GSA news & information

FEBRUARY 1976

Fellowship/Membership? Your Opinion Please!

The Membership Committee has been instructed by the Council to poll your opinion on the present membership structure. Under current procedures, Fellowship is a special class of membership to which members may be elected if they fulfill the following requirements: (1) Society membership for at least one year; (2) at least eight years of experience in geology or related fields; and (3) demonstrated outstanding contribution in one or several of four general categories: research, administration, training of geologists, and other activities. A candidate for Fellowship must have three Fellows as sponsors who attest to the candidate's qualifications; final judgment on qualifications is determined by consensus of the Membership Committee.

Evaluation of Fellowship candidates constitutes one of the major functions of the Membership Committee. The committee gives thoughtful and conscientious consideration to each candidate's qualifications within the specified requirements. Owing to recent changes in the operation of the committee, it is timely to determine (1) the level of interest in maintaining the distinction between Member and Fellow and (2) opinions as to what requirements and procedures should be used to judge Fellowship if maintained as a distinct class.

Since this poll could result in a major change in membership structure and will be used by the Council for its guidance at its May meeting, your response is important.

Please complete the following form and return it to the Membership Department, Geological Society of America, 3300 Penrose Place, Boulder, Colorado 80301, by March 31.

— Andrew D. Baillie, Chairman 1975; Theresa F. Schwarzer, Chairman 1976; E. Julius Dasch, Diana C. Kamilli, William C. Kelly, Franklyn B. Van Houten

Please mail to headquarters before March 31.

A. The present dual class of membership (Member-Fellow) should be abolished. YES ☐ NO ☐

B. The current Fellowship requirements and procedures for election (three sponsors, Membership Committee review) should be changed. YES ☐ NO ☐

C. If Fellowship requirements and procedures are changed, the changes should be made in accordance with one of the following guidelines. CHECK ONE:

- ☐ (1) Fellowship requirements should be made more stringent.
- ☐ (2) Current Fellowship requirements should be more rigorously interpreted by sponsors and the Membership Committee.
- ☐ (3) Three sponsor endorsements, with no committee evaluation, would produce automatic Fellowship.
- ☐ (4) Fellowship should be automatic after a designated period of Society membership.

D. Other suggestions and comments:

I am a
☐ Student Associate
☐ Member
☐ Fellow

Penrose Conferences

Conference on "Hydrogeologic Regime of Inland Lakes" to convene in September 1976

A GSA Penrose Conference on "The Hydrogeologic Regime of Inland Lakes" will be convened by D. A. Stephenson and C.L.R. Holt, Jr., at Devil's Head Lodge, near Merrimac, Wisconsin, September 19-24, 1976.

The hydrogeologic regime of lakes must be adequately assessed in order to intelligently manage lakes and their related shorelands. The quantification of ground-water/surface-water relationships in lake environments is characterized by sparse information and, until recently, has received very limited attention. There is now emerging a nationwide interest in this topic by researchers that spans disciplines of the physical, biological, and social sciences.

This conference is proposed as a mechanism for assembling an interdisciplinary participant group who are likely to be, or to become, the prime movers in researching the conference topics. Some of the participants would be working in developing classification schemes for ground-water/lake-water relationships; others will be concerned with social-legal-economic aspects of lake protection and management; still others will be those who are concerned with identification of ground-water flow systems in lake environments. Collectively, all will share a major interest in identifying areas of needed research and stimulating the same.

The cost of the five-day conference, with a one-day field trip to view research/demonstration lake projects in Wisconsin, is expected to be between $225 and $250 per person, which includes the registration fee, meals, lodging, and field trips.

Attendance will be limited to 70 participants. Those interested in further information or in attending the conference should write to D. A. Stephenson, Environmental Resources Unit, 1815 University Avenue, Madison, Wisconsin 53706. Deadline for applications is May 15, 1976.

Conference on "Evaluation of Fault Activity"

A GSA Penrose Conference, "Evaluation of Fault Activity," is scheduled for September 26–October 1, 1976, at the Sierra Nevada Inn, Mammoth Lakes, California. Conveners are Duane R. Packer and George E. Brogan of Woodward-Clyde Consultants.

This conference will focus upon the determination of recurrence of surface faulting and related earthquakes for individual faults and regions, including identification of active faults, and styles of deformation that are related to seismicity.

Attendance at the conference will be limited to approximately 70 participants, representing diverse disciplines, and will include international attendees. Cost of the conference, including all meals, lodging, field trips, and registration, is expected to be between $250 and $275 per person. Those wishing further information or planning to attend the conference should write to the conveners: Duane R. Packer, Woodward-Clyde Consultants, Two Embarcadero Center, Suite 700, San Francisco, California 94111; or George E. Brogan, Woodward-Clyde Consultants, 4000 West Chapman Avenue, Orange, California 92668.

If you unexpectedly received only News & Information in January . . .

As you know, January 1976 was the month when the new system of five dues options went into effect. As this was a new scheme, there was no way to predict which option an individual member would select until the dues statement, with payment, was returned to headquarters. Add to this fact that the mailing labels for January publications were prepared at headquarters on the 10th of December so that they could be sent to Lane Press in Burlington, Vermont, in time to get all items in the mail to ensure January delivery.

Therefore, if headquarters had not received your selection of an option for 1976 by December 10, 1975, you received in January only the News & Information section of *Geology* magazine. When your option choice, with payment, reaches headquarters, if you choose any option other than "A" your name will be placed on the proper mailing list, and back numbers of the publications you ordered will be mailed to you.

BOOK BRIEFS

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

Silurian conodonts from Wills Mountain anticline, Virginia, West Virginia, and Maryland

SPECIAL PAPER 161 — by Charles T. Helfrich. 1975. vi + 82 p., 20 figures, 16 plates, microfiche appendix of systematic paleontology, $12.50

This paper establishes (1) a Middle and Upper Silurian zonal scheme based on stratigraphic changes in conodont faunas in the central Appalachian Mountains and (2) intrabasinal and extrabasinal correlations of Middle and Upper Silurian strata based on conodonts.

The stratigraphic succession along the Wills Mountain anticline includes formations that range in age from Ordovician through Devonian. This study is limited to conodont biostratigraphy of the Mifflintown, Wills Creek, and Tonoloway Formations. The Rose Hill and Keyser Formations are included in the discussion because they have an extensive megafauna of importance for biostratigraphic correlation in the central Appalachian region. The only other formation of Silurian age in the area is the Tuscarora Sandstone, which is basal Silurian and does not contain a marine macrofauna or a rock type that would be suitable for conodont studies.

Sequential samples of carbonate rocks were collected from six sections with an aggregate thickness of about 760 m. All sections are along the Wills Mountain anticline or along a subsidiary and adjacent structure in Highland County, Virginia, Allegany County, Maryland, and Pendleton, Grant, and Mineral Counties, West Virginia.

The succession of conodont faunas described ranges in age from latest Wenlock through Pridoli. The fauna includes 46 forms (species) assignable to nine form genera. Sixteen new form species and subspecies are described. One platform species, possibly representing a new form genus, occurs in the upper Tonoloway Formation. Four important European species of *Spathognathodus* are reported for the first time from the central Appalachian Mountains. Eleven multielement conodont species are recognized using open nomenclature.

Age relationships of the Golconda thrust fault, Sonoma Range, north-central Nevada

SPECIAL PAPER 163 — by N. J. Silberling. 1975. iv + 28 p., 4 figures, $9.00

This study documents and supports an earlier conclusion that geologic relationships in the Sonoma Range in north-central Nevada do not contradict a Permian or Early Triassic age for the Golconda thrust fault.

Previous structural interpretations of the Sonoma Range have concluded that the Tobin thrust fault—regarded as the equivalent of the Golconda thrust fault—is younger than other thrust faults of post-Triassic age in the range. However, thrust emplacement of the Golconda allochthon in western and north-central Nevada, and perhaps beyond, seems to have taken place prior to deposition of Triassic strata in the region. Therefore, the structural relationships in the Sonoma Range that bear on the age of the Golconda thrust fault have been questioned.

Restudy of the critical part of the Sonoma Range (about 90 km^2 in area) in the vicinity of Clear Creek shows that the Golconda thrust fault is evidently older than faults that cut Triassic rocks. Other conclusions and findings of more than local significance include the following: (1) Prior to emplacement of the Golconda allochthon, lower Paleozoic rocks in the Sonoma Range area, such as the Harmony and Valmy Formations and perhaps the Pebble Formation, were intricately deformed and faulted, presumably during the Antler orogeny of middle Paleozoic age. (2) Coarse clastic detritus derived from the Harmony and Valmy Formations occurs in the Golconda allochthon of the Sonoma Range, which suggests that it was originally deposited along the North American continental margin. (3) Radiometric ages of plutonic rocks in the Sonoma Range suggest that post-Triassic displacement of parts of the Golconda allochthon on the Clear Creek system of thrust faults took place between about 170 and 100 m.y. ago.

Geochronology of Precambrian rocks in the St. Francois Mountains, southeastern Missouri

SPECIAL PAPER 165 — by M. E. Bickford and D. G. Mose. 1975. vi + 48 p., 20 figures, 4 appendix tables, $7.00

The St. Francois Mountains represent the principal exposure of an extensive terrane of Precambrian silicic volcanic and epizonal rocks that extends from central Wisconsin and northern Ohio at least to the Texas Panhandle; therefore, the study area is notable because it provides the most extensive exposure of Precambrian rocks anywhere in the mid-continent region.

The region, which is broadly arcuate, is bounded on the north and west by deep-seated plutonic and metamorphic rocks with ages mostly greater than 1,600 m.y., on the east by 1,000- to 1,200-m.y.-old metamorphic and plutonic rocks of the Grenville province, and on the south by rocks of similar age and lithology in Texas. This extensive terrane records a major addition to, or reworking of, the North American continental crust during late Precambrian time. The Wichita Mountains of south-central Oklahoma lie within the Precambrian terrane, but these rocks are much younger, yielding ages of about 550 m.y.

It was necessary to compile a great deal of data to interpret the ages of rocks in the St. Francois Mountains. U-Pb ages were measured on 22 cogenetic suites of separated zircons, and Rb-Sr ages were measured on 144 large whole-rock samples and separated minerals, beginning in 1968. U-Pb ages from most of these rocks are about 1,500 m.y., but zircons from the Munger Granite Porphyry are apparently 1,400 m.y. old. Rb-Sr whole-rock isochrons from the plutonic and volcanic rocks yield ages close to 1,300 m.y. The data suggest that Rb-Sr ages have been lowered by Sr loss.

The U-Pb ages of the zircon suites are the best estimates of the time of crystallization, and the Rb-Sr ages are related to a

(continued on p. 92)

BOOK BRIEFS (continued from p. 91)

subsequent event during which Sr was lost. This event was most likely a period of extensive hydrothermal alteration, possibly the one that accompanied iron ore bodies. The rocks of the St. Francois Mountains are similar in age to numerous anorogenic plutons in Wisconsin, the Rocky Mountains, and the Southwest.

Diatom stratigraphy and human settlement in Minnesota

SPECIAL PAPER 171 — by J. Platt Bradbury. 1975. vi + 74 p., 17 figures, 4 tables, 6 plates, $8.50

Interest in environmental quality has created a need for specific measures of the change in water quality of lakes and ponds since European-Americans settled in their watersheds and along their shores. Stratigraphic studies of diatoms serve this purpose. Diatoms are sensitive to changes in the chemical and physical properties of lakes, and their resistant siliceous shells commonly allow them to be preserved as fossils in lake sediments. Thus the stratigraphic record of diatom fossils can document the history of limnologic changes.

Fossil diatom assemblages were studied in 10 short cores (60 to 160 cm) of lake sediment from nine lacustrine environments (seven lakes) in Minnesota and South Dakota. The time of settlement is stratigraphically determined generally by an increase in the proportion of *Ambrosia* (ragweed) pollen, which signals late 19th century land clearance and cultivation in this region. Initially, diatom diversity decreases as the lakes become enriched as a result of increased erosion and (or) by disposal of municipal wastes. Littoral (epiphytic and benthic) diatoms become underrepresented in the sedimentary record, perhaps because of excessive shading by blue-green algae, or simply because they are numerically overwhelmed by massive blooms of planktonic diatoms. As enrichment increases, the more or less even distribution of spring, summer, and fall planktonic diatoms changes to a planktonic diatom flora dominated by species that bloom in the early spring—sometimes even under the ice. Foremost among these are *Stephanodiscus minutus* and *S. hantzschii*, the latter characterizing the most eutrophic lakes studied. Apparently the summer and fall diatom plankton cannot compete with the massive blooms of floating, blue-green algae that occur in the warmer seasons. Only in the shallow turbulent lakes do the heavy summer and fall diatom plankters maintain sizable populations that effectively compete with the buoyant blue-green algae.

There are several variations on this theme, depending on the initial trophic state of the lake and other limnologic characteristics such as basin morphometry.

GSA Division on History of Geology proposed

The high attendance at the successful History of Geology session at Salt Lake City indicates interest in history. It has been requested that explorations be made to determine possible support for organization of a GSA Division on History of Geology. Anyone interested in such a division and willing to support it (dues in a division are $2 per year) may so indicate by a note to Professor George W. White, Department of Geology, University of Illinois, Urbana, Illinois 61801.

IGCP of UNESCO approves Archean geochemistry project

The International Geological Correlation Program (IGCP) of UNESCO has approved a new project entitled "Archaean Geochemistry: The Origin and Evolution of the Archaean Continental Crust." One of the aims of this project is to encourage cooperation among Earth scientists whose work pertains to the geochemistry of the Archean, including peripheral studies. The international Working Group is preparing a catalog of investigators and studies pertinent to the project. The U.S. working group, whose temporary chairman is G. N. Hanson, SUNY Stony Brook, accordingly is compiling the domestic part of this catalog. Geologists working either on Archean rocks of the U.S. or on the Archean of other countries but who are housed in the U.S. and who would like to be listed are asked to write for a brief questionnaire. Address the Co-Secretaries, U.S.A. Working Group, Archaean Geochemistry Project, IGCP:

J. G. Arth, Jr., 929 National Center, U.S. Geological Survey, Reston, Virginia 22092; or Fred Barker, U.S. Geological Survey, Box 25046, Denver, Colorado 80225.

Why no abstract fee for Northeastern-Southeastern section meeting?

A clarification is needed, judging from inquiries, about the remission of the $20 abstract fee for the joint Northeastern-Southeastern Section meeting in Arlington, Virginia, March 25-27, 1976. This came about by an accident of timing. The announcements and calls for papers for that joint meeting were being distributed to the entire membership *before* the Council action established the abstract fee. For that reason, the Executive Committee decided that it would not apply the $20 fee to that meeting.

Necrology

Kimball B. Bodoia, Pocatello, Idaho; Carl C. Branson, Norman, Oklahoma; Olaf Holtedahl, Oslo, Norway; William Lodding, Somerset, New Jersey; F. A. Nickell, La Jolla, California; Thomas S. Nye, Burke, Virginia; Serge M. Pertusio, Oklahoma City, Oklahoma; Francis Ruellan, La Richardais, France; Louis J. Scopel, Denver, Colorado; Frank C. Sturges, Pittsburgh, Pennsylvania; Charles D. Woodhouse, Santa Barbara, California.

Publications

Editing of Special Papers and Memoirs now author's responsibility

Under a Council ruling, authors of Special Papers and Memoirs are now required to meet the editorial standards of GSA, as well as the scholarly standards, before their papers can be accepted for publication. This means that such matters as citation style, capitalization, grammar, mathematical formulas, proper use of stratigraphic nomenclature, bibliographic references, proper presentation of tabular data, geographic place names, call-out of figures and tables in proper order, and so forth, will be the *full* responsibility of authors and volume editors. Authors will also have full responsibility for proofreading galleys.

GSA has the following free publications that will assist authors in complying with these specifications:

Information for Contributors

Reprint of Stratigraphic Nomenclature in Reports of the U.S. Geological Survey

Reprint of Serial Publications Commonly Cited in Technical Bibliographies of the U.S. Geological Survey

By consulting these publications and following the directions given, such as those included in the table below, authors should be able to prepare their manuscripts to meet editorial standards of GSA.

TABLE 1. FINER POINTS OF GSA EDITORIAL STYLE

Use a zero for numbers less than 1	For "no data," use two dots ("leaders")	Align decimals, commas, math. signs (+,-,=,±) Use commas 1,000 & above	Symbol ball handy for numbers and symbols	Text entries in body of table
1.05	Data	3,321	700 km^2	Begin first word of text
0.50	Data	1.2	SiO_2	entries with a capital
0.3	..	± 0.0006	P_2O_5	letter. Many text entries
2.5	Data	+ 241	Footnote markers - †,§	have several sentences.
6.81	..	+1,688.31	Greek symbols - β, ∂	Do not put a period after
0.08	..	- 36.02		the final sentence. This
0.7	Data	± 0.3		is a very strange rule

Note: General notes are indented at the bottom, as are footnotes.

** Indent first line of footnote 3 spaces and place below bottom rule. (The asterisk is the symbol for the 1st footnote.)*

† The dagger is the symbol for the 2d footnote. (If the asterisk is used by the author in the body of the table to signify probability, omit asterisks from the footnote series and begin the series with the dagger.)

§ The section mark is the symbol for the 3d footnote.

 # Use the number sign for the 4th footnote.

*** Start over, doubling and tripling, for more footnotes.*

†† At the end of the footnotes, draw another line. The end of the table is always indicated by a horizontal rule.

Direct phone line to Publications Dept.

To Associate Editors and authors:

Direct dialing to the Publications Department at headquarters is now possible. Simply dial (303) 447-8850. All general calls to headquarters may be made to the old number: (303) 447-2020.

GSA Council modifies Bulletin foldout policy

At the meeting of the GSA Council in Salt Lake City, the rule excluding foldout maps and charts from the *Bulletin* was modified. That exclusion was put into effect more than a year ago, largely as an economy measure.

The new regulations permit the inclusion of foldouts in 1976 *only* if the author or his or her institution pays for the preparation and printing of the map or chart and for its insertion into the *Bulletin*, as well as all additional directly related costs. It is anticipated that there will be few foldouts during the year on this basis. Printing and binding costs have escalated rapidly, and the *Bulletin* budget does not provide funds to cover any of the added costs for such items.

IUGS Subcommission approves recommendations

The IUGS Subcommission on the Systematics of Igneous Rocks and its working group on effusive and pyroclastic rocks held a meeting in connection with the IUGG Congress, Grenoble, September 2-4, 1975. The participants were F. Chayes (USA), A. Dudek (CSSR), J. Honnorez (USA), R. Ivanov (Bulgaria), M. J. Le Bas (UK), R. W. Le Maître (Australia), N. P. Mikhailov (USSR), H. de la Roche (France), P. A. Sabine (UK), R. Schmid (Switzerland), A. Streckeisen (Switzerland), P. M. Vincent (France), and B. Zanettin (Italy). After having discussed the principles of the classification of volcanic rocks, the participants unanimously approved the following recommendations and suggestions:

(1) The classification of volcanic rocks should be consistent with the classification of plutonic rocks. Consequently, it should be based in the first instance on mineral parameters, either modal or normative.

(2) Further subdivision of any major group (e.g., basalt, andesite, rhyolite, etc.) can be achieved by using supplementary criteria. Suggestions as to suitable criteria would be very welcome.

(3) There is a need to investigate classifications based on oxides or functions of oxides, that ideally should correspond as closely as possible to classifications by mineral parameters.

(4) To test the relationships between modal mineral contents and the various classification methods that are suggested, it is proposed to circulate to interested colleagues sets of chemical and modal data of selected rocks.

(5) To further test the viability of any normative calculation or any system of classification based on oxides or functions of oxides, it is proposed to circulate the suggested methods to various centers where volcanic data files exist, to determine their consistency with existing usage of nomenclature.

(6) Agreement should be sought to standardize the usage of chemical qualifiers such as, e.g., low-K, high-K, low-Si, etc. Suggestions from colleagues commonly using such terms would be very welcome.

Suggestions may be sent to the chairman, Prof. A. Streckeisen, Mineralog.-Petrograph. Institut, Sahlistrasse 6, CH-3012 Berne, Switzerland.

A special working group on pyroclastic rocks has been formed in order to discuss their classification and nomenclature and to prepare suitable recommendations. Interested colleagues may address themselves to the chairman, Dr. R. Schmid, Institut für Kristallographie und Petrographie ETH, Sonneggstrasse 5, CH-8006, Zürich, Switzerland.

February BULLETIN briefs

Brief summaries of articles in the February 1976 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.*

☐ 60201—Scapolites, granulites, and volatiles in the lower crust (address as retiring president of the Geological Society of America, Salt Lake City, Utah, October 1975). *Julian R. Goldsmith, Department of the Geophysical Sciences, University of Chicago, Chicago, Illinois 60637.* (8 p., 9 figs.)

The stability relations in the systems An-Ab-$CaCO_3$ and An-Ab-$CaSO_4$ are presented; scapolites are stable in these systems to very high temperatures and pressures. Large amounts of Na can be accommodated in the scapolite in the absence of chlorine, and the Ca end-member scapolites (meionite and sulfate meionite) are stable only at temperatures above $\sim$ 800°C. The presence of Na permits stability at lower temperatures. The scapolites are stable on the high-temperature side of the reaction anorthite + $CaCO_3$ (or $CaSO_4$) $\rightleftharpoons$ meionite (or sulfate meionite); sulfate meionite in addition requires high pressure for stability. Scapolite is a stable refractory mineral in the lower crust if oxidized carbon and sulfur are present. It is observed more commonly in granulite inclusions brought up in volcanoes and deep-seated pipes. The lower crust may thus be a principal storehouse for carbon and sulfur. The distribution of Na and Ca between Cl-free scapolite and plagioclase can be used as a geologic thermometer, and it may be possible to use the sulfur content as a geobarometer.

☐ 60202—Geophysical and geological evidence of the relationship of Red Sea transverse tectonics to ancient fractures. *Magnus S. Garson, Geochemical Division, Institute of Geological Sciences, 64178 Gray's Inn Road, London WC1X 8NG, England; and Miroslav Krs, Institute of Applied Geophysics, Podbelorhorska, silnice 47, Prague 5-smichov, Czechoslovakia.* (13 p., 10 figs.)

Wilson's concept that transform faults were initiated along ancient fractures is supported by evidence from southeastern Egypt. Geophysical and geological investigations have outlined blocks bounded by transverse fractures oriented perpendicular to the Red Sea, linear anomalies parallel to the Red Sea due to deep-seated tholeiitic dikes, and shear zones related to left-lateral movement along the Red Sea. Similar features occur in Saudi Arabia. Consideration of bathymetric data and matching of structural features across the Red Sea indicate that left-lateral movement of 75 to 80 km occurred in Late Cretaceous to Eocene time during the opening of the Gulf of Aden, predating the ocean-floor spreading in the Red Sea in late Eocene time. The direction of the Red Sea spreading was guided by continental Precambrian fractures trending east-northeast that extended offshore into transverse tectonic structures on which deposits of metalliferous sediment are located. It is postulated that later Red Sea extension occurred in late Miocene to early Pliocene time and from 3 m.y. B.P. to the present and that the Sinai block moved in a left-lateral direction about 25 km along the Gulf of Suez fault from its original position during the three main periods of ocean-floor spreading.

☐ 60203—Latest Laurentide Ice Sheet: New evidence from southern New England. *Richard Foster Flint and Jeffrey A. Gebert, Department of Geology and Geophysics, Yale University, New Haven, Connecticut 06520.* (7 p., 4 figs.)

Within a 50-km segment of the coast of Connecticut, the discovery of two discontinuous late Wisconsin end moraines—the Old Saybrook moraine and the Madison moraine—extends existing knowledge of end moraines that occur to the east. The moraines trend N75°E, which is oblique to the coast; the Old Saybrook moraine intersects the coast farther east than the Madison moraine.

Offshore, within an area of about 235 km^2, a study of the bottom and subbottom by acoustic-reflection profiling has revealed a probable westward continuation of the Old Saybrook moraine. The 18-km-long continuation was recognized by its form and by concentrations of large boulders. Bedrock shoals were differentiated from shoals believed to be end moraine according to (1) absence of surface boulders and (2) greater relief than that which would be expected on drift reworked by surf and currents during postglacial submergence.

Increased width of the Old Saybrook moraine at the mouth of the Connecticut River may indicate an ice

stream within the former ice sheet. The newly identified moraines fit reasonably into the general framework of similar features between New Jersey and Cape Cod. North of the moraines and parallel with them lies a belt within which ice-contact stratified drift merges into outwash. This belt is believed to approximate a glacier terminus of later date, when the glacial regimen was less active. Search of the Connecticut region north of this line has not thus far yielded evidence of later positions of a discrete margin of the former ice sheet.

☐ 60204—The 1.7- to 1.8-b.y.-old trondhjemites of southwestern Colorado and northern New Mexico: Geochemistry and depths of genesis. *Fred Barker, J. G. Arth, Z. E. Peterman, and Irving Friedman, U.S. Geological Survey, Federal Center, Denver, Colorado 80225 (present address, Arth: U.S. Geological Survey, Reston, Virginia 22092).* (10 p., 9 figs., 4 tbls.)

Four trondhjemitic bodies—three of intrusive and one of extrusive origin—1.7 to 1.8 b.y. in age occur in Precambrian rocks of New Mexico and Colorado. These are the metamorphosed plutonic or hypabyssal trondhjemite of Rio Brazos, New Mexico, the interlayered quartzofeldspathic and metabasaltic metavolcanic Twilight Gneiss of the West Needle Mountains, Colorado, the syntectonic Pitts Meadow Granodiorite of the Black Canyon of the Gunnison River, Colorado, and the late syntectonic to posttectonic Kroenke Granodiorite of the Central Sawatch Range, Colorado.

From south to north over a distance of 235 km, the four rock units show systematic increases in average Al_2O_3 from 13.7 to 16.1 percent, in K_2O from 1.5 to 2.6 percent, in Rb from 28 to 76 ppm, and in Sr from 101 to 547 ppm. Initial Sr^{87}/Sr^{86} ratios are low—0.7015 to 0.7027—and suggest a mafic or ultramafic source. All four trondhjemite bodies have similar light rare-earth element (REE) contents. The trondhjemites of Rio Brazos and the Twilight Gneiss have relatively flat patterns ($Ce/Yb < 5$) and large negative Eu anomalies. The Pitts Meadow and Kroenke Granodiorites have fractionated REE patterns ($Ce/Yb > 10$) with low heavy rare-earth content and small or no Eu anomalies. Whole-rock δO^{18} values for siliceous rocks of three of the bodies range from 5.8 to 8.0 per mil, although the Pitts Meadow Granodiorite gives values of 8.5 to 9.4 per mil.

The parent magmas for these bodies were probably generated from a parental basaltic source, either by partial melting or fractional crystallization.

The magmas probably formed in a ridge-and-basin complex that lay between the early Precambrian craton to the north and the contemporaneous quartzite-rhyolite-tholeiite terrane to the south. A northward-dipping subduction zone can be postulated from the variation in compositions and inferred depths of melting, but complete modern analogues of similar setting are not known. A better tectonic analogue might by the Archean regimes, in which vertical motion is dominant and trondhjemitic magmas may have formed by melting at the base of foundering thick volcanic piles.

☐ 60205—Complex width-discharge relations in natural river sections. *K. S. Richards, Lanchester Polytechnic, Priory Street, Coventry CV1 5FB, England.* (8 p., 5 figs., 2 tbls.)

Hydraulic geometry exponents may be used to discriminate between types of river section. This is illustrated by a discriminant analysis of data from riffle and pool sections. The complexity of most natural channels, however, precludes the use of a single index to cover a wide range of discharges. This is demonstrated in an analysis of several width-discharge curves defined up to, but not beyond, bankfull stage.

☐ 60206—Solution chemistry, mass transfer, and the approach to chemical equilibrium in porous carbonate rocks and sediments. *V. V. Palciauskas and P. A. Domenico, Department of Geology, University of Illinois, Urbana, Illinois 61801.* (8 p., 7 figs.)

The physical and chemical processes that tend to promote an approach to equilibrium between an aqueous solution and one or more minerals in a carbonate system include dispersion, convection, and chemical reactions. When the spatial dependence of ionic constituents is examined from the point of view of these processes, the results show that the distance to attainment of saturation with respect to an individual mineral increases with increasing rates of dispersion and velocity of ground water and decreases with increasing rates of reaction. When all the concentration gradients approach zero, the resulting concentration is demonstrated to be a weighted average of the saturation concentrations for the individual minerals. The qualitative aspects of the predicted concentration behavior are in agreement with both field and experimental observations.

☐ 60207—Petrology and chemistry of a Columbia River basalt section, Rocky Canyon, west-central Idaho. *Gregory S. Holden and Peter R. Hooper, Department of Geology, Washington State University, Pullman, Washington 99163 (present address, Holden: Department of Geology, University of Wyoming, Laramie, Wyoming 82070).* (11 p., 8 figs., 4 tbls.)

Field characteristics, petrography, and major-element analyses are given for 17 of the 19 flows of the Columbia River Group present in a canyon in the southeast corner of the Columbia Plateau. The 17 flows are divided into 4 flows of Imnaha Basalt at the base, 12 flows of lower Yakima Basalt above, and 1 flow of middle Yakima Basalt at the top.

The 4 Imnaha Basalt members are feldsparphyric with lower SiO_2 (48.0 to 52.0 percent) and lower K_2O (0.60 to 1.14 percent) than the lower Yakima Basalt. They may be subdivided into the upper two flows of Rock Creek chemical type that have less SiO_2 (48.8 to 50.5 percent) than the other two members. The Rock Creek flow has uniquely high values of Al_2O_3 and MgO associated with high modal olivine. The lower two members may be distinguished from each other by their TiO_2 contents.

The lower Yakima Basalt flows are fine grained and nonporphyritic with an intergranular to intersertal texture. SiO_2 varies from 52.0 to 56.6 percent and K_2O varies from 1.14 to 2.00 percent. The earlier nine members show an increase in SiO_2 and K_2O and a decrease in MgO upward; the top three members show a reversal of this trend. The less siliceous flows contain small subhedral olivine

crystals or their pseudomorphs, and the more siliceous contain a pigeonitic in addition to an augitic clinopyroxene. Each member has a unique set of properties that is consistent vertically through the thickness of a flow and laterally between two sections 4 km apart and separated by a major fault.

The top flow exposed, with phenocrysts of plagioclase and olivine, falls within the Pomona chemical type previously recorded only from upper Yakima Basalt.

Flow-by-flow correlation can be made of the lower Yakima Basalt with the Whitebird section 20 km to the south. Thinning and cutting out of flows from north to south suggests that many flows are local in origin. Similar types of Imnaha Basalt occur at Rocky Canyon and Whitebird, but flow-by-flow correlation is less convincing.

☐ 60208—Evolution of the lunar fracture network. *Clarence J. Casella, Department of Geology, Northern Illinois University, DeKalb, Illinois 60115.* (9 p., 18 figs., 1 tbl.)

A statistical study of the directions of structural lineaments on parts of the Moon shows three significant preferred orientations that trend generally northwest, northeast, and north. Locally, many preferred directions are radial to large lunar impact basins, indicating that their formation influenced the direction of some fractures.

A systematic fracture pattern exists down to the smallest observable scale on both the near and far sides. The existence of such a pattern at the polar regions is less clear. Geometric regularity of preferred orientations of fractures of pre-Imbrian age indicates that a systematic set of fractures was formed over the lunar surface during the very earliest episode of lunar history, probably before the formation of many large lunar basins. The presence of these same fracture patterns on materials of younger age indicates that this initial fracture pattern was rejuvenated repeatedly through time.

☐ 60209—Holocene sea-level change and coral-reef growth at Huon Peninsula, Papua New Guinea. *John Chappell, Department of Geography, Australian National University, P.O. Box 4, Canberra A.C.T. 2600, Australia; and H. A. Polach, School of Earth Sciences and School of Pacific Studies, P.O. Box 4, Australian National University, Canberra A.C.T. 2600, Australia.* (6 p., 5 figs., 1 tbl.)

At the tectonically rising terraced coast of Huon Peninsula, Papua New Guinea, a Holocene reef is emerging by as much as 12 m. A clean seacliff section 8 m high provides detailed evidence of the relationship between reef development and early Holocene sea-level changes, relative to the rising coast. The section shows a shallow-water reef-crest facies that grew steadily upward while relative sea level rose approximately 7 m. Reef growth terminated with emplacement of a fluvial gravel cap, which was followed by emergence. Twelve C^{14} dates and six Th^{230}/U^{234} dates put the base of the cliff section at 8200 C^{14} yr B.P. and the crest at 6600 C^{14} yr B.P. Four Th^{230}/U^{234} dates from near the base average 9,400 yr old, but C^{14} ages from the same samples average 7,600 yr old; the cause of the discrepancy is not known. Uplift of the section is known from previous studies of the Pleistocene reefs in the area to be approximately 1.9 m/1,000 yr. If uplift has been at a uniform rate, then the position of sea level at 6,000 C^{14} yr ago (around northeast Papua New Guinea) was about -4 m; 8,000 yr ago it was about -14 m. Mean upward growth rate of the reef was 4.7 m/1,000 yr, and the maximum rate was about 8 m/1,000 yr.

☐ 60210—Subsurface distribution of granitic rocks, south-central Maine. *J. F. Sweeney, Department of Geological Sciences, State University of New York at Buffalo, Amherst, New York 14226 (present address: Earth Physics Branch, Department of Energy, Mines and Resources, Ottawa K1A OE4, Canada).* (9 p., 11 figs., 3 tbls.)

Two- and three-dimensional modeling of gravity data from the area north of Penobscot Bay in south-central Maine reveals that major granitic intrusive masses there are tabular in shape. Batholiths are less than 7 km thick on the average and have nearly vertical contacts. Smaller granitic bodies average less than 3 km thick.

Structural and contact metamorphic features of granite and surrounding rocks suggest that felsic masses of batholithic proportions were emplaced at a late stage in the tectonic history of the area. Model configurations combined with structural evidence indicate that the batholiths were probably intruded along faults.

Several previously unmapped felsic masses have been located and defined, mainly within the Passagassawakeag Gneiss. The largest of these is the Stricklen Ridge Granite, an igneous mass up to 3 km thick and 11 km long. The near-surface dip of the Passagassawakeag Gneiss contact northeast of the Mount Waldo batholith is calculated to be 45°N to 55°N on the basis of gravity evidence.

A sill-like tongue of high-density rocks related to the Bays-of-Maine complex has been postulated to extend under the Ellsworth Schist north from Mount Desert Island and approach the Lucerne batholith near its southeastern contact. The Lucerne Granite is bounded on the north by a low-density body, proposed to represent a distinctly earlier felsic intrusion, now covered by a thin veneer of Lucerne Granite.

☐ 60211—Hydraulic fracturing to determine the regional in situ stress field, Piceance Basin, Colorado. *J. D. Bredehoeft and R. G. Wolff, U.S. Geological Survey, National Center, Reston, Virginia 22092; W. S. Keys and Eugene Shuter, U.S. Geological Survey, Denver, Colorado 80225.* (9 p., 17 figs., 1 tbl.)

Several authors have discussed the theoretical aspects of using the techniques of hydraulic fracturing to determine the state of stress within the Earth. Few, however, have attempted systematic hydraulic fracturing for the specific purpose of determining the regional stress field. Using specially designed equipment, the state of stress was determined on a regional scale in the Piceance Oil Shale Basin of northwest Colorado. Structurally, the area is a simple basin that has been subjected to normal faulting.

Seven oil-shale test holes scattered throughout the Piceance Basin were logged with an acoustic borehole televiewer to select unfractured solution-free intervals. Fracture-free intervals, ranging in depth from 60 to 460 m, were isolated between packers and then hydraulically fractured. Induced fractures were propped with ground lucite and relogged with the televiewer to determine their strike and dip. These data, combined with pressure measure-

ments made during the fracturing experiments, were used to compute the orientation and magnitude of the stress tensor.

Field observations showed that in a tectonically relaxed area, vertical fractures can be induced at hydraulic pressures as low as 0.6 of the overburden stress. Below a depth of 120 m, the induced fractures were approximately vertical, with a prominent strike of N70°W. This orientation parallels the major normal faulting in the basin as well as one of the prominent directions of jointing. These results also agree with those obtained at Rangely, about 50 km to the northwest.

☐ 60212—Structure of the Vulcan Peak alpine-type peridotite, southwestern Oregon. *Robert A. Loney, U.S. Geological Survey, Menlo Park, California 94025; Glen R. Himmelberg, Department of Geology, University of Missouri, Columbia, Missouri 65201.* (16 p., 24 figs.)

The Vulcan Peak alpine-type peridotite forms part of the Josephine ultramafic complex in the Klamath Mountains geologic province. The peridotite is a partly serpentinized highly deformed harzburgite-dunite complex, in which three episodes of high-temperature plastic deformation are recognized. The first deformation was the most intense and produced the dominant metamorphic foliation and scattered folds in crosscutting layers and in the foliation itself. The first deformation seems also to have produced an olivine fabric in which X is normal to the foliation. The second deformation superposed a similar and pervasive fabric on the first, in which X olivine is normal to a spotty weak subvertical north-striking foliation that crosscuts the first foliation. These olivine fabrics are analogous to fabrics produced experimentally by either gliding or syntectonic recrystallization at temperatures in the range 1000° to 1200°C. This temperature range agrees with the temperatures of formation calculated from the distribution of Mg and Fe in mineral pairs. The third deformation was characterized by a limited plasticity, in which deformation was restricted to scattered narrow northeast-striking subvertical plastic shear zones. The sense of movement on the shear zones is consistently down on the northwest. A homotactic olivine fabric is present in the shear zones, consisting of a strong Z-point maximum approximately parallel to the zone. This fabric suggests glide on the system {0k1} [100], which has been produced experimentally in the temperature range 800° to 1000°C.

After the high-temperature and presumably deep-seated plastic deformation, the relatively cold peridotite was thrust, probably in post-Middle Jurassic time, northward against a complex of igneous and high-grade metamorphic rocks. Later, probably in Late Cretaceous or Tertiary time, the peridotite and the complex were thrust together westward against the low-grade Dothan Formation.

☐ 60213—Petrology and Rb-Sr age of Precambrian rhyolitic dikes, Llano County, Texas. *Stephen E. DeLong, Department of Geological Sciences, State University of New York at Albany, Albany, New York 12222; Leon E. Long, Department of Geological Sciences, University of Texas at Austin, Austin, Texas 78712.* (6 p., 4 figs., 4 tbls.)

Rhyolite porphyry (llanite) and iron-rich melarhyolite dikes intrude Precambrian metamorphic rocks in north-central and southeastern Llano County, respectively. These dikes are chemically and mineralogically similar, except that rhyolite porphyry is richer in quartz and alkali feldspar phenocrysts; melarhyolite contains a greater abundance of biotite and magnetite. There are corresponding enrichments of SiO_2 in rhyolite porphyry and of $FeO + Fe_2O_3$ in melarhyolite. The two rock types may have originated as two fractions of a common parent magma enriched in salic and mafic phases, respectively, to produce rhyolite porphyry and melarhyolite. This proposed relation is compatible with major-element chemistry and Rb-Sr systematics. Isotopic analyses of five melarhyolite whole rocks, two rhyolite porphyry whole rocks, groundmass and feldspar phenocrysts from rhyolite porphyry, and a nearby diabase dike yield an isochron age of 1,106 ± 6 m.y. ($\lambda_{Rb} = 1.39 \times 10^{-11}yr^{-1}$) and initial $^{87}Sr/^{86}Sr$ of 0.7028 ± 0.0002. Other data indicate subsequent Rb-Sr redistributions. These may be related to devitrification of melarhyolite groundmass and to unmixing of alkali feldspar phenocrysts in rhyolite porphyry.

☐ 60214—Initiation of bed forms and meanders in coarse-grained sediment. *John Lewin, Department of Geography, University College of Wales, Aberystwyth, Wales SY23 3DB.* (5 p., 6 figs., 1 tbl.)

In a straight plane-bed channel in coarse sediment under natural flow conditions, primary transverse bars were rapidly formed during infrequent high flows, and the accompanying flow modifications led to bank erosion. Primary bars were subsequently incorporated as the cores of point-bar complexes, with additional lateral and tail accretion, chute formation, and lesser erosional and sedimentary modifications. The range of natural flows produced a variety of bed forms; therefore, the channel form at any point in time was not strictly attributable to any single controlling discharge, but the broad features of channel development in general relate to the forms of the pseudo-meandering model. A three-phase model of meander development, with these observations exemplifying the first phase, is adequate and useful.

☐ 60215—Erosion on the Line Islands archipelagic apron: Effect of small-scale topographic relief. *William R. Normark and Fred N. Spiess, University of California, San Diego, Marine Physical Laboratory of the Scripps Institution of Oceanography, La Jolla, California 92037 (present address, Normark: U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025).* (11 p., 11 figs., 2 tbls.)

A small area (10 × 16 km) on the northeast flank of the Line Islands archipelagic apron was studied in detail, using a deep-towed geophysical instrumentation system. Along the southern edge of the area, a moat several kilometres wide and 30 m deep lies at the base of an east-trending seamount cresting 1,500 m above the sediment apron. Both surface-ship 3.5-kHz and deep-tow 4-kHz reflection profiles show that much of the relief of this moat is the result of slower deposition of sediment (or the lack of deposition) in the upper part of the sediment apron).

In marked contrast, another moat in the northern portion of the area has been eroded 90 m below the smooth surface of the surrounding apron. This irregularly shaped moat is more than 7 km in length, although the adjacent seapeak (175 m high) is only 1 km in diameter. The deep-

tow, high-resolution subbottom reflection profiles show that many flat-lying horizons in the sedimentary apron are truncated at the walls of the moat, and bottom photographs show outcropping ledges that parallel its contours. Current ripples were observed only in bottom photographs of terraces just above the moat floor. The sediments on the floor itself are suggestive of a coarse lag deposit. Short-term (up to 9 days) current-meter records showed that the prevalent current was about 2 to 3 cm/sec from the northeast, with small tidal perturbations. The morphology of this deep, irregular feature suggests that it may have formed during episodes of intensified bottom-water flow from the west-northwest, possibly as Pacific bottom water intermittently flowed through the area during the glacial intervals of the Pleistocene period.

☐ 60216—Sandstone petrofacies in the Cenozoic High Plains sequence, eastern Wyoming and Nebraska. *K. O. Stanley, Department of Geology and Mineralogy, Ohio State University, Columbus, Ohio 43210.* (13 p., 14 figs., 1 tbl.)

Cenozoic stream systems east of the Laramie Range in Wyoming and Nebraska and their headwater areas in the Laramie and Front Ranges, the Hartville uplift, and North Park basin are better defined by stratigraphic and geographic distribution of sandstone petrofacies in the Cenozoic High Plains sequence than by stratigraphic parameters or paleocurrent measurements. Light and heavy minerals are grouped into four distinct populations: a volcaniclastic sandstone petrofacies transported to the plains from distant volcanic eruptions, a plagioclase sandstone petrofacies derived from the anorthosite complex in the Laramie Range, a feldspathic sandstone petrofacies eroded from granitic and metamorphic rocks in the Front and Laramie Ranges and the Hartville uplift, and a rhyolite-bearing feldspathic sandstone petrofacies derived from Cenozoic volcanic rocks in North Park basin and from granitic and metamorphic rocks in adjacent mountains. Reconstruction of stream systems and their evolution is possible for the High Plains sequence because of distinctive crystalline-rock types in the headwater area, lack of diagenetic alteration of detrital minerals in the sandstones, and lack of mixing of distinctive suites of the channel deposits. The depositional system consists of two major components: (1) coarse-grained stream-channel deposits and (2) widespread fine-grained eolian, wash, and flood deposits made up largely of pyroclastic material. The nature, distribution, and abundance of these components were controlled by the rate of airfall of pyroclastic material in relation to the supply of detritus from crystalline rocks in the Front and Laramie Ranges and the Hartville uplift and by regional uplift, persistent parallelism of stream channels away from the mountains, semiarid to arid climatic conditions, and the shape of the drainage basins.

☐ 60217—Petrographic and geochemical study of the formation of chert around the Thornton reef complex, Illinois. *W. F. Weiner and A. F. Koster Van Groos, Depart-*

ment of Geological Sciences, University of Illinois at Chicago, Chicago, Illinois 60680 (present address, Weiner: Kerr-McGee Corp., Kerr-McGee Center, Oklahoma City, Oklahoma 73102). (9 p., 6 figs., 3 tbls.)

The dolomitized reefs in the Middle and Upper Silurian carbonate rocks of the upper midwest of the United States have a low silica content and are nearly devoid of chert. The surrounding interreef is highly siliceous and cherty.

Two periods of chert formation occurred in the interreef. The first period took place early in the history of the sediment, as indicated by the presence of well-preserved soft-bodied microorganisms in chert nodules, by high strontium contents (as high as 1,900 ppm), and by high $CaCO_3/MgCO_3$ ratios (up to 5.8) of carbonate remnants in the chert. Strontium contents decrease to about 90 ppm, and the $CaCo_3/MgCO_3$ ratio decreases to 1.2 toward the edges of the chert, suggesting that the chert grew during diagenesis and dolomitization of the surrounding sediment.

The second episode of chert formation in the interreef formed a fringe of partial chert, around the nodules of the first chert episode. Because the partial chert has a lower strontium content (85 to 230 ppm) and contains very little organic material and virtually no fossils, it is concluded that diagenesis was much more advanced when the second chert episode occurred.

The strontium content of the dolomite of the interreef is about 55 to 100 ppm. The strontium content of both the dolomite and the chert of the reef flank is lower than in the interreef. This is probably caused by introduction of fresh water through the reef into the interreef during the late Niagaran emergence.

Siliceous organisms provided an adequate supply for the deposition of chert between the Silurian reefs. It is likely that fresh meteoric water filtered down through the reef at the time of chertification and kept chert from forming in most of the Thornton reef while the surrounding interreef was partly chertified.

☐ 60218dr—Experimental study of river incision: Discussion and reply. (2 p., 1 fig.)

Discussion: G. H. Dury, Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, Wisconsin 53706.

Reply: R. G. Shepherd, Department of Geological Sciences, University of Texas at Austin, Austin, Texas 78712; S. A. Schumm, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523.

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