps and Charts series from MC-12 through MC-16; *Memorials* preprints; 3 Memoirs; 4 Microform Publications; 10 Special Papers.
Reprints: Reprints for the year included Microforms Publication #1 and #2; *Treatise on Invertebrate Paleontology*, Part D; Special Papers 80 and 163; and *Bibliography and Index of Geology*, Vol. 40, nos. 1, 2, 3, 4, and 6.
Miscellaneous: Other publications in 1976 were the *Annual Report for 1975* printed in the March, April, July, August, and October issues of "GSA News & Information" sections in *Geology*; Newsletters—*The Engineering Geologist* and *The Hydrogeologist*; the Fall and Winter *Mini-Catalog* of GSA publications, the Headquarters Guidebook, and *Yearbook for 1976*.

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Averitt Named Interim Science Editor

Paul Averitt, who succeeds Warren Hobbs as Interim Science Editor, comes to GSA after nearly 40 years with the U.S. Geological Survey. He is known as a specialist on United States coal resources and spent a year as editor of the Survey's Annual Review; thus Paul is no stranger to the unpredictable world of authors, draftsmen, reviewers, critics, editors, and printers.

We welcome him aboard in the hope that with your continued help, support, forbearance, and sympathy, we can re-educate a soft-rock geologist.

A Call for Petrological Volunteers

Working groups of the International Mineralogical Association and COGEODATA are recruiting volunteers willing to participate in testing the second prototype coding form for use in accumulating information to be stored in a projected electronic data base for igneous petrology. Participants will be required to spend a few hours reading about analyzed rocks in publications of their choice and marking up coding forms for fully analyzed specimens described in these publications. If you are interested in participating in the current phase of the test, please inform

Felix Chayes, Chairman
COGEODATA Task Group on a Retrospective Data Base for Petrology
Geophysical Laboratory
2801 Upton St., N.W.
Washington, D.C. 20008

Rocky Mountain Section Announces Slate

The following slate of nominees will be voted on by the voting membership present at the annual business meeting of the Rocky Mountain Section on Friday, May 13, 1977, at Missoula, Montana:

Chairman . . . . . Morris S. Petersen
Vice-Chairman . . W. Ken Hamblin

Stanley S. Beus will continue to serve as Secretary and Accounting Officer of the Section.

Robert W. Fields, Chairman
Rocky Mountain Section

Necrology

Notice has been received of the following deaths: Harold M. Bannerman, Middleton, Connecticut; Samuel D. Broadhurst, Roanoke, Virginia; Wendell B. Gealy, Pittsburgh, Pennsylvania; John M. Nelson, Seattle, Washington; L. D. Burling, Fallbrook, California; A. E. Fath, Chrisman, Illinois; Louis C. Reed, Abilene, Texas; Monta Eldo Wing, McLean, Virginia; and Keith E. Bullen, New South Wales, Australia.

Second North American Paleontological Convention

The North American Paleontological Convention II will be held at the University of Kansas, Lawrence, Kansas 66045, August 8, 9, and 10, 1977. The meeting is sponsored by the Paleontological Society, the Society of Vertebrate Paleontologists (both affiliated with GSA), Society of Economic Paleontologists and Mineralogists, American Association of Stratigraphic Palynologists, Paleobotanical Section of the Botanical Society of America, Paleontological Section of the Geological Association of Canada, and the newly formed Mexican Paleontological Society.

Eighteen symposia are planned as well as meeting of Friends groups, working groups, and special interest groups. The symposia are Phylogenetic Models; Animal Colonies; Biological Changes near the Mesozoic-Cenozoic Boundary; Fossil Plankton and Paleobiogeography; Evolution of Functional Complexes; Faunas of the Burgess Shale; Evolutionary Biology of Foraminifera; Biostratigraphy of Fossil Plants; Successional and Paleoecological Analyses; Trace Fossils in Lower Paleozoic Communities; Growth Lines; Paleontology and Plate Tectonics, with Special Reference to the History of the Atlantic Ocean; Cretaceous of Northern Temperate Areas; The Control of Diversity in Ecological and Evolutionary Time; Functional Morphology; Biostratigraphy vs. Depositional Models; Echinoderm Paleontology; Evolution and Biostratigraphy of Oceanic Microfossils from Deep Sea Drilling Project Data; and Community Paleoecology.

The March issue of the *Journal of Paleontology* contains abstracts and preregistration materials.

Seventeenth Rock Mechanics Symposium

The 17th Rock Mechanics Symposium was held at Snowbird, Utah, August 24–27, 1976. The theme of the symposium was Site Characterization, which encompassed methods of describing and modeling surface slopes and underground openings, porosity and permeability, effects of blasting, and ground support systems. The symposium was sponsored by the University of Utah, and the preprinted Proceedings volume is available from the Utah Engineering Experiment Station, University of Utah, Salt Lake City, UT 84112. The meeting was attended by more than 200 registrants, fairly evenly divided among university, government, and industrial rock-mechanics workers.

Of particular interest to GSA members is a forthcoming effort on the part of the U.S. National Committee for Rock Mechanics to collect an up-to-date list of people who have interests in the various branches of rock mechanics. The committee plans to take a more active role in keeping the rock mechanics community informed of developments in the field and is in the process of developing a newsletter with that objective in mind. A concerted effort will be made to contact the appropriate GSA members when the project begins.

Fulbright-Hays Awards in Geology Announced

For thirty years the Fulbright-Hays program has provided opportunities for university lecturing and advanced research abroad. In recent years 450 to 500 awards per year have been made to American scholars and other professionals—5 to 11 to specialists in geology. The program also includes awards to foreign scholars for lecturing and advanced research at U.S. institutions.

Announcement of the awards available to American scholars for 1978–1979, in the 31st annual competition, will be published in March 1977. The general composition of the program involving more than 70 countries is expected to be similar to that of recent years. Registration for personal copies of the announcement is now open to U.S. citizens with university or college teaching experience. Forms are available from the Council for International Exchange of Scholars, Suite 300, Eleven Dupont Circle, Washington, D.C., 20036.

Among the 1976–1977 grants, 11 awards in geology were made to American scholars for work in Australia, Colombia, Malaysia, Nepal, New Zealand, Nigeria, Norway, Philippines, and Uruguay; 8 scholars from abroad will be in the U.S. from Austria, India, Italy, New Zealand, Poland, and the USSR. Grantee lists will be sent upon request. Nominations for 1977–1978 awards are now being forwarded to the countries which programmed grants for announcement last spring.

American Fulbright-Hays Scholars, 1976-1977 in Geology

ARTHUR D. BALDWIN, JR. Assoc. Prof. Geology, Miami U, Oxford, Ohio. Environmental Studies, U Agriculture, Kuala Lumpur, Malaysia, 6/76–1/77 (L)

DOUGLAS K. BINGHAM Sheridan, Wyoming. Geophysics, Tribhuvan U, Nepal, 7/76–4/77 (L)

ROBERT B. COLLAGAN Prof. Comprehensive Science and Science Education, Morgan State U, Baltimore, Md. Geology, Philippines, 9/76–1/77 (L)

RICHARD A. DAVIS Prof. & Chairman Geology, U South Florida, Tampa. Geology, U Melbourne, Australia, 3/76–9/76 (LR)

ERIC FORCE Geologist, U.S. Geological Survey, Reston, Va. New Zealand Geological Survey, New Zealand, 10/75–7/76 (Rt)

ERNEST L. LUNDELIUS Prof. Geological Sciences, U Texas, Austin. Geology, U Western Australia and Western Australia Museum, Australia, 9/76–1/77 (R)

NEIL J. MALONEY Assoc. Prof. Earth Science, Calif. State U, Fullerton. Marine geology, physical oceanography, Colombian Oceanographic Commission, Colombia, 6/76–8/76 (L)

WILLIAM B. SIZE Asst. Prof. Geology, Emory U, Atlanta, Georgia. Geology, U Bergen, Norway, 9/76–6/77 (Rt)

RICHARD A. SLATER Asst. Prof. Earth Sciences, U Northern Colorado, Greeley. Geology. U Sydney, Australia, 6/76–8/76 (R)

JAMES W. VOGEL Ph.D. Candidate, Graduate School of Oceanography, U. Rhode Island, Kingston, Marine geology, School of Humanities and Sciences, U Republic, Montevideo, Uruguay, 9/76–11/76 (Lt)

RONALD P. WILLIS Assoc. Prof. Geology, U. Wis, Eau Claire. Petroleum geology, micropaleontology and stratigraphy, U. Benin, Nigeria, 9/76–6/77 (L)

L = lecturing, R = research, j = younger scholar, t = travel only, r = renewal

Interdisciplinary Conference on Landslides, October 10-14, 1977

A Penrose Conference entitled "An Interdisciplinary Conference on Landslides" cosponsored by the Geological Society of America and the American Society of Civil Engineers is scheduled for October 10–14, 1977, in Vail, Colorado. Convenors for this conference are Don C. Banks, U.S. Army Waterways Experiment Station, Vicksburg, Mississippi, and Robert W. Fleming and Robert L. Schuster, U.S. Geological Survey, Denver, Colorado.

The purpose of the conference is to bring together geologists and civil engineers working with landslide problems to exchange ideas on data needs and methods of approach of these two disciplines. The conference will be structured so that key speakers and leadership of each session will be about equally divided between geologists and engineers. The stimulus provided from one discipline to another should discover areas of potentially productive research. Subjects for discussion include (a) landslide identification and investigation; (b) sampling and testing; (c) analysis, evaluation, and design; and (d) research activities.

A 1-day field trip in the Vail area will examine landslide problems within a 50-kilometer radius of the meeting site. Within this past year, comprehensive maps of geologic hazards, especially landslides, have been prepared of areas subject to development in the Vail area. The maps represent a highly professional application of geological principles to the assessment of slope-movement problems. Part of this field trip will be devoted to a field evaluation of the map units. The construction of Interstate Highway 70 through Vail Pass has proceeded through a number of unstable slope areas, including areas underlain by old landslide deposits. Investigative, construction, and performance evaluation techniques will be provided as background to the field inspection of the sites.

Registration will be limited to 60 to 70 participants, about equally divided between geologists and engineers. The registration fee for the conference is expected to be about $275, including lodging, meals, field trip, and transportation from Denver Stapleton Airport and return. Those interested in attending this conference should write to:

Robert W. Fleming, Engineering Geology Branch
U.S. Geological Survey, Mail Stop 903 KCG,
Box 25046
Federal Center, Denver, Colorado 80225.

Application deadline is July 1, 1977.

ABSTRACTS WITH PROGRAMS — VOLUME 9
(for 1977 meetings)

Issue no.		Prices nonmember	member*
1	**GSA South-Central Section** — El Paso, Texas, March 17–18	$2.50	$2.00
2	**GSA Southeastern Section and NAGT Southeastern Section** — Winston-Salem, North Carolina, March 23-25	$2.50	$2.00
3	**GSA Northeastern Section** — Binghamton, New York, March 31–April 2	$2.50	$2.00
4	**GSA Cordilleran Section, Pal Soc Pacific Coast Section, and Seismological Society of America** — Sacramento, California, April 5–7	$2.50	$2.00
5	**GSA North-Central Section, Pander Society, and Pal Soc North-Central Section** — Carbondale, Illinois, April 28–30	$2.50	$2.00
6	**GSA Rocky Mountain Section** — Missoula, Montana, May 12–13	$2.50	$2.00
7	**Annual Meetings:** Geological Society of America, Paleontological Society, Mineralogical Society of America, Society of Economic Geologists, Geochemical Society, National Association of Geology Teachers, Geoscience Information Society, Society of Vertebrate Paleontologists, and Cushman Foundation — Seattle, Washington, November 7–10	$7.00	$5.50

*Member price is extended to all GSA members who wish to buy an issue in addition to the issues for one section meeting and for the Annual Meeting which they receive as part of their membership with Options B through E, or all issues through Option F. No *Abstracts with Programs* are included with Option A.

Member price is also extended to all members of affiliated societies and to nonmember authors for the issue(s) in which they have an abstract. Member price is net.

All others who order single issues are extended the nonmember price, which is subject to a five percent discount when payment accompanies the order. Postage and handling charges are absorbed by GSA on ALL prepaid orders.

Prices subject to change without prior notice.

A New Opportunity for Academic Space Experiments

NASA's LDEF (the Long Duration Exposure Facility) will offer scientists a new opportunity for space research. LDEF is a large passive unmanned structure on which over 70 separate self-contained experiment packages will be mounted. It will be carried aloft by the Space Shuttle Transportation System, left to orbit the Earth for a number of months, then retrieved, brought back to Earth, and the experiments returned to their owners for analysis. LDEF offers prolonged exposure to the conditions at its 300 n.mi. orbital altitude: weightlessness, extreme vacuum, high particle and radiation fluxes. A unique feature is the return of materials and instruments at the end of the mission.

The Universities Space Research Association (USRA) has been given the task of seeking worthwhile experiments for LDEF in all fields of science and technology, particularly from academic scientists. NASA will provide preflight acceptance testing, orbital flight, and return for experiments endorsed by USRA. Experimenters will need to secure research funding. USRA will assist in this and in all phases of experiment development and management, where necessary.

Write:

USRA
Dr. M. H. Davis
P.O. Box 3006
Boulder, CO 80307 (303) 449-3414

Book reviews

Geologic Map of the Grand Canyon National Park, Arizona

Published by the Museum of Northern Arizona and the Grand Canyon Natural History Association, 1976. $3.95.

This nearly wall-size (3½ x 5 ft) multicolored map, published jointly by the Museum of Northern Arizona and the Grand Canyon Natural History Association, is a work of striking beauty as well as notable utility. The map represents an entirely new compilation and supersedes and enlarges upon the Grand Canyon geologic map, prepared by J. H. Maxson, that was published a decade ago by the Grand Canyon Natural History Association. The new map, which includes Marble Canyon to the northeast, benefits from more intensive field work, more river trips into side canyons, and participation by more geologists with special interests. This map represents an ambitious project.

The base map, which encompasses approximately 200 sq km, is shown as grayline background and was reproduced from the U.S. Geological Survey 1:62,500 scale topographic map of Grand Canyon National Park and Vicinity, Arizona (ed. 1962). The geologic map scale (1:62,500) is especially suitable for this project as it avoids major problems in portraying the geologic details of canyon walls; however, size may limit the map's use to classroom and library. Contours are shown at 80-foot intervals and are supplemented in some areas by 40-foot contours. Eight structure cross-sections are shown, two at a yard or more in length, with the vertical scale plotted at map scale.

The map is easily read despite the considerable amount of detailed information contained, thanks in part to careful plotting of geologic boundaries with respect to steep topography. The printing is clean and in good register and the colors, combined with various patterns for some units, are pleasing. Proofing the map has been well done; detailed search will reveal only a few cartographic infelicities (that is, several small patches of ground enclosed by contacts where color was omitted or misrepresented, a few cross-section location lines that do not match precisely with corresponding structure sections).

Thirty-one rock units are distinguished that range in age from Early Precambrian to Triassic; Cenozoic rocks, surficial and largely unconsolidated, are divided into four units. Known and inferred faults are shown clearly and most are designated by name. Estimated vertical offset of many faults is given in feet and unique symbols enable the reader to distinguish between Precambrian and Paleozoic offsets. Trends and names of monoclines are shown, with estimated vertical offset across each fold given in feet; the lengths of arrows perpendicular to monoclinal trends indicate map distances between the anticlinal and synclinal hinges on the land surface. Trends of three generations of Older Precambrian folds are depicted (F_1, F_2, and post-F_2); metamorphic grade is also noted in places, symbolized as lower, middle, and upper amphibolite facies. Among other structural features identified are grabens and prominent breccia pipes.

The stratigraphic nomenclature that is used reflects revisions of the last decade or so. In the Older Precambrian complex, Vishnu Group supplants Vishnu Schist, and the name "Brahma Schist," applied formerly to metavolcanic rocks, has been dropped. The Younger Precambrian units in Grand Canyon are divided into the long-standing Unkar and Chuar Groups which are separated stratigraphically by the Nankoweap Formation, renamed recently from Nankoweap Group. The basal unit of the Unkar Group, known until recently as the Bass Limestone, is referred to as the Bass Formation. Several other Precambrian stratigraphic name revisions can be noted as well. The latest revision in Grand Canyon stratigraphy, the raising in rank of the Supai Formation to Supai Group, was formulated just in time to be included on the map. The Supai Group is divided into four formations that range in age from Early Pennsylvanian to Early Permian (McKee, Edwin D., 1975, The Supai Group—subdivision and nomenclature: U.S. Geol. Survey Bull. 1395-J).

There are several seemingly arbitrary revisions in nomenclature and inconsistencies in lithologic notation. Each of three units of the Unkar Group (Younger Precambrian) is designated formally as a "Formation" even though the respective rock type is identified formally in the unit name in current literature (that is, Hakatai Shale, Shinumo Quartzite, Dox Sandstone). Nevertheless, the rock types of this group—except for the Bass Formation—are noted informally following the formation names in the map explanation. On the other hand, the rock types are not given for the overlying Nankoweap Formation and Chuar Group. Some brief lithologic notation for the rest of these Younger Precambrian units, as was used for all of the Older Precambrian units, would be helpful. In addition, failure to designate the Younger Precambrian section as the Grand Canyon Supergroup (known formerly as the Grand Canyon Series) and the Cambrian section as the Tonto Group is inexplicable.

The map explanation does not impart the known series subdivisions of the various time-stratigraphic systems (that is, Lower, Middle, and Upper). This could have been readily accomplished by allocation of a little more space for the explanation. Finally, the younger of the two great unconformities in Grand Canyon is referred to as Great Unconformity, which appropriately follows customary nomenclature for the Precambrian-Cambrian unconformity. As this term appears in the map explanation, however, it implies a generic distinction relative to the older unconformity that forms where the Younger Precambrian section rests on metamorphosed basement rocks, a distinction in Grand Canyon, based at least on radiometrically determined ages, that probably not many geologists would care to defend.

The geologic map is intended to accompany a major new book on Grand Canyon geology (published concurrently by the publishers of the map) which has been redesigned and extensively revised and enlarged from the first edition published in 1974. Edited by William J. Breed and Evelyn Roat, the 186-page volume summarizes the work and views of thirteen specialists. It reviews the geology and literature and provides discussions of current problems and controversies, some for the first time. Divided among five chapters, the topics range from recent work on the metamorphic rocks of the Inner Gorge to the rock sequences of Younger Precambrian, Paleozoic, and Mesozoic ages, to post-Paleozoic structural geology, along with studies of surficial deposits and processes. A total of 227 references are cited. This book is nicely done, with many illustrations and easily read printing on good paper. There is a handsome watercolor painting of a Canyon scene reproduced on its soft cover.

The authors of the geologic map are Malcolm D. Clark, R. Scott Babcock, and Edwin H. Brown (Older Precambrian geology); William J. Breed, James W. Sears, and Trevor D. Ford (Younger Precambrian geology); George H. Billingsley, Jr. (Paleozoic and younger stratigraphy); and Peter W. Huntoon (post-Paleozoic structural geology). In addition, seven other authorities assisted in the preparation of the map. All participants in this project, including the Williams and Heintz Map Corporation, deserve warm thanks and congratulations for the excellence of the work. They have produced a milestone contribution to publications on Grand Canyon geology.

The geologic map, and also the book (entitled *Geology of the Grand Canyon*), can be purchased from the Museum of Northern Arizona, Route 4, Box 720, Flagstaff, Arizona 86001. Prices are $3.95 for the map and $5.00 for the book.

P. T. Moyer

Bibliography and Index of Colorado Geology 1875 to 1975

Compiled by the American Geological Institute. Published by the Colorado Geological Survey, Bulletin 37, 1976. $10.00

The publication represents the first state bibliography and index to be compiled by the American Geological Institute, utilizing its computer-based data collection system, GeoRef. The resulting work contains more than 12,000 references to Colorado geological literature published between 1875 and January 1, 1975. A really comprehensive bibliography for Colorado had not been published since 1914 (as Colorado Geological Survey Bulletin 7). The importance of this new compilation assuredly will not be overlooked by potential users of AGI's computerized service.

The volume consists of four sections: (1) Bibliography, (2) Subject Index, (3) County Index, and (4) Rock-Unit Index. The reader is also provided with three full-page maps showing county names and locations, generalized geology, and major structural and tectonic features. References such as open-file reports of various governmental agencies have not been included, nor have articles from most trade and industrial journals. Moreover, no attempt was made to screen the listings as to scientific importance. The Colorado Geological Survey provided many of the source materials and intermediate review of the work.

The overall format and indexing system follow that of the Geological Society of America's *Bibliography and Index of Geology*, which is a derivative of the U.S. Geological Survey's *Bibliography of North American Geology* and the Geological Society of America's *Bibliography and Index of Geology Exclusive of North America*.

The bibliographic materials in this volume are now included in GeoRef's magnetic-tape file and are available through normal lease and purchase programs and through contracts for bibliographic search.

This long-awaited new edition of Colorado's geological bibliography and index will serve as a model and inspiration for other such bibliographic projects. The Colorado Geological Survey and the American Geological Institute are to be congratulated, as are several Colorado geologist legislators whose legislative efforts helped obtain funding for this project.

P. T. Moyer

BOOK BRIEFS

This feature is included occasionally in the News & Information section to keep members informed of recent books published by the Society.

Quantitative Studies in the Geological Sciences, A Memoir in Honor of William C. Krumbein

MEMOIR 142 — edited by E. H. Timothy Whitten. 1975. xviii + 406 pages, 138 figures, 60 tables, 4 plates. ISBN: 0-8137-1142-8. $31.00.

This volume is dedicated to William C. Krumbein, professor emeritus at Northwestern University. For the past two decades, Krumbein has been especially instrumental in the transition from the traditional qualitative and descriptive approach to geologic problems to the more rigorous and objective analysis of Earth science problems. Each of the papers reflects the impact of some aspect of Krumbein's research and teaching. They are loosely grouped under six headings: (1) stratigraphic, sedimentary, and paleontological topics (5 papers); (2) sediment transport (3 papers); (3) geophysics and hydrodynamics (3 papers); (4) geochemistry (3 papers); (5) petrology (3 papers); and (6) statistical methodology (6 papers). The range of subject matter is large.

It is appropriate that this volume include both a selection of specific *applications* of objective quantitative techniques to clearly defined Earth science problems and a group of *methodological* papers. Of particular interest in the latter group is Watson's paper, which reviews and develops in detail the mathematics underlying the exciting new work in stereology; recent developments (mainly by French scientists) have demonstrated the importance of stereological techniques to the quantitative study of sedimentary and other particulate rocks. This work, and other methodological research, is likely to be a forerunner of the next cycle of advance in objective, quantitative, and qualitative Earth science.

Contributions to the Stratigraphy of New England

MEMOIR 148 — edited by Lincoln R. Page. 1976. vi + 446 pages, 131 figures, 41 tables. ISBN: 0-8137-1148-7. $30.00.

This volume, containing 22 papers, is an outgrowth of a symposium organized by Page for the Northeast Section meeting of the Geological Society of America held in Hartford, Connecticut, in 1971. The symposium emphasized the Massachusetts and Connecticut areas and the more recent work done in Maine. Thus, the work complimented the then recently published "Billings volume" edited by Zen and others (Interscience Publications, New York, 1968) which contains many excellent papers that thoroughly describe the stratigraphy of many parts of New England, particularly in Vermont, New Hampshire and Maine.

The individual papers present detailed information on each of the major north- and northeast-trending structural units. These are, from west to east, the Green Mountain anticlinorium, the Connecticut-Gaspe synclinorium, the Bronson Hill–Boundary Mountains anticlinorium, and the Merrimack synclinorium. The papers also point out some of the major fault zones that truncate these units.

Some of the areas described have a stratigraphy based on fossils, but most of the areas have been so highly metamorphosed that the stratigraphy must be based on superposition determined from relict primary structures and field relations. Where lithologic similarity has been used as the primary basis for correlation, the resulting interpretations yield very complex or improbable structures. The presence of minor folds within units is common and suggests the presence of larger folds of similar pattern, although few such folds show in the map patterns. This is particularly evident on the east side of the Berkshires in Massachusetts where the rocks of Silurian-Devonian age are isoclinally folded on a broad scale but their lower contact, for many kilometres, is not folded. Skehan and Abu-moustafa discuss places, such as in the Wachusett-Marlborough Tunnel, where it is evident that many minor folds, particularly those with folded foliation, are related to regional faulting, not folding, and are postmetamorphic in age. Other folds with axial plane foliation are related to regional folding or to faulting during the Acadian orogeny.

The most important contributions to stratigraphy in this volume are the individual stratigraphic sections developed for each area. New data on thickness of section, lateral and vertical facies changes, lack of repetition of major lithologic sequences, and observed unconformities have a direct bearing on the solution of some of the more important regional stratigraphic problems, such as (1) the nature of the Precambrian-Cambrian boundary, (2) the lateral and vertical facies changes along the limestone bank or reef that existed in western New England in Cambrian and Ordovician time, (3) the facies changes within the submarine volcanic rocks that predominate to the southeast of this bank, (4) correlation of rock sequences of Ordovician and older age, (5) distribution and source of rocks of Silurian and Devonian age, and (6) variations in relative and radiometrically determined ages.

Pavlides, Dixon, Zen, and Hatch and Stanley had previously published definitive papers on the areas considered and present discussions here pointing out contrary points of view. B. A. Hall, Pollock, and Dolan add materially to an understanding of the upper part of the stratigraphic section; Goldsmith has done the same for the lower part.

Caribbean Gravity Field and Plate Tectonics

SPECIAL PAPER 169 — by Carl Bowin. 1976. viii + 80 pages, 19 figures (including 2 maps in color folded in pocket). ISBN: 0-8137-2169-5. $12.00.

The purpose of this paper is to present a new compilation of the gravity field and to examine the boundaries of the Caribbean lithospheric plate in order to assess geologists' ability to define and interpret the plate-boundary configurations in the area as they exist today. Gravity anomalies, topography, volcanoes, seismicity, and the terrestrial flow of heat are inferred to be indicators of present tectonic activity, and maps illustrating these parameters are presented.

Free-air gravity anomalies in the Caribbean region are among the largest in the world, ranging from −355 mgal north of Puerto Rico over the Puerto Rico Trench to greater than +200 mgal on the adjacent Greater Antilles. Although large positive and negative free-air anomalies are associated with portions of the margins of the Caribbean lithospheric plate, the interior regions of the Caribbean and Atlantic plates generally have anomalies within ±50 mgal of zero and hence are close to being in isostatic equilibrium. The Cayman Trough also is in nearly isostatic equilibrium, which is compatible with its origin by seafloor spreading. Variations of the gravity field are interpreted to indicate that the easternmost end of Cuba, Jamaica, parts of Hispaniola, Puerto Rico, the Lesser Antilles, the Sierra Nevada de Santa Marta, the Eastern, Central, and Western Cordillera of the Colombian Andes, the Coast Range of Colombia, central Panama, and the Nicoya Peninsula of Costa Rica are sites of mass excess and are probably being uplifted. Mass deficiency in the eastern Caribbean is associated with the negative anomaly belt east of the Lesser Antilles, and the east-trending zones along the Puerto Rico Trench north of Puerto Rico and in eastern Venezuela and Trinidad. The mass deficiency east of the Lesser Antillean island arc is due to the underthrusting of the Atlantic plate beneath the arc. It is inferred that compressive forces across transform faults may be responsible for the east-trending negative free-air anomalies. These anomalies may result, north of the Greater Antilles, from depressed lithosphere caused by a former period of underthrusting and, in Trinidad and eastern Venezuela, from a viscoelastic downwarping of the crust. Differential motion between the North and South American plates is inferred to explain the compression across the transform faults bordering the eastern part of the Caribbean plate.

Local variations in topography, gravity anomalies, seismicity, and heat flow along the borders of the Caribbean plate, as well as the lack of consistency in location of the major variations between the data sets, suggest that some degree of nonrigid deformation is important locally in the development of some of the plate boundaries; the cause of this variability is not well known.

Shallow-Level Plutonic Complexes in the Eastern Sierra Nevada, California, and their Tectonic Implications

SPECIAL PAPER 176 — by Richard A. Schwickert. 1976. vi + 58 p., 15 figures, 5 tables. ISBN: 0-8137-2176-8. $7.50.

Twelve plutons and several related volcano-plutonic complexes of probable Early Jurassic age form the main topic of this paper and are the first of their kind to be described in the Sierra Nevada region. The data relate to evidence that the Sierra Nevada region records the superposition of two distinct Andean-type arcs during Mesozoic time, the older having been buried and contact metamorphosed by the younger.

The related sequences of plutonic and metavolcanic rocks of probable Early Jurassic age occur between Lake Tahoe and Mono Lake in the eastern Sierra Nevada and Sweetwater Range, California. The plutons, 1.5 to 50 km^2 in areal extent, solidified at very shallow levels; some broke through to the surface to erupt compositionally similar pyroclastic rocks and lava flows. The older felsic plutons in the drainage area of the West Walker River are composed predominantly of quartz monzonite. Unlike the younger plutons that cut them, the older plutons have been extensively altered. Two of the older felsic bodies, the China Garden pluton and the Desert Creek pluton, are discussed in detail. The four small mafic plutons that lie in the Sweetwater Range between the east and west forks of the Walker River predate and are intruded by all felsic plutons that surround them. Compositions range from mafic quartz diorite to olivine gabbro or troctolite. The West Walker pluton and the Swauger Creek pluton are discussed. K-Ar analyses of 12 biotite and hornblende separates from 10 samples collected from five of the plutons yield ages that fall in the range of 76 to 93 m.y.

The pre-Cretaceous volcano-plutonic complexes are part of a terrane of shallow-level mafic and felsic intrusions and remnants of metamorphosed sedimentary and volcanic rocks, all of probable Late Triassic to Middle Jurassic age, that extends the length of the Sierra Nevada in eastern California and Nevada. The felsic plutons form a low-quartz and high-K_2O group that is modally and chemically distinct from Upper Jurassic and Cretaceous plutons that occur locally among them and that also form the main expanse of the Sierra Nevada batholith to the west. The extent and arrangement of this easterly terrane suggest that it is part of an Andean-type magmatic arc that developed between Late Triassic and Middle Jurassic time in eastern California and western Nevada, generally east of the site of the second, much larger, magmatic arc that developed mainly in Cretaceous time. Triassic and Jurassic subduction linked to the evolution of this older arc probably occurred in the foothills of the western Sierra Nevada. Later subduction of the Franciscan Complex in the California Coast Ranges was linked to Sierra Nevada plutonic activity that occurred after Middle Jurassic time.

March BULLETIN briefs

Brief summaries of articles in the March 1977 GSA Bulletin *are provided on the following pages to aid members who chose the lower dues option to select* Bulletin *separates of their choice. The Document Number of each article is repeated on the coupon and mailing label in this section.*

☐ 70301—Stratigraphy and structure of the Saddlebag lake roof pendant, Sierra Nevada, California. *Charles A. Brook, Department of Geology, California State University, Fresno, Fresno, California 93710 (present address: U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025)* (14 p., 4 figs., 3 tbls.)

Geologic mapping of the southern part of the Saddlebag Lake roof pendant, east-central Sierra Nevada, California, reveals three rock sequences that have been multiply deformed. The oldest sequence consists of the metamorphosed equivalents of marine sedimentary rocks of Silurian(?)-Ordovocian(?) age. Metamorphosed volcanic and volcaniclastic rocks and basal conglomerate (possibly in part continental) of Permian age unconformably overlie the older sequence. Another metavolcanic and metasedimentary sequence of unknown age, here designated Permian(?)-Triassic(?), and of uncertain boundary relationships with the two older sequences crops out in the southern part of the pendant.

Field observations of minor structures and structural analysis indicate that rocks of the Silurian(?)-Ordovician(?) sequence have undergone three episodes of deformation, whereas the Permian and Permian(?)-Triassic(?) rocks have been affected by only the later two deformations. Axial surfaces of folds formed during the first deformation had an original strike of approximately north but have been largely reoriented by later folding. Structures attributed to the first deformation occur only in the Silurian(?)-Ordovician(?) sequence. Axial surfaces of folds formed during the second deformation strike N21°W and are the first-formed folds in the Permian and Permian(?)-Triassic(?) sequences. All rock sequences were subsequently refolded around axial surfaces striking N61°W.

Superimposition relationships and trends of fold systems in the Saddlebag Lake roof pendant are comparable with those in other roof pendants of the central Sierra Nevada. This suggests that the deformations were episodic and regional in scale. Ultimate tectonic causes for each deformation may have been different.

☐ 70302—Superimposition and timing of deformations in the Mount Morrison roof pendant and in the central Sierra Nevada, California. *Stephen Russell, Warren Nokleberg, Department of Geology, California State University, Fresno, California 93740.* (11 p. 13 figs., 5 tbls.)

The Mount Morrison roof pendant, the only roof pendant in the central Sierra Nevada containing Paleozoic fossils, is complexly deformed and contains three generations of structures, including folds, reverse faults, schistosities, and lineations. All three generations of structures occur in the Ordovician-Silurian(?) metasedimentary rocks, whereas only the younger two are recorded in the Pennsylvanian-Permian(?) metasedimentary rocks and the Permian(?)-Jurassic(?) metavolcanic rocks. The average strike directions of axial planes of folds are north-south, N25°W, and N60°W in the first, second, and third generations, respectively. Generations of structures having similar styles, orientations, and relative age relations occur in other pendants of the central Sierra Nevada.

The pendant is interpreted as a thin sequence with tight isoclinal folds instead of a thick homoclinal sequence. The first deformation occurred during Devonian or Mississippian time, perhaps during the Antler orogeny. Uplift, erosion, and volcanism occurred in Late Permian time between the first and second deformations, perhaps as an expression of the Sonoma orogeny. The second generation structures formed in several pulses between Early Triassic and Early Cretaceous time, as indicated by temporal relations between deformed wall rocks and younger, crosscutting granitic plutons. The third generation structures formed between Early and Late Cretaceous time, during which these structures were crosscut by granitic rocks.

The wall rocks of the batholith may form an anticlinorium instead of a synclinorium. Other roof pendants in the axial portion of the batholith may be relatively old, because they contain the same three sets of structures as found in the Ordovician-Silurian(?) rocks of the Mount Morrison roof pendant. Locally, various age belts of granitic rocks have shielded roof pendants from subsequent deformation.

☐ 70303—Tectonic structures on the Juan de Fuca Ridge. *E. E. Davis, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139; C.R.B. Lister, Geophysics Group and Department of Oceanography, University of Washington, Seattle, Washington 98195.* (18 p., 14 figs., 3 tbls.)

The northern Juan de Fuca Ridge is an actively spreading part of the East Pacific Rise system that is flooded with young turbidite sediments from the nearby continental margin. A detailed geophysical survey was completed at the intersection of the ridge with the Sovanco Fracture Zone. North-south and east-west seismic reflection profiles, spaced 10 km apart on a grid 110 km on a side, were taken with a medium-frequency (200 Hz) electromagnetic source. Profiles give as much as 1.5 sec of penetration, yet show very detailed structure in the turbidite layering. The ridge-crest area is typified by its two axial valleys and associated normal-fault blocks rotated away from the crest. These fault blocks, made strikingly visible by the once-horizontal turbidites, range in horizontal dimension from less than 1 km to 8 km, and they are rotated as much as 8°. Normal faults are clearly visible in the sediments of the axial valley (Middle Valley) as discontinuities along acoustic reflectors. These faults dip toward the center of the valley at angles from about 45° to nearly vertical (>80°). Of the two axial valleys, only one (West

Valley) is currently active. Profiles and bottom photographs show pillow basalt cropping out over most of the West Valley floor, but some rifted sediments exist as well. The second axial valley is completely sediment filled (sediment thickness as much as 3.0 km), and although clearly visible normal faults extend through the full section seen in the profiles, extensional rates calculated on these faults are only about 0.2 cm/yr. Over the rest of its length, the Juan de Fuca Ridge crest has no significant axial valley. Only on its northern end near its intersection with the Sovanco Fracture Zone does it develop an axial valley. Similar observations have been made on the Explorer Ridge and on the East Pacific Rise, Gulf of California. Other observations of axial valleys in general—namely, the nonisostatic relief of the valleys, their dependence on spreading rate for generation, and the formation and rotation of normal-fault blocks away from the valley floors—all seem best explained by a passive mechanism where complete crust and upper mantle accretion occurs by passive intrusion over a zone wider than the width of the initial formation of a rigid surface layer.

☐ 70304—Alternative derivation of the minimum variance hypothesis. *A. D. Knighton, Department of Geography, University of Sheffield, Sheffield S10 2TN, England.* (3 p.)

In view of criticisms leveled at the original derivation, an alternative approach based on well-defined Euclidean space concepts is used to derive Langbein's minimum variance hypothesis. Changes in stream behavior at a channel cross section are considered here. The main assumption of this alternative method is that the stream will approach or converge to a limit or quasi-equilibrium state through a sequence of channel adjustments. By arguing in Euclidean space terms, the minimum variance hypothesis is shown to be a special case of a more general problem, and I suggest that further development of the model should concentrate on this more general formulation.

☐ 70305—Upper Cretaceous–Paleocene magnetic stratigraphy at Gubbio, Italy. I. Lithostratigraphy and sedimentology. *Michael A. Arthur and Alfred G. Fischer, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540.* II. Biostratigraphy. *Isabella Premoli Silva, Istituto di Paleontologia, University of Milan, Italy.* III. Upper Cretaceous magnetic stratigraphy. *William Lowrie, Institut für Geophysik, ETH-Hönggerberg, CH-8049, Zürich, Switzerland; Walter Alvarez, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964.* IV. Upper Maastrichtian–Paleocene magnetic stratigraphy. *William M. Roggenthen, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540; Giovanni Napoleone, Istituto di Geologia e Paleontologia, Via Lamarmora, 4, Florence, Italy.* V. Type section for the Late Cretaceous–Paleocene geomagnetic reversal time scale. *Walter Alvarez, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964; Michael A. Arthur and Alfred G. Fischer, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540; William Lowrie, Institut für Geophysik, ETH-Hönggerberg, CH-8049, Zürich, Switzerland; Giovanni Napoleone, Istituto di Geologia e Paleontologia, Via Lamarmora, 4, Florence, Italy; Isabella Premoli Silva, Istituto di Paleontologia, University of Milan, Italy; William M. Roggenthen, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540.* (23 p., 11 figs., 5 tbls.)

An essentially complete section of mid-Cretaceous to Paleocene calcereous pelagic sediments is exposed at Gubbio in the Umbrian Apennines of Italy. Biogenic coccolith-globigerinid oozes were deposited along with a constant but low background of fine terrigenous detritus at a mean sedimentation rate (compacted) of 6.6 m/m.y. from Albian to Eocene time. The upper Santonian to upper Paleocene sediments yield a remarkably continuous succession of rich planktic foraminiferal faunas, providing the biostratigraphic framework for the geomagnetic reversal sequence observed in the same section. Paleomagnetic study of the Upper Cretaceous part of the Scaglia Rossa pelagic limestone in the section at Gubbio yielded a sequence of magnetic polarity zones that corresponds precisely with the polarity sequence inferred from marine magnetic anomaly profiles. Independently studied pelagic limestones ranging in age from mid-Maastrichtion through Paleocene yield several well-defined magnetic polarity zones which are tied to the planktic foraminiferal zonation at this site and are correlated with magnetic anomalies 26 through 31.

Because of these favorable results, the Gubbio locality is formally proposed as the magnetostratigraphic type section for the Upper Cretaceous and Paleocene.

☐ 70306—Model of climate evolution based on continental drift and polar wandering. *William L. Donn, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964, and City College, New York, New York 10031: David M. Shaw, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964.* (7 p. 7 figs., 1 tbl.)

The thermodynamic meteorologic model of J. Adem is used to trace the evolution of climate from Triassic to present time by applying it to changing geography as described by continental drift and polar wandering. Results show that the gross changes of climate in the Northern Hemisphere can be fully explained by the strong cooling in high latitudes as continents moved poleward. High-latitude mean temperatures in the Northern Hemisphere dropped below the freezing point 10 to 15 m.y. ago, thereby accounting for the late Cenozoic glacial age. Computed meridional temperature gradients for the Northern Hemisphere steepened from 20° to 40°C over the 200-m.y. period, an effect caused primarily by the high-latitude temperature decrease. The primary result of the work is that the cooling that has occurred since the warm Mesozoic period and has culminated in glaciation is explainable wholly by terrestrial processes. However, comparison of computed Mesozoic temperatures for North America with observed conditions shows that more polar wander is required than is included in the geography reconstructed primarily on the basis of continental drift.

☐ 70307—Rb-Sr and K-Ar geochronometry of Mesozoic granitic rocks and their Sr isotopic composition, Oregon, Washington, and Idaho. *Richard Lee Armstrong, Department of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1W5; William H. Taubeneck, Peter O. Hales, Department of Geology, Oregon State University, Corvallis, Oregon 97331. (Hales, present address: Gulf Oil Company, P.O. Box 1392, Bakersfield, California 93302)* (15 p., 10 figs., 1 tbl.)

Mesozoic orogeny and magmatism began in the northwestern United States soon after deposition of Permian strata, but no rocks have yet been dated from the Permian-Triassic orogenic period. Middle Triassic to Late Jurassic sediment sequences include major unconformities and evidence of several episodes of igneous activity. An early culmination of magmatism occurred in Late Triassic and Early Jurassic time (200–217 m.y. ago) in eugeosynclinal parts of far western Idaho. A widespread and intense culmination in Late Jurassic time was the final major orogenic event in the Oregon eugeosyncline. The Bald Mountain (147 to 158 m.y. old), Wallowa (probably 143 to 160 m.y. old but affected by Cretaceous metamorphism), Deep Creek (at least 137 m.y. old), and many other plutons in the Blue and Klamath Mountain regions in Oregon and in western Idaho were emplaced shortly before the end of Jurassic. The bulk of the Idaho batholith was emplaced during a Cretaceous culmination of igneous activity—the southern (Atlanta) lobe about 75 to 100 m.y. ago and the northern (Bitterroot) lobe about 70 to 80 m.y. ago. Much of the batholith was affected by Eocene magmatism which resulted in widespread resetting of isotopic dates for older rocks to values of 50 m.y. or less. Between 55 and 70 m.y. ago, there was a lull in igneous activity in the northwestern United States.

Sr isotope initial ratios change abruptly across a boundary in western Idaho from $\sim$0.7040 or less, to the west, to $\sim$0.7060 or greater, to the east. This change marks the boundary between Precambrian crust and Phanerozoic eugeosyncline. The geologic setting of the observed transition of its time independence suggests that it is due to contamination and assimilation processes involving magmas from the mantle and enclosing crustal rocks. Contamination of magmas with radiogenic Sr renders the Sr whole-rock isochron technique useless in dating the Idaho batholith and other intrusive rocks in central and eastern Idaho, areas underlain by Precambrian basement.

☐ 70308—Upraised Pacific Ocean floor, southern Malaita, Solomon Islands. *G. Wyn Hughes, Mineral and Water Resources Division, Ministry of Natural Resources, Honiara, Solomon Islands (present address: Department of Geology, University of Wales, Aberystwyth, Dyfed, Wales, SY23 30B, United Kingdom); Colin C. Turner, Overseas Division, Institute of Geological Sciences, 154 Clerkenwell Road, London, ECIR 5DU, Great Britain (present address: Mineral and Water Resources Division, Ministry of Natural Resources, Honiara, Solomon Islands).* (13 p., 10 figs., 2 tbls.)

Oceanic tholeiitic basalt flows of probable Early Cretaceous age form the basement rocks exposed in the southern half of Malaita and also on adjacent Small Malaita in the Solomon Islands. In the northern part of the area, these are conformably overlain by as much as 270 m of siliceous mudstone. This appears to wedge out farther south, where Upper Cretaceous to Eocene pelagic limestone containing chert horizons is found conformably overlying the basement tholeiites. Similar limestones with chert horizons also conformably succeed the siliceous mudstone in the north.

In this Upper Cretaceous to Eocene limestone in the south, thick horizons of oceanic alkalic basalt are found that differ from the basement tholeiite in micropetrography as well as in having higher TiO_2, P_2O_5, and total alkali percentages. Oligocene to Pliocene pelagic limestones conformably overlie the older limestone throughout the whole area.

Folding and uplift occurred during Pliocene time, and Pleistocene reef limestones and conglomerates were formed in places during the final emergence of the islands. The pre-Pleistocene succession shows close similarities with those discovered in nearby ocean-floor boreholes.

It is evident that Malaita is a part of Pacific Ocean floor that has a very similar stratigraphic succession to the Ontong Java Plateau to the north and probably originated somewhat to the east of its present position. Subduction of the Pacific plate along a southwest-dipping Benioff zone on the north side of the Solomons may possibly have occurred in pre-Miocene times, until it was blocked by the thick oceanic crust of the Ontong Java Plateau. Further subduction may then have occurred on the south side of the Solomons, along a steep northeast-dipping seismic zone, which is, at least in part, still active today.

☐ 70309—Carbonate platform facies and new stratigraphic nomenclature of the Morrowan Series (Lower and Middle Pennsylvanian), northeastern Oklahoma. *Patrick K. Sutherland, School of Geology and Geophysics, University of Oklahoma, Norman, Oklahoma 73019; Thomas W. Henry, U.S. Geological Survey, Reston, Virginia 22092.* (16 p., 15 figs.)

Marine carbonates dominate the Morrowan Series in northeastern Oklahoma and contain abundant megafossils in beds that correlate with sparsely fossiliferous strata in the type area of the series in Arkansas. Greatly refined biotic zonations are feasible for brachiopods, coelenerates, and pelmatozoans, all sparsely represented in northwestern Arkansas. The type area should be extended 64 km (40 mi) westward to include this highly fossiliferous facies.

A regional unconformity within the Morrowan Series in northeastern Oklahoma and northwestern Arkansas occurs at the base of the Dye Shale Member (Bloyd Shale) in Arkansas and separates the Sausbee Formation from the overlying McCully Formation (both new names) in Oklahoma. The Sausbee Formation (Lower Pennsylvanian) is divided into the Braggs and Brewer Bend Limestone Members (both new names), correlating eastward with the Hale Formation plus the Brentwood Limestone and Woolsey Members of the Bloyd Shale. The McCully Formation (lower Middle Pennsylvanian) includes the Chisum Quarry, shale "A," Greenleaf Lake Limestone, and shale "B" members (all new names) and correlates with the Dye Shale Member and possibly the Kessler Limestone and Trace Creek Shale Members (upper Bloyd Shale) in Arkansas.

The Sausbee Formation represents marine transgression across an irregularly eroded surface cut into Mississippian strata, followed by widespread, shallow, open-marine carbonate deposition (Braggs Member). The shelf subsequently shoaled, and a widespread carbonate mudbank developed (Brewer Bend Limestone Member). This regressive cycle terminated with regional emergence of the shelf and limited erosion.

The McCully Formation was subsequently deposited on the resubmerged shelf, with periodic, widespread influxes of terrigenous mud from the northeast (shale "A" and shale "B" members), which prevented normal carbonate deposition except in limited areas (Chisum Quarry and Greenleaf Lake Limestone Members).

Morrowan to Atokan deposition was continuous in

Arkansas and easternmost Oklahoma, but a regional tilting to the south in the area west of Tenkiller Reservoir produced subareal erosion of the post-Morrowan surface in that area. Fluviatile and deltaic complexes of early Atokan age were deposited on the erosional surface and were derived from the northwest, in contrast to a predominantly northeastern terrigenous source during the time of deposition of the Morrowan series.

☐ 70310—Rb-Sr isochron age of the Precambrian basement complex, Bighorn Mountains, Wyoming. *Alan M. Stueber, Department of Geology, Miami University, Oxford, Ohio 45056; Richard A. Heimlich, Department of Geology, Kent State University, Kent, Ohio 44242.* (4 p., 2 figs., 3 tbls.)

Rb-Sr analyses of 13 whole-rock samples of gneiss, quartz monzonite, and quartz diorite from the Precambrian basement complex in the Bighorn Mountains provide an isochron age of 2,849 ± 60 m.y. and an initial $^{87}Sr/^{86}Sr$ ratio of 0.7016 ± 0.0005. This age is interpreted as the time of regional metamorphism and metasomatism which produced the gneiss and the granitic rocks; independent isochron ages for both groups of rocks are not significantly different. The 2,850-m.y. age for the metamorphic event is consistent with other radiometric ages from the Bighorns and can be correlated with ages reported from several other mountain ranges in Wyoming.

☐ 70311—Gravity and magnetic investigations of the Sierra Nevada batholith, California. *Howard W. Oliver, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025.* (17 p., 6 figs., 3 tbls.)

Gravity data are now available for about 90 percent of the Sierra Nevada batholith, magnetic data for about 30 percent. About 1,000 density and 250 magnetic property measurements have been made on selected samples. Bouguer gravity anomalies decrease about 200 mgal, from −40 to −240 mgal, eastward across the batholith and gradually rise about 50 mgal on its east side. Gravity calculations show that these Bouguer anomalies are consistent with the general form of Bateman and Eaton's seismic model of the central Sierra Nevada and are inconsistent with the model of Carder and others. The calculations confirm Eaton's velocity-density relation for crystalline rocks. The major gravity step across the western Sierra Nevada is caused primarily by a mafic mountain root, not the batholith. Local anomalies of −5 to −40 mgal are associated with the most leucocratic felsic plutons. Correlation with available isotope ages shows the gravity anomalies to be largest and broadest over the youngest Cretaceous plutons, which suggests that they extend to greater depths than the older, exposed plutons.

Magnetic contrasts between plutons are generally much greater than density contrasts, and they provide a method for mapping some of the more magnetic plutons under some types of cover. The depth extent of magnetic plutons in Yosemite National Park is at least 7 km and probably greater. A regional magnetic low centered near the western edge of the Sierra Nevada correlates with a regional depression in the Curie isothermal surface, as evidenced by low surface heat flux. Because the depression in the isotherm allows for a greater thickness of material to be magnetic, the magnetic low is unexpected, and the relation is a noteworthy paradox.

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Bouguer gravity anomalies correlate fairly well with initial Sr^{87}/Sr^{86} ratios, and the magnetic field correlates with oxidation ratios of sampled granitic rocks. These data, together with physical property measurements of gneissic and peridotitic xenoliths discovered in volcanic pipes by J. P. Lockwood, form a foundation on which new models of the petrogenesis and structure of the batholith must be based.

☐ 70312dr—Late Cenozoic volcanism in the Aleutian Arc: Information from ash layers in the northeastern Gulf of Alaska: Discussion and reply. (3p., 1 fig.)

Discussion: *Chadderdon Price, Department of Geology, University of St. Andrews, St. Andrews. Fife, Scotland.*

Reply: *K. F. Scheidegger, L. D. Kulm, School of Oceanography, Oregon State University, Corvallis, Oregon 97331.*

☐ 70313—Structure, petrology, and petrogenesis of the Treasurevault stock, Mosquito Range, Colorado. *Mel A. Kuntz, Thomas N. Brock, Department of Geology, Amherst College, Amherst, Massachusetts 01002 (present addresses: Kuntz, U.S. Geological Survey, Federal Center, Denver, Colorado 80225; Brock, School of Applied Earth Sciences, Stanford University, Stanford, California 94305)* (15 p., 16 figs., 3 tbls.)

The Treasurevault stock intrudes highgrade metamorphic rocks approximately 10 km east of Leadville, Colorado, in the northern Mosquito Range. The stock is roughly circular in exposed plan and about 3 km in diameter. It consists of quartz monzonite that is remarkably uniform in mineralogical and chemical composition. Three textural facies occur in roughly concentric zones: medium-grained rocks occur between fine-grained rocks at the contacts and coarse-grained rocks near the center of the stock. Primary flow structure near the contact suggests that the upper part of the stock is hemispherical. Primary radial and diagonal joints are well developed near the contact. Both flow structures and joints probably formed just before and after consolidation as a result of compression perpendicular to contacts. The K-Ar age of the stock is 1,430 ± 45 m.y. (Precambrian Y), indicating emplacement during the Silver Plume magmatic event.

A model for the petrogenesis of the Treasurevault stock includes derivation of the parent magma by partial melting of lower crustal rocks at a depth of $\sim$40 km, emplacement of the magma due to gravitational instability to a depth of $\sim$10 km, and crystallization of most of the magma under conditions of water undersaturation. A water-saturated pegmatite magma developed after more than 97 percent of the stock had crystallized.

☐ 70314dr—Franciscan blueschist-facies metaconglomerates, Diablo Range California: Discussion and reply. (1 p.)

Discussion: *T. W. Bloxam, Department of Geology, University College of Swansea, Singleton Park, Swansea, Wales SA2 8PP, United Kingdom.*

Reply: *Jeremy B. Platt, J. G. Liou, Ben M. Page, Department of Geology, Stanford University, Stanford, California 94305. (Platt, present address: Electric Power Research Institute, 3412 Hillview Avenue, P.O. Box 10412, Palo Alto, California 94303).*

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