GSA news & information

SUPPLEMENT TO GEOLOGY MAGAZINE

OCTOBER 1977

Come to Seattle—The heart of the Pacific Northwest

Not too long ago, when you asked knowledgeable Seattleites what to do in their city, their initial reply probably would have been an alarming "Get out of town!" Not that Washington's "Queen City" is an inhospitable place, it merely boasts an abundance of nearby outdoor attractions. The Yakima Park meadows of Mount Rainier National Park are less than two hours' drive from downtown, and the ski slopes of Snoqualmie Pass lie only fifty miles distant. In the other direction, Seattle area residents navigate the waters of Puget Sound on more than 100,000 pleasure craft and aboard the world's largest ferry system.

The nation's seventeenth largest city, with 515,000 residents (more than a million if you count its metropolitan area), Seattle has only recently come of age. Its economy has become more and more diversified—no longer is Seattle the Boeing company town.

SEATTLE'S WATERFRONT

The port city of Seattle offers great opportunity for the adventurous convention delegate with spare time. The city's waterfront is a prime attraction. Pier 70, a warehouse during the days when sailing ships frequented the waters of Puget Sound, is now a combination shopping and dining area. With more than forty merchants on hand, Pier 70 is inviting to both the serious shopper and the browser. The mixture of restaurants will appeal to the gourmet as well as to the quick-snack enthusiast.

Farther down the waterfront are import and specialty shops and restaurants and Gold Rush Strip, where a ton of gold was landed at the foot of Union Street in the late 1890s. Also of interest is Seattle's Marine Aquarium, with dolphin, whale, and sea lion shows and numerous examples of the Pacific Northwest's marine life.

PIONEER SQUARE

During the 1920s, when the city's central business district moved north, Pioneer Square—America's original Skid Road, so named because ninety years ago lumbermen fixed skids to the street and rolled logs down into Elliot Bay—went into decline. Today its 1890 buildings have been restored and Skid Road has become a neighborhood of fashionable shops and restaurants. A popular feature of Pioneer Square is the Pioneer Square Wax Museum, which exhibits scenes from Seattle and world history.

DOWNTOWN

The water boundaries that contain downtown Seattle have made it one of America's simpler places to explore. Downtown bus service has been made free of charge to discourage bringing cars into the city. Less than two miles to the north of Pioneer Square lies the Seattle Center, cultural hub of the city and the site of the 1977 Annual Meeting. The opera, symphony, and Seattle Repertory Theatre all make their home here. The Pacific Science Center offers dramatic displays of the history of United States space exploration, including recent color photos from the surface of Mars.

For a good over-all view of the city, visit the Space Needle, a 600-foot-high observation tower with a restaurant at the top, built for the World's Fair in 1962.

PUGET SOUND

Another superior panorama requires you to take a Washington State Ferry across Puget Sound to Winslow and Bremerton, where at the Puget Sound Naval Shipyard you can stand on the deck of the USS *Missouri* on the very spot where Japan signed the surrender that ended World War II. Views of Olympic Mountain summits, the distant bulk of 14,410-foot Mount Rainier, and the Queen City skyline make the ferry ride a spectacular one.

Come to the 1977 Annual Meeting and experience Seattle for yourself. For further information about the meeting, contact the Annual Meeting Department, 3300 Penrose Place, Boulder, CO 80301 (phone: 303-447-2020).

For more information and changes at the Annual Meeting in Seattle—
TURN TO PAGE 607.

Report of Committee on Investments

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

The Committee on Investments is pleased to submit its report on the investments of the Society for 1976.

On December 31, 1976, the market value of the combined investment accounts of the Society was $8,449,647 as compared to $7,652,000 on December 31, 1975, a gain of 10.4%.

For several years, the committee has felt that having all the investment responsibility in the hands of one advisory institution left something to be desired. Accordingly, interviews with other advisors of national stature were commenced over two years ago when Dr. Harry Burgess chaired the committee. At Council meeting in November, approval was given to place approximately $2,000,000 of Penrose Endowment Fund securities in the hands of Faulkner, Dawkins, and Sullivan for their management on a nondiscretionary basis. The funds transferred were in the form of stocks not included in the options list and commercial bonds.

During the year, the committee spent a major part of its time considering the options market, whether we could legally enter this market in compliance both with our charter and IRS regulations. Upon advice of legal counsel, the Executive Committee and Council approved a plan whereby we assigned approximately $2,000,000 in listed securities to Irving Trust Company. With full discretion, Irving Trust is authorized to sell option contracts on these securities. The objective of this program is to maximize return-on-investment on investments which, for the most part, have been considered "growth stocks." As of December 31, 1976, the proceeds of open option contracts amounted to $46,968, with an unrealized loss of approximately $11,000.

At its November meeting, Council approved the appointment of Robert L. Fuchs as chairman of the Committee on Investments replacing William B. Heroy, Jr. Dr. Fuchs is well qualified and, being in the New York area, should do a better job of keeping in close touch with the advisors and the stock market.

THE GEOLOGICAL SOCIETY OF AMERICA, INC.
SUMMARY OF INVESTMENTS BY FUNDS
IN CUSTODY OF IRVING TRUST COMPANY
DECEMBER 31, 1976

Principal Amount	Security	Cost	Approximate Market Value
	CURRENT FUND		
$ 265,000.00	Short Term Investments	$ 265,000.00	$ 265,000.00
363,000.00	U.S. Government & Agency Obligations	366,114.40	383,346.25
60,000.00	Corporate	60,000.00	61,650.00
Total Current Fund Investments		$ 691,114.40	$ 709,996.25
	MAJOR REPAIRS FUND		
$ 69,000.00	Short Term Investments	$ 69,346.25	$ 70,000.00
41,000.00	U.S. Government & Agency Obligations	41,159.25	42,761.25
Total Major Repairs Fund Investments		$ 110,505.50	$ 112,761.25
	RETIREMENT RESERVE FUND		
$ 69,000.00	Short Term Investments	$ 69,000.00	$ 69,000.00
134,000.00	U.S. Government & Agency Oblications	134,611.35	137,947.50
185,000.00	Corporate	186,325.00	185,181.25
28,625.63	Private Placements	28,625.63	24,009.75
130,000.00	Convertible Fixed Income	135,663.75	124,775.00
	Common Stocks	300,561.67	288,466.25
Total Retirement Reserve Fund Investments		$ 854,787.40	$ 829,379.75
	INCOME STABILIZATION FUND		
$ 47,000.00	Short Term Investments	$ 47,137.50	$ 47,400.00
251,000.00	U.S. Government & Agency Obligations	252,279.23	266,598.75
Total Income Stabilization Fund Investments		$ 299,416.73	$ 313,998.75
	PENROSE ENDOWMENT FUND		
$ 30,000.00	Short Term Investments	$ 30,207.75	$ 30,600.00
540,000.00	U.S. Government & Agency Obligations	542,340.00	566,625.00
200,000.00	Canadian Government	200,000.00	207,500.00
900,000.00	Corporate	884,061.50	878,250.00
403,000.00	Private Placements	402,881.00	310,191.25
	Sub-Total	2,059,490.25	1,993,166.25
	PENROSE ENDOWMENT FUND STOCK OPTION INVESTMENT		
$ 136,000.00	Short Term Investments	136,000.00	136,000.00
	Common Stocks	1,481,287.10	1,768,137.50
	Sub-Total	3,676,777.35	3,897,303.75
	PENROSE ENDOWMENT FUND--SECURITIES MANAGED BY FAULKNER, DAWKINS & SULLIVAN	1,941,825.39	2,101,962.50
Total Penrose Endowment Fund Investments		$5,618,602.74	$5,999,266.25
	PENROSE MEDAL FUND		
$ 5,000.00	U.S. Government & Agency Obligations	$ 5,012.50	$ 5,150.00
$ 4,000.00	Corporate	$ 3,990.00	$ 4,110.00
Total Penrose Medal Fund Investments		$ 9,002.50	$ 9,260.00
	DAY MEDAL FUND		
$ 7,000.00	U.S. Government & Agency Obligations	$ 7,043.75	$ 7,210.00
12,000.00	Corporate	12,000.00	12,330.00
20,000.00	Convertible Fixed Income	22,750.00	16,050.00
	Common Stocks	12,006.98	5,650.00
Total Day Medal Fund Investments		$ 53,800.73	$ 41,240.00
	BRYAN MEMORIAL FUND		
$ 7,000.00	U.S. Government & Agency Obligations	$ 6,780.00	$ 7,191.25
6,000.00	Corporate	6,000.00	6,165.00
Total Bryan Memorial Fund Investments		$ 12,780.00	$ 13,356.25
	STEARNS AWARD FUND		
$ 10,000.00	U.S. Government & Agency Obligations	$ 10,000.00	$ 10,387.50
Total Stearns Award Fund Investments		$ 10,000.00	$ 10,387.50
	BIRDSALL AWARD FUND		
$ 10,000.00	Short Term Investments	$ 10,000.00	$ 10,000.00
Total Birdsall Award Fund Investments		$ 10,000.00	$ 10,000.00

Respectfully submitted,

WILLIAM B. HEROY, JR., Chairman; PETER T. FLAWN; ROBERT L. FUCHS; MICHEL T. HALBOUTY; AUGUST GOLDSTEIN, JR., Treasurer; JAMES BOYD, Conferee; ROBERT E. KING, Conferee

Annual Report for 1976
The Geological Society of America

Digby McLaren appointed board chairman of International Geological Correlation Program

At its 5th annual meeting held in Paris, the Board of the International Geological Correlation Program appointed Dr. D. J. McLaren to succeed Sir Kingsley Dunham as its Chairman. The International Geological Correlation Program was formally launched in 1973 as a joint program of UNESCO and the International Union of Geological Sciences.

Dr. McLaren, who is currently a Councilor of GSA, is Director-General of the Geological Survey of Canada.

American Institute of Physics reduces rates for GSA members

We have received at headquarters the following information and generous offer from the American Institute of Physics.

It is the policy of the Institute to offer reduced-rate subscriptions for its own journals to members of affiliated societies. This offer is limited to one subscription per person to each journal. Following is a list of Institute-owned journals showing the member rates that are available to members of your society, and the nonmember rates, for 1978:

	Member Rate	Nonmember Rate
Journal of Applied Physics	$24.50	$112.00
Applied Physics Letters	13.00	55.00
The Journal of Chemical Physics	42.00	195.00
Journal of Mathematical Physics	18.00	95.00
The Physics of Fluids	18.00	95.00
Physics Today	10.00	24.00
The Review of Scientific Instruments	15.00	50.00
Current Physics Index	30.00	95.00
Journal of Physical and Chemical Reference Data	25.00	90.00

If any GSA member wishes to take advantage of this offer, he should send his subscription orders, with remittances, directly to the American Institute of Physics, 335 East 45th Street, New York, NY 10017, and include a statement indicating that he is a member of GSA, an affiliated society.

Annual Reports for 1974 and 1975 available on request

Those librarians who wish to receive a copy of the Annual Report for 1974 and 1975 of the Geological Society of America for archival purposes may obtain a photocopy by writing to

The Geological Society of America
3300 Penrose Place, Boulder, Colorado 80301
(Attention: Administrative Assistant)

National Committee on Rock Mechanics offers three reports and directory

The 18th Symposium on Rock Mechanics was held at Keystone, Colorado, June 22–24, 1977. The theme of the symposium was "The Application of Rock Mechanics to Energy Resources and Excavation Technology." Of particular interest to geologists were sessions on the specific topics of coal and oil-shale mining, drilling of oil and gas wells, problems related to geothermal energy, and rock mechanics related to certain types of mining problems, such as acoustic emissions, *in situ* stress measurements, and rock structure stability. The symposium was attended by more than 200 registrants. The sessions were well attended and discussions were often lively.

The U.S. National Committee for Rock Mechanics is nearing completion of three reports covering areas in which rock mechanics problems are the limiting ones, and major research efforts are required. The reports suggest future directions that appear to have the most promise for solving these problems. The areas covered are (1) energy resource recovery and development, (2) earthquake hazard reduction, and (3) underground construction and tunneling. Copies of these reports will be available from the Executive Secretary, USNC/RM, National Research Council, 2101 Constitution Avenue, Washington, D.C. 20418.

The Committee is also in the process of compiling a list of scientists and engineers who are active in the field of rock mechanics. The list will make it possible for the rock mechanics community to vastly improve communications and to become better informed about news and developments within the field. If your geological activities include some aspect of rock mechanics, you are strongly urged to contact the Executive Secretary for a copy of the questionnaire. You may use the coupon below.

Prepared by *Bruce R. Clark*
GSA Representative

EXECUTIVE SECRETARY
USNC/RM
2101 CONSTITUTION AVENUE
WASHINGTON, D.C. 20418

PLEASE SEND ME ______ COPIES OF THE ROCK MECHANICS PERSONNEL QUESTIONNAIRE.

NAME: ______________________

ADDRESS: ______________________

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Minority scholarships awarded by American Geological Institute to fifty-seven geoscience students

At their March meeting, the Advisory Committee for the AGI Minority Participation Program reviewed the applications received for scholarship aid to cover the 1977–78 academic year. As a result, some fifty-seven geoscience students were awarded scholarships ranging from $250 to $1,250. Those students receiving these AGI scholarships are listed separately. Total funds committed amounted to $50,922, which represented a 26% increase in funding over the previous year. The total number of scholarships increased by 35% over the previous year.

The purpose of the AGI program for minority geoscience students is to establish objectives and goals for attracting Blacks, American Indians, and Hispanics of American citizenship into the geoscience discipline and to award scholarships to these minority students on the basis of past and current academic achievement, maturity and background, financial need, and potential for future professional success. Another purpose is to provide advisory counseling services to minority students, universities, employers, and professional societies on minority geoscience matters.

This program, which started in 1974, has financially helped some 140 minority geoscience students toward development of a career in the geoscience discipline. Although the majority of these scholarship recipients are still in their academic programs, sixteen are known to have completed their degree requirements and are gainfully employed.

The scholarship program is dependent upon funds contributed by industrial organizations, member professional societies, and by a large group of individuals. These contributors include American Geophysical Union; American Metal Climax Company; Cities Service Company; Dowell Division of the Dow Chemical Company; Exxon Company, U.S.A.; Foote Mineral Company; General Crude Oil Company; members of the Geological Society of America; Greenberg and Glusker; Houston Oil and Minerals Corporation; Hunt Oil Company; Kennecott Copper Corporation; Kinemetrics, Inc.; Marathon Oil Company; Mobil Oil Corporation; Natural Gas Pipeline Company; members of the National Association of Geology Teachers; members of the Seismological Society of America; Society of Economic Geologists; Society of Economic Paleontologists and Mineralogists; St. Joe Minerals Company; Standard Oil Company of California; Sunmark Exploration Company; Tenneco, Inc.; Union Oil Company of California; Utah International, Inc.; and Ward's Natural Science Establishment, Inc.

The Advisory Committee would like to enlarge the number of contributors for the 1978–79 academic year. Inquiries would be welcomed by interested industrial organizations, professional societies, or individuals. These inquiries should be addressed to *Earl H. Bescher, Jr.*; Chairman, AGI Minority Participation Program; c/o Exxon Company, U.S.A.; P. O. Box 2180; Houston, Texas 77001 (713) 656-3323.

The AGI Advisory Committee will be receiving applications for the 1978–79 academic year studies starting in September 1977; all applications must be submitted by February 1, 1978. Requests for application forms and all completed applications should be made to *William H. Matthews*, Director of Education, American Geological Institute, Box 10031, Lamar University Station, Beaumont, Texas 77710.

1977–1978 AGI SCHOLARSHIP RECIPIENTS

Donna Adams - Black geology freshman at the University of New Orleans

Eugenio Asencio - Puerto Rican geophysics graduate student at Colorado School of Mines

Carolyn J. Ates - Black geology graduate student at East Texas State University

Barbara A. Barreiro - Puerto Rican geology graduate student at the University of California, Santa Barbara

Patricia Ann Bautista - Puerto Rican geology graduate student at the University of Texas, El Paso

Manuel Berumen - Mexican-American geology graduate student at the University of Texas, Austin

Rufus D. Catchings - Black geology junior at Appalachian State University

Dwight M. Coleman - Black geology junior at Princeton University

William Comeaux - Black meteorology junior at Kean College

Angel Curet - Puerto Rican geology graduate student at the University of California, Santa Barbara

James E. Davis - Black geology graduate student at the University of Southern Mississippi

Celeste F. Diggs - Black geology senior at Howard University

Richard F. Escandon - Mexican-American geology senior at the University of California, Los Angeles

Elliot Fisher - Black math/physics senior at York College who has been designated the Seismological Society of America Scholar

Patricia M. Ford - Black earth science sophomore at the University of New Orleans

Eduardo Gonzales - Mexican-American geology senior at Texas Tech University

Bryan D. Goodwin - Black geochemistry sophomore at Howard University

Juan A. Guerrero - Mexican-American geology senior at the University of Southern California

Cynthia M. Gurule - Mexican-American earth science junior at New Mexico Highlands University

Sylvia Gutierrez - Mexican-American geology senior at Texas Southern University

Frank R. Hall - Black geology senior at Kean College

Joseph M. Hayden - Black geology senior at Western Kentucky University

Eldewins Haynes - Black meteorology graduate student at North Carolina State University

Raul Huerta - Mexican-American geology graduate student at the University of Houston

Anthony G. Johnson - Black geology junior at the University of Texas, Austin
Germaine P. Johnson - Black earth science freshman at the University of New Orleans
Alvin L. Jones - Black geology senior at Elizabeth City State University
Felix F. Lopez - Puerto Rican geology graduate student at Arizona State University
Lupe K. Macias - Mexican-American geophysics senior at the University of Minnesota
Edward Magdaleno - Mexican-American geology senior at the University of Southern California
Daniel C. Martinez - Mexican-American geology graduate student at the University of Texas, Austin
Vernal R. Martinez - Mexican-American civil engineering/ hydrology graduate student at the University of Colorado
Jose E. Nevarez - Puerto Rican geology freshman at Louisiana Tech University
Edwin Nunez - Puerto Rican meterology graduate student at Colorado State University
Dixon A. Oriola - Black geology graduate student at the University of California, Santa Barbara
Brenda C. Outler - Black geology graduate student at Florida State University
Gary R. Pagan - Puerto Rican geology graduate student at York College
Odell Pilot - Black geology junior at Texas Southern University
Robert J. Quintanar - Mexican-American geology graduate student at the University of New Mexico
Abelardo L. Ramirez - Puerto Rican engineering geology graduate student at Purdue University
Melanie E. Reed - Black geology freshman at the University of New Orleans
Lisa K. Ricard - Black geology sophomore at the University of New Orleans
Rudy Rodriguez - Mexican-American geology senior at Texas Southern University
Brenda L. Rouse - Black geology junior at West Texas State University
Edward Ruiz - Puerto Rican oceanography graduate student at City College of New York
Phyllis J. Rutherford - American Indian geology senior at Southern Oregon State College
Victor W. Sargeant - Black geophysics senior at the University of Arizona
Charles H. Smith - Black geology senior at Bishop College
Dane B. Sparrow - Black geology senior at Howard University
Marilyn J. Suiter - Black geology senior at Franklin & Marshall College
Angelita Thorp - Mexican-American geology junior at the University of Texas, Austin
Susan C. Torres - Puerto Rican geology junior at York College
Ronald P. Trujillo - Mexican-American geology senior at Colorado State University
Ella Jean Woods - Black geology graduate student at Rutgers University
George E. Young - Black geology senior at California State University
Ricard L. Zepeda - Mexican-American geology junior at the University of California, Los Angeles

NOAA's National Ocean Survey hydrographic data to be cataloged and distributed

Over the past several years NOAA's National Ocean Survey has been engaged in digitizing hydrographic data from more than 3,200 hydrographic surveys as part of a project to automate the nautical chart production process.

The Environmental Data Service (EDS) of NOAA has been designated as the agency to disseminate these data to the public. To describe and clearly define geographic coverage of available data, a series of catalogs is being produced. Further information is available from National Geophysical and Solar-Terrestrial Data Center, NOAA/EDS, Boulder, Colorado 80302.

Metamorphic map of Europe published

The map of metamorphic facies of Europe consists of 16 sheets on a scale of 1:2,500,000 and one special sheet of the Alps on a 1:1,000,000 scale. The map is published by UNESCO and the Subcommission for the Cartography of the Metamorphic Belts of the World.

The topographic base and the division of the map into sheets are the same as the new tectonic map of Europe, permitting a direct comparison.

All 17 sheets are available now from the Department of Structural Geology, Garenmarkt 1B, LEIDEN (The Netherlands). The price of the complete set, including the explanatory text, is $60 plus postage and transfer costs.

GOING ....

GOING .....

GONE . . .

The 5% discount for cash with order will be a thing of the past beginning January 1, 1978. All our current order forms state "When payment accompanies order, 5% may be deducted. When member or quantity discount is applicable, it should be deducted before the 5% is computed."

There is now a time limit on that 5% discount. All cash orders postmarked January 1, 1978, and thereafter must be accompanied with full payment, less applicable member or quantity discount. So, don't delay any longer getting your order in for that Special Paper, Memoir, and (or) part of the *Treatise on Invertebrate Paleontology* you just haven't got around to ordering yet.

GSA will continue to absorb postage and handling charges on all orders that are received with full payment.

Penrose Conference on mélanges scheduled for April 23-28, 1978, at Avila Beach

A Penrose Conference on mélanges will be held in Avila Beach, California, from April 23 to April 28, 1978. Mélanges are an important but enigmatic component of most orogenic belts, and the relative roles of gravitative and subduction-related processes in their formation have not yet been well defined.

The purpose of the conference is to promote broad communication among geologists working on mélanges in various orogenic belts throughout the world and among marine geophysicists working on modern mélanges. The conference intends to (a) compare several well-known mélange belts and assess the significance of the variations between them; (b) examine the character and magnitude of strain within mélanges and work toward identifying fabric criteria definitive of the strain path(s) of mélange formation; (c) search for areas of agreement on the origins and modes of emplacement of mélanges, particularly with respect to the relative importance of gravity sliding and underthrusting in mélange generation; and (d) consider the subsequent evolution of melange bodies after mélange generation.

Field trips to the pelitic-matrix Franciscan mélange near Morro Bay and the serpentine-matrix mélange of the Sierra foothills will be included in the five-day conference. Attendance will be limited to 60 persons and the cost will be about $300 per person. Those interested in attending should contact either of the co-convenors: Edward C. Beutner, Department of Geology, Franklin and Marshall College, Lancaster, PA 17604, or Eli A. Silver, Board of Earth Sciences, Applied Sciences Bldg., University of California, Santa Cruz, Santa Cruz, CA 95064. Please include a brief statement of your potential contribution to the conference. Deadline for applications is February 10, 1978.

October BULLETIN briefs

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

• 71001—Surface faulting associated with the 5.2 magnitude Galway Lake earthquake of May 31, 1975: Mojave Desert, San Bernardino County, California.

Robert L. Hill, David J. Beeby, California Division of Mines and Geology, Los Angeles, California 90012. (7 p., 10 figs.)

An earthquake of magnitude 5.2 occurred on May 31, 1975, near Galway Lake in the Mojave Desert, San Bernardino County, California. Preliminary information from the Seismological Laboratory at the California Institute of Technology placed the hypocenter at a depth of 5.8 km with the epicenter at lat 34°31.4′N and long 116°29.3′W. This event was accompanied by surface rupture in a zone 6.8 km long and as much as 100 m wide, trending N25°W to due north along an existing but unmapped fault. Field evidence and aftershock data by others indicate that the fault is vertical. Left-stepping en echelon fractures indicate predominant right-lateral displacement. Individual fractures are vertical and have right slip generally from 0.2 to 0.5 cm up to a maximum of 1.5 cm. Shallow pits dug across surface faults in Quaternary alluvium revealed plant roots concentrated in fractures indicating that surface rupture occurred along these fractures during at least one previous event. These and other features combined with topographic evidence confirm previous Quaternary displacement and may indicate at least one previous event accompanied by surface rupture in Holocene time. This rupture zone has been named the Galway Lake fault zone.

• 71002—Recent plate motions in the Galapagos area.

Richard Hey, Department of Geological & Geophysical Sciences, Princeton University, Princeton, New Jersey 08540 (present address: Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii 96822); G. Leonard Johnson, Office of Naval Research, Arlington, Virginia 22217; Allen Lowrie, U.S. Naval Oceanographic Office, Washington, D.C. 20732. (19 p., 15 figs., 3 tbls.)

Recent accretion on the Cocos-Nazca spreading center has been asymmetric, with more material (along most of the rise) added to the Cocos than to the Nazca plate. There is evidence in the magnetic record that some of this asymmetric accretion has resulted from small discrete jumps of the rise axis to the south, forming and destroying transform faults.

Relative and absolute models of instantaneous plate motions derived here provide an accurate representation of recent motions in the east Pacific. The existence of a self-consistent model that fits all the relative-motion data provides strong support for the hypothesis that plates behave rigidly. In addition, the exceptional agreement between the relative-motion and absolute-motion models provides strong support that the Wilson-Morgan hotspot hypothesis holds for the recent past. In particular, the agreement of the predicted instantaneous azimuths of the Cocos and Carnegie Ridges with their observed azimuths strongly suggests that at least the young parts of both aseismic ridges were formed by the motion of the Cocos and Nazca plates over a Galapagos hotspot.

• 71003—Tectonic evolution of the Cocos-Nazca spreading center.

Richard Hey, Department of Geological & Geophysical Sciences, Princeton University, Princeton, New Jersey 08540 (present address: Hawaii Institute of Geophysics, University of Hawaii, Honolulu, Hawaii 96822). (17 p., 9 figs.)

Magnetic and bathymetric data from the eastern Pacific have been analyzed and a model for the evolution of the

Galapagos region developed. The Farallon plate appears to have broken apart along a pre-existing Pacific-Farallon fracture zone, possibly the Marquesas fracture zone, at about 25 m.y. B.P. to form the Cocos and Nazca plates. This break is marked on the Nazca plate topographically by the Grijalva scarp and magnetically by a rough-smooth boundary coincident with the scarp. The oldest Cocos-Nazca magnetic anomalies parallel this boundary, implying that the early Cocos-Nazca spreading center trended east-northeast. This system soon reorganized into an approximately east-west rise–north-south transform configuration, which has persisted until the present, and the Pacific-Cocos-Nazca triple junction has since migrated north from its original location near lat 5°S. If correct, the combination of these simple geometric constraints produced the "enigmatic" east-trending anomalies south of the Carnegie Ridge.

The axes of the Cocos-Nazca spreading center and the Carnegie Ridge are essentially parallel; this can lead to paradoxical conclusions about interpretation of the Cocos and Carnegie Ridges as hotspot tracks. Hey and others (1977) have shown that recent accretion on the Cocos-Nazca spreading center has been asymmetric, resulting at least in part from small discrete jumps of the rise axis. I show here that the geometric objections to both the "hotspot" and "ancestral-ridge" hypotheses on the origin of the Cocos and Carnegie Ridges can be resolved with an asymmetric-accretion model. However, all forms of the ancestral-ridge hypothesis encounter more severe geometric difficulties, and these results support the hotspot hypothesis.

• 71004—Northern Trans-Pecos magmatic province: Introduction and comparison with the Kenya rift.

Daniel S. Barker, Department of Geological Sciences, University of Texas at Austin, Austin, Texas 78712 (7 p., 9 figs.)

The Trans-Pecos magmatic province of West Texas and southern New Mexico is a more eroded analogue of the Kenya (Gregory) rift in East Africa. Trans-Pecos alkalic rocks are similar to the basalt-phonolite-trachyte-rhyolite assemblage from fissure and multicenter eruptions, and from some central volcanoes, in the Kenya rift. In both provinces, quartz-normative and nepheline-normative mafic rocks occur, providing likely parents for the entire observed range of silica saturation. Thus, no special mechanism is needed for deriving silica-undersaturated and silica-oversaturated rocks from one another, because both groups evolved independently. The Kenya rocks tend to be more mafic and, at the silicic end of their compositional range, more peralkalic than the Trans-Pecos rocks.

Similarities in tectonic style, extent and duration of magmatism, and igneous rock compositions in the two provinces suggest that the alkalic rocks in both regions were generated by differentiation from quartz- and nepheline-normative parents in the upper parts of elongate mafic or ultramafic intrusions, probably diapiric welts that caused doming and normal faulting.

• 71005—Mineralogy of intrusions in the Diablo Plateau, northern Trans-Pecos magmatic province, Texas and New Mexico.

Daniel S. Barker, Floyd N. Hodges, Department of Geological Sciences, University of Texas at Austin, Austin, Texas 78712 (present address, Hodges: Department of Geology, Furman University, Greenville, South Carolina 29613). (9 p., 7 figs., 5 tbls.)

Electron probe microanalyses of minerals in the nine intrusive rock types of the Diablo Plateau document compositional changes accompanying magmatic differentiation. Plagioclase occurs only in the least differentiated rock type. Alkali feldspar phenocrysts show little compositional variation. Groundmass feldspar compositions were modified by exsolution and deuteric alteration, particularly during growth of natrolite. Nepheline compositions in these hypabyssal rocks are intermediate between those of volcanic and plutonic nephelines elsewhere.

Mafic minerals show wider compositional variations. Clinopyroxene, the most abundant of these, changed from sodian augite toward hedenbergite, and then toward acmite. The more sodic pyroxenes crystallized later than feldspars and nepheline from residual liquids after emplacement at the now-exposed level. Amphiboles and biotites show progressive decreases in Ti, Mg, and tetrahedral Al/Si. In the least differentiated rock type and in some autoliths, the amphibole is kaersutite; in later formed rocks, hornblendes and sodic amphiboles are widespread. Other prominent minerals showing compositional variation are manganoan fayalite, aenigmatite, and eudialyte.

For the nepheline syenites, crystallization temperatures are estimated at 700 to 725 °C, with $\log(f_{O_2}) = -20$ and $\log(f_{H_2O}) = +1.6$ to 2.1.

• 71006—Petrology and Rb-Sr isotope geochemistry of intrusions in the Diablo Plateau, northern Trans-Pecos magmatic province, Texas and New Mexico.

Daniel S. Barker, Leon E. Long, G. Karl Hoops, Floyd N. Hodges, Department of Geological Sciences, University of Texas at Austin, Austin, Texas 78712 (present address, Hodges: Department of Geology, Furman University, Greenville, South Carolina 29613). (10 p., 9 figs. 5 tbls.)

Shallow intrusive bodies in a 65-km-long belt consist of quartz-bearing and feldspathoidal syenite, trachyte, and phonolite, all within a narrow range of composition. K-Ar ages (35 ± 2 m.y.) and modal, whole-rock chemical, Rb-Sr isotopic, and mineralogic data suggests that all the intrusive rocks were derived from one magma reservoir.

Nine intrusive rock types are divisible into two groups. The older group, commonly forming sills and laccoliths, is fine- to coarse-grained and has little or no flow structure, low Rb, high Sr, and initial $^{87}Sr/^{86}Sr$ ratios of 0.703 to 0.709. The younger group, tending to form discordant sheets, is finely porphyritic and has strongly developed flow structure, high Rb, low Sr, and initial strontium ratios of 0.705 to 0.712. The younger group shows more extreme compositional variation, including the most silica-oversaturated and the most silica-undersaturated rocks. Each group contains both quartz-bearing and feldspathoidal rock types.

Fractional removal of plagioclase and biotite from mugearitic liquid progressively enriched the remaining liquid in sodium while depleting it in calcium, magnesium, and titanium. Later differentiation proceeded mostly by removal of alkali feldspar.

• 71007—Origin of the northwestern Bahama Platform: Review and reinterpretation.

Henry T. Mullins, Curriculum in Marine Sciences, 12-5 Venable Hall, University of North Carolina, Chapel Hill, North Carolina 27514; George W. Lynts, Department of Geology and Marine Laboratory, Duke University, Durham, North Carolia 27708. (15 p., 13 figs.)

The origin of the Bahama Platform has been the subject of debate for more than a century. The major points if disagreement are (1) whether the Bahamian basement is continental or oceanic, and (2) the age and origin of the deep Bahama channels. Geophysical data indicate only that the Bahamian basement is of intermediate density, seismic velocity, and thickness. We propose that this basement was originally pre-Triassic continental material that was pervasively intruded by mafic and ultramafic material during the rifting of North America from Africa and South America in Late Triassic time. To alleviate the Bahama overlap in reconstructions of the North Atlantic we suggest that the Bahama Platform has been rotated approximately 25° to the northeast by the relative impinging motion of the Caribbean plate during Cretaceous and early Tertiary time. By accounting for this postulated rotation, the Bahama Platform forms an excellent fit between Africa and South America.

We propose the following model for the origin of the northwestern Bahama Platform: (1) The platform is continental and was originally part of Africa. (2) Rifting of North America from Africa and South America began in the vicinity of the northwestern Bahamas during the Late Triassic, preceded by a large domal uplift of the continents that initiated the deep Bahama Channels as grabens. (3) The Bahama Platform rifted from Africa principally along a large right-lateral shear and thus evolved as a transcurrent-type continental margin. (4) During the incipient development of the deep Bahama channels, Late Triassic continental arkosic rudites and arenites were deposited at the base of these grabens; (5) Initial marine conditions in Early to Middle Jurassic time may have resulted in the deposition of salt and organic-rich shales in the channels due to restricted circulation. (6) With the onset of more open marine conditions 3 to 6 km of Jurassic to Holocene deep-water carbonate and bioclastic turbidite sediments were deposited in the channels. (7) Most of the intraplatform relief of the northwestern Bahamas appears to be the result of the build-up of the banks relative to the channels during regional subsidence.

• 71008—Silurian and Devonian coral zones in the Great Basin, Nevada and California.

J. G. Johnson, Department of Geology, Oregon State University, Corvallis, Oregon 97331, W. A. Oliver, Jr. U.S. Geological Survey, Washington, D.C. 20560. (7 p., 1 fig.)

Charles W. Merriam studied Paleozoic stratigraphy and paleontology of Great Basin rocks for four decades. This culminated in 1973-1974 with the publication of four important monographs on the systematics and biostratigraphy of Silurian and Devonian rugose corals in the area. Merriam died in 1974 before completing work on the Late Devonian corals and without attempting to relate his coral zones to zones based on other biologic groups.

Merriam described the rugose corals of 12 coral zones and based his age assignments almost entirely on a comparison of the Great Basin corals with those known from other areas of the world. Analysis of associated invertebrate fossils shows that some of Merriam's age assignments were in error. In this paper, we discuss the relationships of the coral zones to those based on brachiopods, conodonts, and graptolites; we assign three of Merriam's zones to the Silurian, six to the Early Devonian, and three to the Middle Devonian. Merriam designated two additional (higher) zones, but he did not describe the included corals. These two zones are noted, and lists of Great Basin rugose coral genera of Late Devonian age are presented herein to complete this review of the coral succession in a major North American area.

• 71009—Seismic structure of the Transverse Ranges, California.

David Hadley, Hiroo Kanamori, Seismological Laboratory, California Institute of Technology, Pasadena, California 91125. (10 p., 7 figs., 1 Tbl.)

Travel-time data obtained from both natural and artificial events occurring in southern California indicate a major, lateral crustal transition within the Transverse Range Province. The eastern crust is very similar to the adjacent Mojave region, where a crustal velocity of 6.2 km/sec is typically observed. The western ranges are dominated by an extensive 6.7 km/sec layer. P_n velocity beneath the western Mojave, Transverse Ranges, and northern Peninsular Ranges is 7.8 km/sec. The crustal thickness of these provinces is 30 to 35 km. The Transverse Ranges do not have a distinct crustal root. Unlike other provinces within southern California, the Transverse Ranges are underlain at a depth of 40 km by a refractor with a P-velocity of 8.3 km/sec. P-delays from a vertically incident, well-recorded teleseism suggest that this velocity anomaly extends to a depth of 100 km. These data indicate that this high-velocity, ridge-like structure is coincident with much of the areal extent of the geomorphic Trnasverse Ranges and is not offset by the San Andreas fault. Four hypotheses are advanced to explain the continuity of this feature across the plate boundary: (1) dynamic phase change; (2) a coincidental alignment of crust or mantle anomalies; (3) the lithosphere is restricted to the crust; (4) the plate boundary at depth is displaced from the San Andreas fault at the surface. Within the content of the last model, we suggest the plate boundary at depth is at the eastern end of the velocity anomaly, in the vicinity of the active Helendale-Lenwood-Camprock faults. The regionally observed 7.8 km/sec layer is suggested as a zone of decoupling necessary to accommodate the horizontal shear that must result from the divergence of the crust and upper mantle plate boundaries. The geomorphic Transverse Ranges are viewed as crustal buckling caused by the enhanced coupling between the crust and upper mantle which is suggested by the locally thin, 7.8 km/sec layer.

• 71010—Timing of mid-Tertiary volcanism in the Sierra Madre Occidental between Durango City and Mazatlán, Mexico.

Fred W. McDowell, Richard P. Keizer, Department of

Geological Sciences, University of Texas at Austin, Austin, Texas 78712. (9 p., 4 figs., 3 tbls.)

The relatively flat-lying rocks of the upper volcanic supergroup exposed between Durango City and Mazatlân in western Mexico consist of two distinct sequences. Near Durango about 800 m of ignimbrites and associated lavas and tuffs were emplaced between 32.1 and 28.3 m.y. ago (23 K-Ar dates). About 100 to 200 km to the west, at least 1,000 m of ignimbrites, lavas, and tuffs were emplaced 23.3 ± 0.3 m.y. ago, as indicated by 8 K-Ar dates. The two calc-alkalic sequences have significant but slight chemical and mineralogic differences, the older and eastern one being more alkalic. In the Durango vicinity, distinctive alkali basalts were erupted during normal faulting about 12 m.y. ago. Tholeiitic basalt of Quaternary age is also widespread there. Neither the normal faulting nor the basalts are prominent to the west, except near the Gulf of California.

The upper volcanic supergroup commonly rests upon an older volcanic-intrusive complex approximately 100 to 45 m.y. old. Between 45 and 32 m.y. ago little or no magmatism occurred in the Sierra Madre Occidental, but major rift-related alkalic volcanic rocks were erupted then in Trans-Pecos Texas. Voluminous rhyolitic activity occurred between 32 and 23 m.y. ago in western Mexico. Intense volcanism began in southern Baja California 20 m.y. ago. The shifting position, nature, and amount of volcanism may correspond to changes in lithospheric plate motions in the east Pacific region, and 45 m.y., 32 m.y., and 23 m.y. ago appear to be key times of plate-boundary reorganization.

• 71011—Transition analysis of structural sequences.

M. A. Naylor, N. H. Woodcock, Department of Geology, Sedgwick Museum, Downing Street, Cambridge CB2 3EQ, United Kingdom. (5 p., 5 figs.)

Analysis of the frequency of transitions between pairs of lithologic or metamorphic states yields valuable results in sequences where contacts are partly or wholly deformational. The transition matrix method described here is illustrated with four examples: a Silurian slump sequence from Wales, an olistostrome terrane in the northern Appennines, the schuppen zones of the Assynt area in Scotland, and the Mamonia Complex of Cyprus. In some cases it is possible to remove the primary sedimentary or igneous component of the sequence and reveal the secondary deformational sequence. The pattern of these secondary transitions may suggest important mechanistic controls over the stacking of the sequence.

• 71012—Mineralogy of spinel peridotite inclusions of alkali basalts from Sardinia.

C.A.R. de Albuquerque, Department of Geology, Saint Mary's University, Halifax, Nova Scotia, Canada B3H 3C3; S. Capedri, Instituto de Mineralogia e Petrologia, Universita di Modena, Modena, Italy; J. Dostal, Department of Geology, Saint Mary's University, Halifax, Nova Scotia, Canada B3H 3C3. (4 p., 4 figs., 1 tbl.)

Alkali basalts of Pliocene-Quaternary age from Sardinia contain inclusions of spinel peridotites: lherzolite, harzburgite-lherzolite, wehrlite, and pyroxenite. Although the mineral of the basalts have distinctive chemical compositions, there are remarkable similarities in the compositions of olivine, orthopyroxene, and clinopyroxene of the inclusions. Chromian spinels show large variations in composition, although their Al contents show a good correlation with those of the coexisting orthopyroxene and clinopyroxene. The minerals of the inclusions are generally not zoned. However, the clinopyroxene of lherzolites is zoned: the rims are higher in Mg and Ca and lower in Al and Na that the cores. Glass unrelated to the host basalt occurs in several specimens.

The mineralogy of the inclusions, the chemistry of the minerals, and the composition of the glasses are consistent with the hypothesis that these spinel peridotite inclusions were originated by different degrees of partial melting of mantle material and were possibly re-equilibrated at different mantle depths.

• 71013—Formation of peridotites by deserpentinization in the Darrington and Sultan areas, Cascade Mountains, Washington.

Joseph A. Vance, Department of Geological Sciences, University of Washington, Seattle, Washington 98195; Michael A. Dungan, Geology Branch, Code TN6, NASA Johnson Space Center, Houston, Texas 77058. (12 p., 18 figs., 4 tbls.)

In the Darrington and Sultan basin areas of the Cascade Mountains, mafic and ultramafic rocks occur as sheets and lenses that were tectonically emplaced along high-angle faults. The ultramafic rocks comprise pseudomorphic serpentinite (lizardite-chrysotile), antigorite serpentinite, and metamorphic peridotite (olivine-talc-tremolite). The peridotites are of two types: (1) subordinate black-weathering peridotite characterized by iron-poor olivine (Fo_{98}–Fo_{94}) and essential magnetite, and (2) dominant orange-weathering peridotite with more iron-rich olivine (Fo_{94}–Fo_{85}) and little magnetite. In contrast to upper-mantle peridotites, olivine composition in the orange-weathering peridotites is variable on all scales down to a few micrometres.

Field relations, textural and mineralogical relics, mineral composition, and oxygen isotope values all reflect formation of the Darrington peridotites by deserpentinization. Field relations demonstrate the prograde metamorphic sequence lizardite-chrysotile serpentinite → antigorite serpentinite → metamorphic peridotite. Incipiently dehydrated serpentinites exhibit veinlets and scattered porphyroblasts of new-formed high-Mn olivine. Altered chromite, Fe and Ni-Fe sulfides, magnetite, and Mg carbonates in the peridotites have been inherited from the serpentinite parent. In the black-weathering peridotites, relict textures such as bastite pseudomorphs after pyroxenes are inherited from the parent serpentinites and survive as ghosts marked by the distribution of fine-grained magnetite.

In the black-weathering peridotites, iron is bound largely in magnetite inherited from the parent serpentinites; thus the olivine is iron poor. The variability of olivine composition in the orange-weathering rocks is thought to be related to the variable content of iron in antigorite of the parent serpentinites.

Progressive metamorphism of these rocks reached middle amphibolite facies (500 to 600 °C). Deserpentinization occurred prior to Tertiary tectonic transport and emplacement into fault contact with the unmetamorphosed rocks of the present structural setting.

• 71014—Emplacement history of the Tatoosh volcanic-plutonic complex, Washington: Ages of zircons.

James M. Mattison, Department of Geological Sciences, University of California, Santa Barbara, Santa Barbara, California 93106. (6 p., 3 figs.)

The Tatoosh volcanic-plutonic complex exposed in and near Mount Rainier National Park, Washington, is one of a series of Tertiary igneous bodies that are exposed along the axis of the Pliocene to Holocene High Cascades volcanic chain of the Pacific Northwest. It is possible that these Tertiary bodies are the eroded roots of an ancestral calc-alkalic arc. The Tatoosh complex was emplaced in an Eocene and Oligocene volcanic terrane that evidently was oceanic in character. Isotopic ages of zircons from plutonic, hypabyssal, and volcanic phases of the complex show that Tatoosh igneous activity, probably fed by repeated injections of magma from a deep source, spanned some 12 m.y. The earliest activity was emplacement of a dike and sill swarm about 26 m.y. ago. Subsequently, about 25 m.y. ago and again about 22 m.y. ago, magma broke through to the surface to form thick welded tuffs. Magmatism culminated with the rise of the core of the pluton (in part invading its own earlier volcanic and hypabyssal cover) in two stages, 17.5 and 14.1 m.y. ago.

• 71015—Mineralogical and chemical evolution of contaminated igneous rocks at a gabbro-limestone contact, Christmas Mountains, Big Bend region, Texas.

Raymond Joesten, Department of Geology and Geophysics and Institute of Materials Science, University of Connecticut, Storrs, Connecticut 06268. (15 p., 8 figs., 5 tbls.)

Reaction between alkali gabbro magma and limestone produced a 0.2- to 3-m-thick zone of nepheline pyroxenite and a 0.1- to 1-m-thick band of calc-silicate skarn at their contact. The sinuous embayed pyroxenite-skarn contact, the presence of rounded skarn xenoliths in pyroxenite, and textural evidence for growth of calc-silicate skarn by replacement of both marble and solid pyroxenite indicate that reaction involved assimilation of carbonate wall rock by magma and loss of Al and Si to the skarn. The uneven modal distribution of euhedral titanaugite and enveloping nepheline in pyroxenite, the restricted occurrence of nepheline syenite as dikes in pyroxenite and skarn and the mineralogical similarity of nepheline syenite and the leucocratic matrix of pyroxenite suggest that pyroxenite represents an accumulation of titanaugite cemented by an alkali-rich residual magma and that nepheline syenite represents a part of the residual contaminated magma that was squeezed out of the clinopyroxene crystal mush. Limestone assimilation is modeled by reaction of calcite and magmatic plagioclase, which results in resorption of plagioclase, growth of clinopyroxene enriched in Fe, Ti,

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and Al, and solution of nepheline and wollastonite in residual contaminated magma. The bulk composition of pyroxenite evolved by addition of Ca from dissolved limestone, loss of Al and Si to skarn, and local segregation of solid clinopyroxene and nepheline syenite magma. The predominance of pyroxenite among contaminated rocks and their restriction to a narrow zone along the intrusive contact provide little evidence for the genesis of a significant volume of nepheline syenite magma by limestone assimilation.

• 71016—Structural-metamorphic chronology in a roof pendant near Oakhurst, California: Implications for the tectonics of the western Sierra Nevada.

L. R. Russell, S. E. Cebull, Department of Geosciences, Texas Tech University, Lubbock, Texas 79409. (5 p., 3 figs.)

Foliation, broken bedding, and two "shear zones" in pre-Cretaceous clastic metasedimentary rocks in a roof pendant west of Oakhurst, California, are on trend with the western Sierra Nevada metamorphic belt to the northwest. In the pendant, foliations define a westward-verging, upward-diverging fan, and lineations have orientations that plot along a great circle, or a small circle of large diameter, with a maximum at the intersection of the circle and the synoptic foliation. Rock microtextures are characterized by porphyroblast clasts, especially of hornblende, in a matrix of aligned cataclastic fragments and some superimposed static mineral growth.

Three major events are interpreted. The first, M_1, is characterized by probable synkinematic metamorphism of the epidote-amphibolite facies. The second, here correlated with the classical Nevadan orogeny, involved the cataclastic development of the prominent, penetrative, northwest-striking foliation surface, S_1, and the incomplete transposition of M_1 hornblende lineations (*a* kinematic axis: N50°E, 64°NE). During this event, bodies of ultramafic and granodioritic rocks were emplaced and deformed along the "shear zones." Finally, contact metamorphism, M_2, chiefly of the albite-epidote-hornfels facies, resulted from the intrusion of batholithic rocks between approximately 98 and 136 m.y. ago.

Regional implications include the following: (1) the shear zones may be southerly remnants of the Foothills fault system, probably the Melones fault zone; (2) M_1 could represent a moderately deep expression of the Sonoma or Antler orogenies; and (3) the kinematics of S_1 favor an interpretation of primarily vertical displacement for the Nevadan deformation and, hence, lend possible support to most subduction models.

• 71017dr—Radiocarbon profile of Hanauma Reef, Oahu, Hawaii: Discussion and reply. (2 p.)

Discussion: *Harold T. Stearns, 4999 Kahala Avenue, Apartment 445, Honolulu, Hawaii 96816.*

Reply: *W. H. Easton, Department of Geological Sciences, University of Southern California, Los Angeles, California 90007.*

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