GSA news & information

SUPPLEMENT TO GEOLOGY MAGAZINE

NOVEMBER 1976

GSA Penrose Conference Scheduled for May 2–6, 1977

A Penrose Conference on the "Tectonic Significance of Metamorphic Complexes in the North American Cordillera," sponsored by the Geological Society of America with additional support from the Department of Geosciences of the University of Arizona, is scheduled for May 2–6, 1977. Conveners are Max D. Crittenden, Jr., U.S. Geological Survey, and Peter J. Coney and George H. Davis of the University of Arizona. It will be held at the Tanque Verde Ranch, at the foot of the Catalina-Rincon Mountains near Tucson.

Our objective is to gather together a group of interested scientists in order to discuss in some depth the geologic characteristics of these enigmatic complexes and to explore the tectonic significance they must have had in Cordilleran tectonic evolution.

Similarities and differences that apparently exist among the core complexes along the Cordillera will be denoted through a review of the metamorphic terrains stretching from the Yukon-Tanana in Alaska and the Yukon, through the Cassiar and Shuswap in the central and southern Canadian Cordillera, the Washington-Idaho and eastern Great Basin complexes in the western United States, into the southern Arizona and Mexican complexes in the southern Cordillera. The intention then is to pursue an array of puzzling topical problems dealing with the evolution of these complexes, including consideration of the geochronology, geochemistry and petrology, structural-metamorphic fabric, geophysics, and economic geology of these terrains. An attempt will be made to evaluate relationships with major tectonic elements such as Cordilleran foreland thrust belts and volcano-plutonic terrains of arc affinity. Particular attention will be paid to those complexes coincident in space and time with widespread mid-Tertiary ignimbrite eruptions south of the Snake River Plain. Participants should thoughtfully consider how best to reconstruct evolving geometry, kinematics, and dynamics in the framework of Cordilleran regional tectonic evolution.

Field trips to the beautifully exposed and proximate Catalina-Rincon core complex will be an integral part of the conference. Registration fee for the conference is expected to be approximately $285, including lodging, meals, transportation to the ranch and return to the airport, and field trip.

Those interested in participation should write to the conveners, indicating why they wish to attend. Closing date for applications is January 30, 1977.

Hydrogeology Planned for Penrose Conference

Geostatistical concepts and stochastic methods to be examined and discussed

A GSA Penrose Conference on "Geostatistical Concepts and Stochastic Methods in Hydrogeology" will be held August 29–September 2, 1977, at Harrison Hot Springs, near Vancouver, British Columbia.

The purpose of the conference is to examine the applicability of geostatistical methods in hydrogeological modeling. Discussions will focus on geostatistical descriptions of hydrogeological parameters in heterogeneous geological systems; stochastic models in hydrogeology (including Monte Carlo simulation, and stochastic differential equations); and methods of model calibration under uncertainty. The latter topic has implications for the inverse problem.

The number of participants will be limited to 70. Fees are expected to be in the $250 to $300 range. They will cover room, meals, and registration. The deadline for applications is May 1, 1977. Applications should include

(a) Name, position, and affiliation

(b) Field of interest pertinent to participation in the conference

(c) Topics on which the correspondent is prepared to present material either as a talk or as part of a discussion group

Inquiries and applications should be sent to the convener: Dr. R. Allan Freeze, Department of Geological Sciences, University of British Columbia, Vancouver, Canada.

1977 NAGT Summer Geology Field Course Scholarship Program

With the generous help of industrial sponsors, NAGT will again operate a Summer Geology Field Course Scholarship program in 1977. The program will provide scholarships to superior students who take a summer geology field course that is at least four weeks in duration and that engages the student in field work rather than classroom work. The chief criteria for the award is academic excellence.

There will be two application deadlines and announcement dates for the 1977 program. The first deadlines are January 1, 1977 (application deadline), and February 1, 1977 (announcement date). This is the Early Decision category. It is for those students whose decision to attend a summer field camp or not hinges on the availability of financial aid. The second set of dates are April 1, 1977, and May 1, 1977. This is the Regular Decision category. It is for applicants who are committed to, and have been accepted in, a summer program. Application blanks are available from college geology departments and by writing directly to

Dr. Thomas E. Hendrix
Department of Geology, Indiana University
Bloomington, Indiana 47401

Because of the large number of anticipated applications, a limit of five applicants per school is placed on the 1977 program.

Letter from American Geological Institute

Dear GSA Students, Fellows, and Members,

I want to thank each GSA fellow, member, and student who contributed to the $3,354.27 gathered by GSA and forwarded to the American Geological Institute's Minority Participation Program. You have been kind and generous. Your gift will go directly for the scholarship grants with no overhead of any type charged against it.

We appreciate your gift for several reasons. From a pragmatic viewpoint there is much talent in our young minority people and the profession and industry, and our country would be that much the poorer for not availing ourselves of this talent.

From a moral point of view, if we are to claim a position of leadership in the world today then we must lead in making sure that all of our young people have a chance in training for the profession of their choice, which in our situation, is the Earth sciences.

Thank you, all of you, for your part in helping make these goals come true.

Sincerely,

Fred S. Honkala
Executive Director

Nominations for Gilbert H. Cady Award Sought

Nominations will be accepted until January 15, 1977, for the Gilbert H. Cady Award for outstanding contributions in the field of coal geology. The award is sponsored by the Coal Geology Division of the Geological Society of America and was authorized by the Council to honor the late Dr. Cady by recognition of outstanding contributors to the field of coal geology.

The area from which nominations may be made is defined as "that field of knowledge concerning origin, occurrence, relationships, and geologic characteristics of the many varieties of coal and associated rocks, including economic implications." The award is designed primarily for outstanding contributions to coal geology in North America, but is not restricted to North American geologists.

Nominations, in quintuplicate, should be submitted to the award committee chairman

William H. Smith
1319 Alms Avenue
Champaign, Illinois 61820

If additional information is needed, please contact the chairman of the award committee.

Minority Participation Program Scholarships

The American Geological Institute will again offer scholarships for geoscience majors who are United States citizens and members of the following ethnic minority groups: American-born Blacks, American Indians, Mexican Americans, and Puerto Ricans. Approximately 40 such awards (ranging from $500 to $1,250) were granted in 1976–1977. About the same number (and amounts) will be awarded for 1977–1978.

The term "geoscience" is used broadly to include major study in the fields of geology, geochemistry, geophysics, hydrology, meteorology, oceanography, and space and planetary sciences.

Monies for support/funding of this program are administered by the Institute's Minority Participation Program Advisory Committee and have come from 6 member societies, including GSA, more than 14 mining, petroleum, geological supply, and geophysical companies, and many individuals.

Requests for application materials or nominations for scholarships should be addressed to William H. Matthews III, Director of Education, American Geological Institute, Box 10031, Lamar University Station, Beaumont, Texas 77710. The deadline for filing the completed application is February 1, 1977.

Necrology

Notice has been received of the following deaths: Alvin L. Lugn, Hickory, North Carolina; Ian Donald Mackenzie, Montreal, Canada; Eugene Clifton Reed, Lincoln, Nebraska; J. Marvin Weller, Greenbrae, California.

Theory of the Earth—The Lost Drawings

James Hutton's *Theory of the Earth* is a landmark in the history of scientific literature. The original paper, read in 1785, was printed in Volume I of the Transactions of the Royal Society of Edinburgh in 1788. In 1795 Hutton made arrangements with Cadell and Daview for the publication of the *Theory of the Earth* in a three-volume edition, but the manuscript of the third volume was mislaid and the original drawings lost. Eventually the missing Volume III was published by the Geological Society of London in 1899 but without the original drawings.

These drawings have now been found, apparently in their entirety, almost 200 years after their completion. The find is of major geological and historical importance. The drawings were made in Hutton's company by his close friends, John Clerk of Eldin, Lord Eldin his son, and Sir James Hall. The sketches and water colors cover many of the excursions and famous localities which were described by Hutton in the *Theory of the Earth* and by Playfair in the *Illustrations of the Huttonian Theory*.

The book of *The Lost Drawings* will be published by the Scottish Academic Press, 33 Montgomery Street, Edinburgh EH7 5JX, Scotland, early spring 1977.

Nominations Committee asks members' suggestions

The Committee on Nominations seeks members' advice in one of the most important contributions that can be made to the health of the Society. Early in 1977, the committee will draw up a list of Members or Fellows whom they consider to be suitable replenishments for the gradually changing group that guides and manages Society affairs. Their final lists will be presented to the Council in May. In its turn, the Council will decide on a slate of officers to be placed on the ballot for the fall election. Chances are that a single slate will be presented for vote of the membership, though write-in votes are encouraged and are always welcome. The single slate concept, however, is all the more reason why your advice is needed for the Committee on Nominations. Its members cannot possibly know all of the potential leaders of the Society—they need your help. Nominations are to be made for president (usually the incumbent vice-president), vice-president, treasurer, and four councilors.

All suggestions received by February 1, 1977, will receive careful consideration. Write directly to headquarters. Suggestions will be forwarded to the committee.

To ensure thorough consideration by the committee, please back up each suggested nomination with a brief biographical sketch and a summary of his or her chief contributions to geology.

South-Central Section announces slate

The following slate of nominees will be voted on by the voting membership present at the annual business meeting of the South-Central Section on Thursday, March 18, 1977, at El Paso, Texas.

Chairman ..... Norman J. Hyne (1978-79)
Vice Chairman ..... Norman F. Williams (1978-79)
Secretary-Treasurer .... Melvin C. Schroeder (1978-79)
Management Board (2-year terms, 1977-79)
Member-at-Large ..... Donald E. McGannon
Member-at-Large ..... John S. Wickham
Member-at-Large ..... Robert L. Cullers
Member-at-Large ..... H. Ed Eveland

Melvin C. Schroeder
Secretary

Choose your membership option now

1977 dues statements were mailed to all members in September. Time is running short for those who have not yet selected an option and mailed the statement back to headquarters along with their dues payment.

Mailing labels for January issues of the *Bulletin* and *Geology* will be made up December 1, so only those members who have submitted their option form and payments before November 30 will be guaranteed uninterrupted mailings. Remember also that mailings of the *Abstracts with Programs* for some of the spring section meetings begin in January.

Don't delay—we want to serve you.

Honors and Awards Committee seeks suggestions

The Committee on Honors and Awards needs your help in nominating potential recipients of GSA's highest honors—the Penrose Medal, the Day Medal, and Honorary Fellowship. The criteria for these honors are described in the booklet *Council Rules, Policies, and Procedures,* or you can get a good idea of the kinds of scientists who have been honored in the past by glancing at the lists on pages ix and xi of your *1976 Yearbook*.

Suggestions for consideration for 1977 awards must be received by headquarters by January 15, 1977. They will be forwarded to the appropriate subcommittee chairmen.

To ensure thorough consideration by the particular subcommittee, please back up each suggested nomination with a *brief biographical sketch* and a *summary of his or her chief contributions to geology.* In the case of the Penrose and Day Medals, a *selected bibliography* must accompany the nomination.

Please follow the same procedure for nominating your candidates for the National Medal of Science.

Book review

Natural Gas from Unconventional Geologic Sources

Proceedings of a Forum by the Board on Mineral Resources, National Academy of Sciences, 1976, National Technical Information Service, Springfield, Virginia 22161, Publication FE-2271-1, 245 p., $9.00.

The energy produced from wells in the United States in the form of natural gas (largely methane) is greater in quantity than that obtained from domestic crude oil. It supplies the heat for more than half of the residences and more than half the energy for industry. Like petroleum, reserves and production of natural gas are dropping. If present trends continue, there will be severe shortages in the next few years. The shortage of natural gas and the cost and uncertainty of finding more through conventional drilling has led to increased interest in four types of occurrences of large amounts of methane that have not been exploited to any significant degree in the past. These are (1) in the deep geopressured zone of the Gulf Coast; (2) in association with the brown shales of the Appalachian and other eastern Devonian-Mississippian basins; (3) in tight sands of the Uinta, Piceance, Green River, San Juan, Denver-Julesberg, and other western basins; and (4) in association with coals.

This growing interest, along with published reports attributing extremely large estimates of gas reserves to these sources, prompted the Board on Mineral Resources, National Research Council, to hold a forum to examine the natural gas potential from these unconventional geologic sources. This book is a transcript of the proceedings of this forum. It contains twelve prepared papers, plus extensive discussions of the papers and of related subjects. The purpose of the forum was to have specialists give a broad review of the size of the resource base, an estimate of possible reserves, and a discussion of the technology of exploration and recovery, for each of the four unconventional geologic sources. Four objectives were stated: to provide as background what is known about the physical nature and dimension of these resources, to provide a forum for the exchange of expert views, to clarify problems by identifying key uncertainties, and to develop recommendations for further research and data collection in evaluating the potential for future exploitation of the resources. As far as data was available, the first three objectives appear to have been achieved. The report does not develop recommendations for further research, which from the context of the forum is clearly needed.

This book contains much information not previously published and represents the first time this type of data has been assembled in one source. The Board on Mineral Resources does not draw conclusions concerning the resources in the body of the text, leaving it to the reader to digest the papers and discussions and to draw his own conclusions. However, in a short summary the board does present some overall impressions of the forum. It concludes that total resource figures are highly speculative and much work must be done to produce even marginally acceptable estimates, that methane from the sources will not be cheap nor easy to produce, that the level of funding devoted to investigating new sources of methane has been minuscule, and that knowledge of the geology, possible production technology, and extent of the resource is fragmentary.

Natural Gas from Unconventional Geologic Sources is a useful overview of a complex problem. Unfortunately, many more questions are raised than answered.

R. L. Jodry
Sun Oil Company
503 N. Central Expressway
Richardson, Texas 75080

Geologic Map of Mexico now available

Sociedad Geológica Mexicana informs us that the 1976 edition of the *Geologic Map of Mexico* at the scale 1:2,000,000 is now available from the Instituto de Geología, Apartado Postal 70-296, México 20, D.F., for $250 M.N. ($20 U.S.).

COCORP REPORT

Abo Pass Area, New Mexico

The second field test to demonstrate the feasibility of applying sophisticated continuous seismic reflection techniques to the solution of geologic problems in the deep basement was conducted during October-November 1975 by the Consortium for Continental Profiling (COCORP) at a site spanning the eastern margin of the Albuquerque-Belen Basin of the Rio Grande Rift in central New Mexico. The work was funded by the National Science Foundation and is part of the United States program for the International Geodynamics Project.

Two lines of continuous profiling were run: an east-west line 28.7 km long starting in the basin, thence over the pre-Cambrian basement outcrop through Abo Pass, and along the Paleozoic sediments on the eastern edge of the rift; and a north-south cross line 9.4 km long in the basin area.

BOOK BRIEFS

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

Geology of Romania

Special Paper 158 by B. C. Burchfiel with contributions by M. Bleahu. 1976. vi + 82 pages, 19 figures (including 6 black and white foldouts in pocket), 1 table. $12.75.

This paper focuses attention on the contributions of Romanian geologists and presents an outline of Romanian alpine geology not readily available to the American geologist. In addition, geologists already acquainted with the Western Alps will be able to extend their knowledge to a more easterly part of the orogenic belt that contrasts significantly with the western alpine model.

Romania consists of four major areas where Mesozoic and older rocks crop out: the Southern Carpathians, the Eastern Carpathians, the Apuseni Mountains, and Dobrogea. Upper Tertiary sedimentary rocks cover connections between these four areas and rest on older rocks in the Pannonian and Transylvanian Basins and in the Skythian (Russian) and Moesian Platforms. The Carpathian orogenic belt forms a continuous convex-east arc through Romania; orogenesis began in Triassic time.

The Southern Carpathians consist of three structural and paleogeographic units. They are, from east to west, the Danubian terrane, the Severin nappe, and the Getic terrane. The Danubian and Getic terranes consist of shallow-water marine and nonmarine Mesozoic rocks; rocks of the Getic terrane have been thrust relatively eastward over rocks of the Danubian terrane. Rocks of the Severin nappe, a thin slice of flysch and associated rocks of Late Jurassic to Late Cretaceous age, may represent remnants of an oceanic terrane. Emplacement of the Getic and Severin nappes most likely occurred during latest Cretaceous to earliest Tertiary time.

The Eastern Carpathians consist of two main paleogeographic and structural units: from east to west, the inner crystalline zone and the outer Flysch zone. Mesozoic rocks of the inner crystalline zone are primarily shallow marine or nonmarine and are similar to rocks of the Southern Carpathians. Structurally, the inner crystalline zone consists of essentially four relatively east-directed thrust slices; all but the uppermost slice contain pre-Mesozoic crystalline rocks. The uppermost nappes (Transylvanian) consist of isolated masses of Mesozoic sedimentary rocks which were probably emplaced by gravity during Early Cretaceous time. Thrusting of the lower three units occurred during late Albian to early Vraconian time; the crystalline nappes were thrust relatively eastward over the westernmost nappes of the Flysch zone.

The Flysch zone, which consists of seven nappes, contains sedimentary rocks of Late Jurassic to late Sarmatian age. Stratigraphic units in the flysch nappes change markedly from one nappe to another as a result of the migration of the axis of flysch deposition outward in time. Deformation of the Flysch zone extended over a long period, probably from Albian to Holocene time; Pleistocene rocks are folded at the south end of the flysch zone.

The Apuseni Mountains are situated in central Romania north of the Southern Carpathians and west of the Transylvanian Basin. They consist of two different structural elements—the Northern Apuseni and Southern Apuseni Mountains. Rocks in the Northern Apuseni Mountains consist of Mesozoic shallow-marine and nonmarine sedimentary rocks; north-directed thrust faults, nearly all involving pre-Mesozoic basement rocks, cut the rocks in the southern part of the Northern Apuseni Mountains. The nappes were emplaced during Late Cretaceous time.

The Southern Apuseni Mountains consist of several large bodies of mafic and rare ultramafic rocks, probably representing a Middle Jurassic ophiolite sequence, and thick sequences of flysch, wildflysch, and molasse of Late Jurassic to Late Cretaceous age. The stratigraphy and structure of the sedimentary rocks appear to represent several sedimentary basins that have been brought together by a long series of Cretaceous events, giving the Southern Apuseni Mountains a crude fan structure.

The Dobrogea area comprises a group of low mountains in southeastern Romania east of the main Carpathian chain. Dobrogea can be divided into four northwest-trending structural zones, each bounded by major faults: (1) The Pre-Dobrogea depression is an asymmetric syncline with a steep south flank and is filled with Jurassic rocks. (2) North Dobrogea contains a basement of rocks that were deformed and metamorphosed in Hercynian time; they are overlain by alpine-type Mesozoic rocks. Structurally, the rocks are thrown into northeast-directed folds and thrusts, probably formed either at the end of Jurassic time or in late Early Cretaceous time. (3) Central Dobrogea contains a basement of Precambrian metamorphic rocks that are overlain by weakly folded Jurassic rocks. (4) South Dobrogea contains rocks similar to Central Dobrogea and dips gently south, forming the east margin of the Moesian Platform. Only the Pre-Dobrogea depression can be traced east of the Carpathians into Poland.

The Pannonian and Transylvanian Basins are superposed on the structural elements of the Carpathians. They clearly represent post-tectonic basins, partly created by extension in middle and late Tertiary time.

Graptolites from the Lower Ordovician Pogonip Group of Western Utah

Special Paper 166 by Lee F. Braithwaite. 1976. vi + 106 pages, 10 figures, 2 tables. $9.75.

Well-preserved Lower Ordovician graptolites were collected from 30 localities in the Ibex region of Millard County, western Utah. They are preserved in the shale that is interbedded with fossiliferous limestone of the Pogonip Group, which comprises six formations and is 1,000 m and more in thickness. These formations are, from oldest to youngest, the House Limestone, Fillmore Limestone, Wahwah Limestone, Juab Limestone, Kanosh Shale, and Lehman Formation. The limestone fauna constitutes the best-known Lower Ordovician miogeosynclinal reference assemblage in western North America.

In this region, 45 species of graptolites from 13 genera are recognized. Of these, 15 are new and are described and named; 26 were collected in great enough numbers to be accurately identified and statistically analyzed; and 12 have excellently preserved ontogenetic and (or) early astogenetic developmental stages, descriptions of which add considerably to our present knowledge of graptolites of Early Ordovician age.

Seven graptolite zones are established for biostratigraphic correlation; this zonation is the first to be established in the Great Basin of the western United States. Zone 1 (Family Dendrograptidae) comprises the House Limestone and approximately the lower 198 m of the Fillmore Limestone; zone 2 (*Adelograptus*) ranges from approximately 198 to 378 m above the base of the Fillmore Limestone; zone 3 (*Clonograptus flexilis–Phyllograptus archaios* n. sp.) extends from approximately 378 to 381 m above the base of the Fillmore Limestone; zone 4 (*Didymograptus fillmorensis* n. sp.–*D. millardensis* n. sp.) comprises the uppermost 76.2 m of the Fillmore Limestone; zone 5 (*Tetragraptus*) extends throughout almost the entire Wahwah Limestone; zone 6 (*Didymograptus nitidus–D. patulus*) occupies a narrow stratigraphic sequence in the Juab Limestone; zone 7 (*Didymograptus bifidus*) is found throughout most of the lower 91.4 m of the Kanosh Shale.

Zone 1 of this study corresponds with W.B.N. Berry's (Marathon region of west Texas) *Anisograptus* zone, and zone 2 corresponds with his *Adelograptus-Clonograptus* zone, although the Utah zone may be slightly younger. Thereafter, correlation of the regions breaks down except for the useful *Didymograptus bifidus* zone, which is common to both regions. The four intervening zones of both regions have little in common, undoubtedly because of provincial barriers to distribution.

Interpretation of Aeromagnetic Anomalies between Latitudes 37° N and 38° N in the Eastern and Central United States

Special Paper 167 by Edward D. Lidiak and Isidore Zietz. 1976. iv + 38 pages; 4 figures including one foldout map, in color. $8.75.

The aeromagnetic map reflects the regional structure and lithology of the magnetic crystalline rocks; differences in the crustal fabric associated with each tectonic unit are strikingly apparent in the magnetic data. The major crustal units that are delineated are the Appalachian Mountain system, the buried southwesterly extension of the Grenville province, the prominent fault zones across Kentucky, southern Illinois, and Missouri, the igneous rocks of the St. Francois Mountains and vicinity, and the buried belt of low-grade metamorphic rocks in southeastern Kansas. The map also reveals a series of conspicuous, essentially east-trending magnetic lineaments, anomaly trends, and breaks in anomaly pattern along the entire survey area. Most of these east-trending features coincide in part with Phanerozoic surface faults, deflections in structural pattern, or the presence of intrusive rocks. Along one of the segments in eastern Kentucky, near the 38th parallel, magnetic and gravity anomalies associated with the Grenville front are offset to a greater degree than is the crest of the Cincinnati arch. The lineaments, therefore, probably represent ancient zones of dislocation that are more extensively developed in the basement than in the overlying rocks. Their association with Phanerozoic structures suggests that some of the dislocation segments were reactivated.

Similar magnetic and structural dislocations have been reported from other parts of the continent. There is no apparent relation between any of these continental structures and the east-trending fracture zones in nearby ocean basins. Their approximate parallelism suggests, however, that the oceanic fractures may be recent expressions of an east-trending lineament direction that has persisted for a long time.

Flight lines roughly parallel the circles of latitude and are generally about 8 km apart. Flight elevation approximates 1,525 m barometric pressure. Maps of residual total magnetic intensity are contoured at intervals of 100, 200, and 500 m; principal map scale is 1:2,500,000.

Paleoceanography of the Mesozoic Alpine Tethys

Special Paper 170 by Kenneth J. Hsü. 1976. iv + 44 pages, 11 figures. $7.00.

This work reviews the sedimentological problems of pelagic strata in the Alpine region and speculates on three particularly puzzling questions concerning these rocks: the origin of nodular limestone, the depth of radiolarite sedimentation, and the cause of penecontemporaneous chertification. The paper opens with a comprehensive historical review of investigations into the significance of Alpine pelagic sedimentary rocks.

Three important Alpine pelagic lithologic types are ammonitico rosso, Radiolarite, and Maiolica, which range in age from late Early Jurassic to Early Cretaceous.

Ammonitico rosso is in many places red nodular limestone, overlying continental crust. This pelagic deposit bears some resemblance to some Holocene nodular deposits in the eastern Mediterranean. A somewhat restricted Middle Jurassic Alpine Tethys sea has been postulated to account for the occurrence of the "homemade" bottom currents that led to partial dissolution of aragonite and precipitation of calcite nodules.

The sudden appearance of the radiolarite facies in Late Jurassic time may signify a major tectonic event that sufficiently altered the Tethyan paleogeography to permit the intrusion of an equatorial current into the Alpine realm. The radiolarite facies is commonly believed

(continued on p. 674)

to have been deposited beneath the calcite compensation depth, but calcite aptychi have been found in radiolarite, and Aptychus Limestone is intimately associated with this mainly siliceous formation. The depths of the Radiolarite sea during Late Jurassic time were probably closer to the lysocline for aragonite. Because the Radiolarite is the first sediment deposited on ophiolite, one might postulate that the Tethys at the time of Radiolarite deposition had an oceanic depth comparable to that in regions of newly formed crust. The author suggests that the Tethys in Late Jurassic time had a depth of 2,500 ± 200 m, not 4,000 to 5,500 m as postulated by some authors.

The Maiolica Formation consists of pelagic limestone with slump interbeds and intraformational chert nodules. The radiolarite-limestone succession in the Alpine Tethys is exactly the opposite of the simple model constructed by plate stratigraphers, who generally have found a limestone–radiolarite–red clay succession on an aging crust. The Alpine Tethys, being disadvantageously situated at the close of the Jurassic equatorial current system, could no longer receive enough silica to produce radiolarians. In their place, a calcareous flora of nannofossils flourished, resulting in the change from Radiolarite sedimentation to Maiolica sedimentation.

Considering the rate of the silica transport, chert in the Maiolica deposit could not have been formed by submarine diagenesis. Nodules took millions of years to grow in formations in which concentration gradients existed between the domain where amorphous biogenic silica was being dissolved and the nuclei around which quartz or cristobalite was being precipitated.

Structure of the Canyon Mountain (Oregon) Ophiolite and Its Implications for Sea-floor Spreading

Special Paper 173 by Hans G. Avé Lallemant. 1976. vi + 49 pages, 16 figures, 2 tables. $7.00.

This paper presents flow models for oceanic lithosphere that are consistent with the structure and fabric of ophiolites. The Canyon Mountain Complex, in east-central Oregon, is a true ophiolite consisting of three lithologic zones, characterized by peridotite, gabbro, and volcanic rocks, respectively, and represents a fragment of Permian oceanic lithosphere. Internal structures may reveal modes of flow in the upper mantle, the direction of sea-floor spreading, and modes and direction of emplacement on the continental crust. Pre-emplacement structures originated probably in the upper mantle during formation of the ophiolite at a Permian spreading center; they comprise two deformations, F_1 and F_2. F_1 affected all peridotite and most gabbro, which exhibit a pervasive foliation parallel to axial planes of isoclinal folds and lineations paralleling their fold axes (B_1). The Z axes of olivine and pyroxene and the [100] axes of plagioclase are preferably oriented subparallel to B_1. F_2 resulted in broad open folds with fold axes B_2 parallel to B_1. The style and restored attitude of F_1 and F_2 are consistent with flow in a diapir; the western and eastern parts of the complex appear to be fragments of two different diapiric walls. The attitudes of the foliations and lineations indicate that sea-floor spreading occurred in a west-northwest–east-southeast direction. The silicic nature of many plutonic and volcanic rocks of the complex suggests an origin near a volcanic island arc, perhaps within a marginal basin. This is in agreement with recent reconstructions of late Paleozoic geography in California and Nevada. The emplacement structures (F_3) were formed by overthrusting toward the west during the closing of the basin; these structures are correlated with Upper Triassic north-trending folds in the country rocks. The post-emplacement structures (F_4 and F_5) can be correlated with Jurassic to Tertiary deformations.

Tectonic Map of Rio Grande Rift, New Mexico

MC-11 by Lee A. Woodward, J. F. Callender, and R. E. Zilinski. 1975. In color, 28" x 40", with index and references. Scale: 1:500,000. Folded in 9" x 12" envelope: $5.00. Rolled in sturdy mailing tube: $6.00.

The Rio Grande graben is considered to be a rift valley extending at least 500 km, from central Colorado to central New Mexico. The graben merges south of Socorro into block-fault structure with a foreland Basin and Range aspect. Possibly related structure can be traced into Canada and Mexico. The graben resulted from epeirogenic uplift in the interval 30 to 20 m.y. B.P. In a wider perspective, the graben might be an element of a middle to late Cenozoic extensional system, related to plate-margin tectonics, occupying the western parts of the United States and Mexico (see Lindrith Cordell and Frank E. Kottlowski, conveners, 1975, Penrose Conference Report, Geology of the Rio Grande graben: *Geology*, v. 3, p. 420–421).

The tectonic map of the rift zone extends south-southwesterly from the Colorado border to southern New Mexico, terminating about 150 km south of Socorro; the scale is 1:500,000. In addition to tectonic features, including seven major basins, and a diagrammatic structure section, the map shows rock units or groups that are distinguished on the map by color. Precambrian basement units are mafic and ultramafic intrusive rocks, greenstone, schist and gneiss, and acidic intrusive rocks. Other pre-rift units are sedimentary rocks (Cambrian through Oligocene); mainly intermediate intrusive rocks (Cretaceous and Tertiary); volcanic and subordinate volcaniclastic rocks (Paleocene through Oligocene); and clastic, volcaniclastic, and minor volcanic rocks (lower Miocene). Units that are contemporaneous with rifting are sedimentary graben fill, with Santa Fe Group and younger sediments (middle Miocene through Holocene); and basaltic, intermediate, and rhyolitic volcanic and minor hypabyssal rocks (Pliocene and younger). There are structure contours (in thousands of feet) on top of the Precambrian rocks; the estimated elevation of the top of Precambrian rocks in the rift ranges from about 4,000 to 18,000 feet below sea level.

The oldest inherited structure is probably Precambrian in age. Regional northeasterly and secondary northwesterly Precambrian structural grain, with strong local easterly trends, is recognized. The major graben faults are en echelon along the east side and zigzag on the west.

The reverse side of the map sheet gives a regional index to the geologic mapping used in the compilation; 137 individual map areas are outlined and referenced.

Bibliography of American-Published Geology, 1669-1850

Microform Publication 4 by Robert M. Hazen. 1976. iv + 980 pages on 11 98-frame microfiche for use on 24X readers. $10.00.

The early geological literature of the United States is extensive and diverse. This bibliography, which contains approximately 13,700 entries, is an attempt to compile such references from the first pamphlet of 1669 through 1850. The references included reflect the interests, problems, and opinions, both scientific and popular, in the Earth sciences, and as such they chronicle the growth and maturation of American science and society. American reviews of foreign publications and American editions of foreign works are listed as well. Broadly conceived, the bibliography includes references relating to a variety of geological disciplines. Journal articles, notes and reviews, textbooks, government documents, mining company reports, broadsides, and geological maps are the principal types of sources included.

The core of the bibliography was constructed from approximately 4,000 references drawn from pre-1851 geological citations in other bibliographies. The number of journal articles in this preliminary list was then supplemented by additional references discovered during an examination of 700 serial titles from the Union List of Serials, for which complete runs were available. These journal titles include popular, literary, review, eclectic, juvenile, agricultural, medical, military, mechanical, religious, and scientific periodicals, and thus contain a wide variety of Earth science literature. The core list of references was further expanded by entries found during a search of National Union Catalogs and selected library card catalogs for additional books and pamphlets by authors whose names had been obtained previously from other bibliographies or journal articles. Although no attempt was made to examine systematically the vast newspaper literature, a few important original newspaper articles have been included, and many such articles that were republished in journals are also listed.

Each reference contains several elements: author; reference number, for ease of referral, indexing, and cross-referencing; date of publication; title; source, including journal title, volume, and pagination for periodical articles, and place, publisher or printer, and pagination for books and pamphlets, and place, lithographer or engraver, and size for maps and charts; and additional information, which may include clarification of subject and cross-references to closely related works, or data on the original source of extracted articles.

November BULLETIN briefs

Brief summaries of articles in the November 1976 Bulletin *are provided on the following pages and 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.*

☐ 61101—Continuous seismic reflection profiling of the deep basement, Hardeman County, Texas. *Jack Oliver, Department of Geological Sciences, Cornell University, Ithaca, New York 14850; Milton Dobrin, Department of Geology, University of Houston, Houston, Texas 77004; Sidney Kaufman, Department of Geological Sciences, Cornell University, Ithaca, New York 14850; Robert Meyer, Department of Geology and Geophysics, University of Wisconsin at Madison, Madison, Wisconsin 53706; Robert Phinney, Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08540.* (10 p., 5 figs.)

Our understanding of the crust and upper mantle would be enhanced if geophysical studies of the deep basement rocks provided information of resolution and character more nearly like that of geological observations of basement rocks at and near the surface. A test of the continuous seismic reflection profiling technique, the geophysical method with by far the highest resolution and the best potential in this regard, at a site in the midcontinent provided abundant information on intrabasement diffractors and reflectors to depths as great as about 45 km. Conventional equipment and techniques, including nonexplosive vibratory sources, were used with minor modification. In the upper part of the section below the sediments, there are reflectors continuous over the entire length of a profile that give evidence for warping, faulting, unconformities, and other structural features. An age of

1,265 ± 40 m.y. for a sample from a nearby hole indicates that these are Precambrian rocks and not part of the Cambrian basement rocks of the Wichita province. Detailed correlation with the Precambrian section is inhibited by scarcity of geological information. In the lower part of the section, reflections are not, in general, continuous over more than a few kilometres, but zones and discontinuities within the basement may be distinguished on the basis of spatial density, length, and dip of reflectors. Zones of low reflector density may be plutons; curvature of reflections may indicate deep folded structures. The scale of such features is a few kilometres, and it contrasts with the markedly larger scale of the smallest features of the deep basement that can be resolved by other methods. The method appears to have outstanding potential.

□ 61102—Structural evolution of the Vardar root zone, northern Greece. *Jay Zimmerman, Department of Earth and Space Sciences, State University of New York at Stony Brook, Stony Brook, New York 11790 (Present address: Department of Geology, Southern Illinois University at Carbondale, Carbondale, Illinois 62901); John V. Ross, Department of Geology, University of British Columbia, Vancouver 8, British Columbia.* (4 p., 6 figs.)

Allochthonous alpine ophiolites in northern Greece are related to destruction of an ocean basin during Late Cretaceous time. Associated plate interaction caused regional-scale flexure of the internal portions of obducted thrust sheets composed of continental and oceanic rocks. This flexure, the Vardar root zone, is characterized by at least four successive phases of mesoscopic folding accompanied by development of mylonites and rotation of s surfaces from a subhorizontal to a vertical or near-vertical attitude. Earlier fold sets (F_1 and F_2) in a number of lithologic units have been rotated and flattened in the core of the root flexure during its formation (F_3), which suggests that this deformation phase represents a single tectonic event. Subsequent collision of Rhodopian zone basement with the root zone may have caused renewed southwest-directed thrusting and F_4 kink folds. The Olympus window through late Paleozoic Pelagonian basement rocks into Eocene flysch suggests that the Vardar root zone and other major tectonic units in north-central Greece may be allochthonous.

□ 61103—Petrology and geochemistry of the Beemerville carbonatite-alkalic rock complex, New Jersey. *Lawrence R. Maxey, Department of Geosciences, Rider College, Lawrenceville, New Jersey 08648. (Present address: Direktorat Geologi, Jalan Diponegoro 57, Bandung, Indonesia.)* (9 p., 3 figs., 4 tbls.)

The Beemerville carbonatite-alkalic rock complex of Late Ordovician age consists of two stocklike bodies of nepheline syenite and dikes or sills of phonolite, tinguaite, lamprophyre micromalignite, lamprophyre micromelteigite, and carbonatite. The complex also includes several lamprophyric diatremes with xenoliths of sedimentary rock and gneiss and autoliths of carbonatite, potassic syenite, and lamprophyre micromelteigite. The largest diatreme also contains a small pluglike body of nepheline syenite; fenite after graywacke occurs adjacent to one of the diatremes. Intense hydrothermal alteration is particularly evident in phonolite, lamprophyre, diatreme autoliths, and diatreme matrix rock.

Field and bulk chemical evidence suggests that parental magma was of either highly carbonated melteigitic or slightly carbonated malignitic composition. A petrogenetic model based on each of these possibilities is explored. The model that begins with highly carbonated melteigite magma involves immiscibility relations between melteigite and carbonatite magmas as well as fractional crystallization processes. The model that begins with slightly carbonated malignite magma includes, in addition, immiscibility relations between carbonated melteigite and syenite magmas.

□ 61104—Spreading history of the eastern Indian Ocean and Greater India's northward flight from Antarctica and Australia. *B. D. Johnson, C. McA. Powell, J. J. Veevers, School of Earth Sciences, Macquarie University, North Ryde, New South Wales 2113, Australia.* (7 p., 4 figs., 3 tbls.)

Recent information from magnetic surveys and from deep-sea drilling allows Sclater and Fisher's Late Cretaceous and Cenozoic reconstructions of the eastern Indian Ocean to be extended back almost to the beginning of the Cretaceous Period. After a short phase of spreading off northwestern Australia in Middle and Late Jurassic time, Greater India and Antarctica-Australia dispersed near the beginning of Cretaceous time (130 m.y. B.P.) with the opening between them of a landlocked sea; between 110 to 120 and 105 m.y. B.P., Greater India cleared Antarctica-Australia, and the sea floor generated between them became continuous with the rest of the Indian Ocean. In Santonian time (80 m.y. B.P.), a new pattern of rapid spreading (as much as 17.5 cm/yr) began and caused an oceanic part of the Indian plate to be transferred to the Antarctic-Australian plate. Rapid spreading continued nearly to the end of Paleocene time (53 m.y. B.P.). With the inception at this time of spreading between Antarctica and Australia, three plates (Indian, Antarctic, and Australian) spread at a slow rate until the end of early Oligocene time (32 m.y. B.P.). At 32 m.y. B.P., the separate Indian and Australian plates became united, as they are today, while Antarctica remained a separate plate.

Together with paleomagnetic and other determinations that show that Southeast Asia lay at or north of the Equator, the trail of sea floor generated during Greater India's northward flight implies that Southeast Asia rotated westward across this trail to its present position no earlier than middle to late Miocene time (10 m.y. B.P.).

□ 61105—Application of the empirical discriminant function to regional geochemical data from the United Kingdom. *Rolando Castillo-Muñoz, Dirección de Geología, Minas y Petroleo and Escuela Centroamericana de Geología, Universidad de Costa Rica, San José, Costa Rica; Richard J. Howarth, Applied Geochemistry Research Group, Imperial College, London SW7 2BP, England.* (15 p., 12 figs., 13 tbls.)

The nonparametric empirical discriminant function was applied to stream-sediment geochemical data from the Derbyshire and Denbighshire areas in the United Kingdom in an attempt to predict both the stratigraphic af-

finity and occurrence of mineralization in the local bed rock. The discriminant functions were defined on the basis of small "training sets" of samples collected from the important geologic features of the two areas; we were successful in correctly assigning 63 and 56 percent of the stream sediments in both areas to their proper stratigraphic or mineralization class for the two areas. Log transformation of the geochemical data materially improved the classification rate. The technique seems clearly to be of use in efficiently recognizing (1) bedrock areas of geochemical similarity, despite the presence of mixed lithologies in the bedrock formations and the presence of extensive glacial overburden, and (2) localized areas of unusual geochemistry due to manganese enhancement (scavenging?) in the secondary environment or to past mining and smelting activities.

☐ 61106—Petrogenesis of McKinney (Snake River) olivine tholeiite in light of rare-earth element and Cr/Ni distributions. *William P. Leeman, Department of Geology, Oregon State University, Corvallis, Oregon 97331.* (5 p., 1 fig., 3 tbls.)

Samples of McKinney Basalt, including a pillow glass, are characterized by light rare-earth element–enriched abundance patterns with small positive Eu anomalies (relative to chondrites) and high Cr/Ni ratios. In particular, the positive Eu anomaly observed in the pillow glass is considered to be characteristic of the McKinney parental magma. These compositional features are apparently inconsistent with derivation of McKinney magma by partial fusion of garnet- or plagioclase-bearing lherzolite or clinopyroxenite or by crystal fractionation of likely liquidus phases at high or low pressure. Rather, partial melting calculations show that fusion of spinel peridotite or aluminous clinopyroxene peridotite can yield liquids with the rare-earth–element patterns and Cr/Ni ratios of McKinney Basalt. An essential feature of the favored models is a relatively large contribution of clinopyroxene to the melt. This result suggests an origin of McKinney magma by fusion of mantle lherzolite at pressures between the stability fields of plagioclase peridotite (low *P*) and garnet peridotite or garnet clinopyroxenite (high *P*), that is, at depths within the continental lithosphere in this region.

☐ 61107—Oxygen and hydrogen isotope studies of a Precambrian granite-rhyolite terrane, St. Francois Mountains, southeastern Missouri. *David B. Wenner, Department of Geology, University of Georgia, Athens, Georgia 30602; Hugh P. Taylor, Jr., Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125.* (12 p., 6 figs.)

Isotopic analyses were made on whole-rock samples and minerals from 25 granites, 21 rhyolites, and 10 basaltic dikes and sills from the 1,500-m.y.-old St. Francois Mountains terrane. The δD of chlorite is relatively uniform at -44 to -65, but the whole-rock and feldspar $\delta^{18}O$ values systematically increase from +7 in the northeast to +14 in the southwest, correlating with an increasing intensity of "brick-red" alteration of the K-feldspars. Coexisting quartz and feldspar are typically not in isotopic equilibrium, except in the northeast. The coarser grained (>1 mm) quartz ($\delta^{18}O$ = 8.8 to 10.6) is isotopically similar to "normal" igneous quartz, but the $\delta^{18}O$ of the finer grained quartz correlates with the whole-rock $\delta^{18}O$ pattern. Although the St. Francois terrane is geologically similar to many low-^{18}O Tertiary volcanic plutonic complexes that have interacted with meteoric-hydrothermal fluids at high temperatures, only a single locality (Stono Mountain) contains low-^{18}O quartz and feldspar ($\delta^{18}O$ quartz = 4.6 to 5.4). Even at this locality, the feldspars were later enriched in ^{18}O by the same alteration event that affected the rest of the region. This second stage of hydrothermal activity apparently involved aqueous fluids having $\delta^{18}O \approx 0$ to -6 and $\delta D \approx 0$ to -25. The temperature of alteration may have been as low as 50° to 100°C in the southwest (upper part of the volcanic section). This event affected some of the basaltic dikes and sills, but others were not altered and must have been intruded afterward. Rb-Sr and K-Ar age data suggest that the regional alteration occurred as late as 1,100 to 1,200 m.y. ago, long after the age of primary igneous activity. The hydrothermal fluids apparently originated as meteoric surface waters, indicating that during late Precambrian time such waters were isotopically similar to present-day meteoric waters in warm climates; this interpretation implies that the late Precambrian oceans must have been isotopically similar to present-day oceans.

☐ 61108—Devonian geology of Banks Island, Arctic Canada, and its bearing on the tectonic development of the circum-Arctic region. *Andrew D. Miall, Institute of Sedimentary and Petroleum Geology, 3303 33rd Street N.W., Calgary, Alberta T2L 2A7, Canada.* (10 p., 7 figs.)

New information, predominantly from the subsurface, shows that the Devonian rocks of Banks Island comprise four units: a shelf carbonate formation (Siegenian? to Eifelian), a basin-slope calcareous shale (Emsian to late Givetian), a basinal cherty shale (Emsian to Eifelian), and a predominantly deltaic clastic unit (Givetian to Famennian). Paleogeographic reconstructions show southern Banks Island as part of the stable shelf in Early Devonian time. During Middle Devonian time, subsidence took place, and basinal conditions encroached on the shelf from the north. The deep basin is considered to be part of Hazen Trough, which probably was connected with Richardson Trough of northern Yukon.

Subsequent tectonic events have left the Devonian rocks of Banks Island relatively undisturbed, in comparison with those of the Parry Islands to the north. Evidence of subduction and plate collision—such as strong deformation, the development of orogenic welts, and the production of thick, locally derived clastic wedges—is absent in Banks Island, in contrast to areas such as northern Ellesmere Island and northern Alaska. Therefore, if plate movements did take place in the Arctic during Devonian time, Banks Island may have lain opposite an embayment in the advancing plate, resulting in incomplete suturing, as described by Dewey and Burke. However, no satisfactory hypothesis of plate motion in the Arctic has yet been developed, in spite of many attempts.

☐ 61109—Seismic profile tying Caribbean DSDP Sites 153, 151, and 152. *George T. Moore, Chevron Oil Field Research Company, La Habra, California 90631; Davis A. Fahlquist, Department of Geophysics and Department of Oceanography, Texas A&M University, College Station, Texas 77843.* (6 p., 3 figs.)

In April and May 1971, the R/V *Alaminos* (cruise 71-A-4, leg 5) recorded a 710-km-long seismic profile in the central Caribbean Sea. This southeast-northwest profile began on the lower Colombian-Venezuelan continental margin, crossed the Aruba Gap, Beata Ridge, and Colombian Basin, and ended on the southern flank of the Nicaraguan Rise. Our principal purpose was to tie three significant Deep Sea Drilling Project (DSDP) sites on one continuous profile. Within the accuracy of our satellite navigation, we tied Sites 153, 151, and 152, respectively, on the north edge of the Aruba Gap, crest of the Beata Ridge, and lower southern flank of the Nicaraguan Rise.

Two seismic reflectors, designated Horizons A″ and B″, have been identified and traced through much of the southern Caribbean Sea. The former is a lower Paleogene siliceous or cherty chalk or limestone; the latter is basalt or a coarser grained mafic equivalent, overlain directly by Upper Cretaceous sedimentary rocks. Overlying Horizon A″ is an upper Paleogene and Neogene unit of acoustically transparent and pelagic fossiliferous chalk, ooze, and marl. The pelagic section between the reflectors is similar but more indurated and siliceous than the unit above.

Horizon A″ is somewhat more restricted in area than Horizon B″. Along this profile it is absent from the crest and steep flanks of the Beata Ridge and from local promontories on the lower flanks of the Beata Ridge and Nicaraguan Rise, and it is masked through the central Colombian Basin by a prominent set of reflectors. DSDP results at Site 152, where Horizon A″ is absent, indicate uplift of the ridge and erosion prior to deposition of the upper pelagic unit.

Excellent correlation between this profile and the DSDP results permits reconstruction and interpretation of the complete stratigraphic history along this section. We believe that with the stratigraphic data available and with the gift of hindsight, scientists can now program seismic lines that will be extremely useful in illustrating stratigraphic patterns and solving problems. Tying a series of selected DSDP sites into a continuous profile or a network of lines will permit the study of regional and three-dimensional stratigraphic patterns, sedimentational processes, and tectonics. This is another method of further utilizing these drilling results.

☐ 61110—Microbial infestation of carbonate substrates planted on the St. Croix shelf, West Indies. *Ronald D. Perkins, Constantine I. Tsentas, Department of Geology, Duke University, Durham, North Carolina 27708. (Present address, Tsentas: Dames and Moore, 7101 Wisconsin Avenue, Washington, D.C. 20014)* (14 p., 46 figs.)

Carbonate substrates prepared from the shells of living organisms and inorganic calcite were planted on the St. Croix shelf and periodically harvested to determine the nature and extent of microbial infestation by endolithic organisms. Substrates, 1 to 10 mm in diameter, were mounted on plexiglass sheets and anchored at five sites at depths ranging from the intertidal to 30 m. Samples were harvested after exposure times ranging from 9 days to 18 months. Scanning electron microscope (SEM) examination of plastic-impregnated endoliths and their resultant microborings, in association with specimens isolated through acid dissolution of host substrates, formed the basis for this investigation.

Blue-green algae were found to be the dominant microborers, and green algae were of secondary importance. Red algae and fungi were relatively scarce. In order of decreasing abundance, the following endolithic organisms were observed: *Mastigocoleus testarum* (blue-green alga), *Plectonema terebrans* (blue-green alga), *Phaeophila engleri* (green alga), *Hyella* sp. A (blue-green alga), *Ostreobium brabantium* (green alga), *Calothrix* sp. (blue-green alga), *Ostreobium constrictum* (green alga), moniliform fungus(?), *Conchocelis* stage of *Porphyra* sp. (red alga), *Scytonema* (blue-green alga), microboring sponge, reticulate fungus(?), and *Hyella* sp. B (blue-green alga).

Initial infestation of planted substrates was detectable after exposure periods of as little as 9 days and heavy infestation within 2 to 4 months. Less than 10 percent of the grains exposed for 9 days were colonized by endoliths; after 4 months approximately 95 percent of the grains were colonized. The distributional patterns of microborers that infested substrates planted on the St. Croix shelf are believed to be environmentally controlled and may be applicable in the paleoecological analyses of ancient carbonates.

☐ 61111—Structure of the glacier Charles Rabots Bre, Norway. *M. J. Hambrey, Geographical and Geological Institutes, Swiss Federal Institute of Technology, Sonneggstrasse 5, Ch-8006 Zürich, Switzerland.* (9 p., 10 figs., 1 tbl.)

Sedimentary stratification, foliation, and crevasse traces (including those of healed crevasses) are well displayed at the surface of the small, steep glacier Charles Rabots Bre. Two main flow units, cropping out as convex downglacier arcuate systems of stratification, are recognizable, but others, related to the irregular distribution of the accumulation areas, also contribute significantly to the outcrop pattern. Between the flow units and at the margins of the glacier, strong, steeply dipping longitudinal foliation crops out parallel to longitudinally striking stratification. Much of this foliation is believed to form as a result of shearing and recrystallization in the planes of favorably oriented sedimentary layers. The persistence of crevasse traces below the sets of marginal and transverse crevasses in an area of strong ablation indicates that fracture occurs to greater depths in temperate glacier ice than is generally believed.

☐ 61112—Fossilized pigments as stratigraphic indicators of cultural eutrophication in Shagawa Lake, northeastern Minnesota. *Eville Gorham, Department of Botany, University of Minnesota, St. Paul, Minnesota 55108 (Present address: Department of Ecology and Behavioral Biology, University of Minnesota, Minneapolis, Minnesota 55455); Jon E. Sanger, Department of Botany and Bacteriology, Ohio Wesleyan University, Delaware, Ohio 43015.* (5 p., 4 figs., 2 tbls.)

The recent cultural eutrophication of Shagawa Lake is reflected in the content of fossilized pigments in organic matter from a core of profundal sediment. Concentrations of chlorophyll derivatives and carotenoids in the organic matter of recently deposited sediment (1 to 10 cm deep) are three times as high as in the organic matter of sediment from the presettlement period (34 to 149 cm). Concentrations of the fossilized pigments prior to settlement also indicate that at that time Shagawa Lake was not among the more oligotrophic lakes on noncalcareous glacial drift in northeastern Minnesota. Owing to cultural eutrophication, it now appears to be the most eutrophic of the northeastern lakes and is probably somewhat more eutrophic than the average lake in Minnesota, although the ratio of sedimentary chlorophyll derivatives to sedimentary carotenoids remains characteristic of its original condition.

☐ 61113—Geophysical study of the continental margin of southern Africa. *Philip D. Rabinowitz, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964.* (11 p., 10 figs.)

Marine gravity and magnetic anomalies determine a model for the boundary between oceanic and continental basement off southern Africa. A nearly linear high-amplitude positive magnetic anomaly (about 300 to 800 γ) is coincident with an isostatic gravity anomaly where the Agulhas fracture zone is bounded to the north by the African continent. The magnetic anomaly is interpreted as a magnetic "edge effect" separating oceanic basement in the south from continental basement in the north. Where deep ocean lies on either side of the fracture zone, negative magnetic anomalies occur that are modeled by assuming a broad zone of zero magnetization within the fracture zone. Mesozoic magnetic lineations M0 (~108 m.y. B.P.) through M12 (~128 m.y. B.P.) are adjacent to the western margin of southern Africa (Cape Sequence). West of the Orange River, the magnetic anomaly amplitudes are attenuated, which is attributed to a partial demagnetization of basement rocks due to an increase in sediment overburden. A prominent magnetic anomaly (anomaly G) borders the Cape Sequence on its landward side and is coincident with an isostatic gravity anomaly. Anomaly G is interpreted as a magnetic edge-effect anomaly separating oceanic from continental basement, similar to the magnetic anomaly associated with the Agulhas fracture zone. Southwest of Capetown, anomaly G is located on the continental slope, implying that continental basement has subsided to form the slope. Farther north, anomaly G lies nearly 125 km landward of the shelf break; this implies that the shelf break in the north was formed by a prograding of sediment over an oceanic basement, in general agreement with available seismic (sonobuoy) measurements.

☐ 61114—Analysis of joints in two monoclines in Israel. *Ze'ev Reches, Department of Geology, Hebrew University, Jerusalem, Israel. (Present address: Department of Geology, Stanford University, Stanford, California 94305).* (9 p., 18 figs., 2 tbls.)

Areal and detailed studies of joints in the Hathira and Hazera monoclines of the northern Negev, Israel, pose several questions concerning relations between jointing and folding in this area. The joints can be divided into five areal sets: three of the sets have become slickensided by shear displacements and might be called small faults, and the other two sets appear to be extension fractures.

Use of the co-appearance matrix, a method introduced here, indicates that members of a conjugate set of joints intersect at a nearly constant angle throughout the area but that the acute bisector of the conjugate set trends in different directions in different areas. This suggests that areal sets of joint sets should be defined in terms of angular relations among members rather than in terms of trends.

The patterns of the joints seem to bear no simple relationship to the Hazera and Hathira monoclines. One might expect the acute bisector of conjugate sets to trend normal to axes of the monoclines; however, the bisector in the areas studied deviates 30° to 45° from normal to the axes.

Average strain due to strike-slip displacement along steeply dipping joints or small faults was measured by detailed mapping of one area. The maximum shortening accommodated by slip along joints was 1.5 percent. The axis of maximum shortening calculated from strain analysis is horizontal and trends to N78°E, whereas the normal to the axes of the monoclines is in a direction of about N45°W. Thus, direction of deformation accommodated by slip along joints and direction of deformation due to monocline formation deviate markedly.

☐ 61115dr—Unified theory of the onset of folding, boudinage, and mullion structure: Discussion and reply.

Discussion: *P. R. Cobbold, Institut de Géologie, Université de Rennes, Avenue du General-Leclerc, B.P. 25A, 35031 Rennes-Cedex, France.*

Reply: *R. B. Smith, Department of Astro-Geophysics, University of Colorado, Boulder, Colorado 80309.*

☐ 61116d—Development of chevron folds: Discussion.

Discussion: *M. B. Bayly, Department of Geology, Rensselaer Polytechnic Institute, Troy, New York 12181.*

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