GSA news & information

SUPPLEMENT TO GEOLOGY MAGAZINE

SEPTEMBER 1978

Message from the President

Multiple working hypotheses and policy analysis: T. C. Chamberlin revisited

T. C. Chamberlin was a distinguished geologist and President of the University of Wisconsin. Geologists know him best, perhaps, through his essays on the "Method of Multiple Working Hypotheses" (Chamberlin, 1890). It is an intellectual approach to investigation and problem resolution that develops a number of alternative hypotheses to test against the data and is contrasted to the "Ruling Theory" method in which the data are forced to the theory. The method of multiple working hypotheses is especially suited to those areas of investigation characterized by a large number of variables and a wide range in quality and quantity of data—for example, the natural sciences. Out of the method of multiple working hypotheses grows a theory that is consistent with and presents the best explanation of the data.

In his 1890 essay, Chamberlin discussed application of his method to "practical affairs" and referred ". . . especially to those inquiries and inspections that precede the coming-out of an enterprise rather than to its actual execution." He said further, "The methods that are superior in scientific investigation should likewise be superior in those investigations that are the necessary antecedents to an intelligent conduct of affairs."

Chamberlin preceded the development of the methodology of policy analysis as it is practiced today, but the development of multiple working hypotheses and the development of policy options have much in common. In each case the investigator or analyst is deriving from data or information a series of alternative explanations or actions that is rational as tested against an objective analysis of the data.

The best hypothesis or the preferred option comes out of a process of rigorous testing for conformity and consistency and from either a formal or intuitive consideration of probability. Although Chamberlin was a natural scientist, and there is no indication in his essay that he was aware of the classic nineteenth century work on probability theory that forms the underpinning for twentieth century decision analysis (Laplace, 1825; De Morgan, 1847), his exposition is clearly relevant to latter-day policy consideration.

> The use of the method leads to certain peculiar habits of mind which deserve passing notice, since as a factor of education its disciplinary value is one of importance. When faithfully pursued for a period of years, it develops a habit of thought analogous to the method itself, which may be designated a habit of parallel or complex thought. Instead of a simple succession of thoughts in linear order, the procedure is complex, and the mind appears to become possessed of the power of simultaneous vision from different standpoints. Phenomena appear to become capable of being viewed analytically and synthetically at once.

The formulation of public policy related to an issue or area of activities is, in its best sense, a rational, considered, deliberate analysis of alternatives, consequences, resources, capabilities, costs, and benefits that results in a decision to adopt the most beneficial alternative within the capability of the governing body; it rests upon a solid base of information. The policy analyst is working toward a decision(s) that will realize certain objectives and is concerned with more than explaining the data. He is pursuing the best decision(s) rather than theory, but the intellectual process involved is not, as I hope I have demonstrated, in any way alien to the intellectual process that has developed the science of geology. There is no intellectual or methods barrier between the geologist and the public policy process; the jargon barrier is not formidible.

The purpose of this presentation is to encourage those geological scientists who are concerned about the public policy that governs the relationship between our society and the Earth—its resources and its processes—to enter boldly

(continued, next page)

(President's Message, *continued from p. 537)*

into the halls of policy. The intellectual tradition and processes that have built the geological sciences are fully compatible with the traditions and processes of policy analysis. And insofar as public policy affects the man-Earth system, the geologist is the master of a critical part of the data—that part dealing with Earth composition, structure, and processes, and that part developed by measuring, mapping, monitoring, and modeling.

REFERENCES CITED

Chamberlin, T. C., 1890, The method of multiple working hypotheses: Reprinted in Science, v. 148, p. 754-759, 1965.

De Morgan, Augustus, 1847, Formal logic or the calculus of inference, necessary and probable: London, Taylor and Walton, 336 p.

Laplace, Pierre Simon, 1825, A philosophical essay on probabilities [translation from the 6th French Edition, by F. W. Truscott and F. L. Emory]: New York, Dover Press, 196 p., 1951.

Peter T. Flawn
President, Geological Society of America

Honors and Awards Committee solicits suggestions

The Committee on Honors and Awards solicits 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 viii and x of your 1978 *Membership Directory.*

The deadline for receipt of nominations has not been established because of the restructuring of the subcommittees. We ask that you please send your documented nominations to headquarters where they will be held until the new deadline has been established. Those nominations arriving before the new deadline will be forwarded to the appropriate subcommittees; those arriving after the deadline will be held for the following year.

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.

A new remote sensing division?

There will be a meeting of those interested in possibly organizing a GSA division on remote sensing during the Toronto meeting. Time and place to be announced later.

Toronto—"The People City"—to host GSA's Annual Meeting, October 23–26, 1978

Toronto—Canadian city and Huron Indian word for a "place of meeting"—will host a unique gathering in 1978, the October 23–26 Joint Annual Meeting of the Geological Society of America and its Associated Societies, the Geological Association of Canada and the Mineralogical Association of Canada.

Canada's second largest city, Toronto, has undergone such significant changes that visitors would hardly believe the transformation that has taken place. Today's Toronto with a population of over 2,000,000, is a bustling metropolis with cultural institutions, theaters, parks, excellent restaurants, fine stores and an intriguing variety of people and dress that blend to create a unique civic personality.

Its present image started taking shape in the early 1940's when a steady flow of ethnic groups into the predominately British environment gave the city an international flair. In 1959, the development of the St. Lawrence Seaway turned its port into one of the busiest in North America, handling vessels from over 60 countries. Although Toronto is a leading trade and financial center and one of Canada's fastest growing cities, it is still a "people city."

For the adventurous meeting delegate with spare time, Toronto provides a great opportunity to visit such attractions as the Royal Ontario Musuem, Canada's largest museum and one of the world's best. With its renowned collection of Chinese artifacts, its unique mineral collection, its geology and paleontology galleries and its special exhibits of Canadian natives, the Royal Ontario Museum will be the site of this year's Welcoming Party.

For a taste of Ontario history, visit the Black Creek Pioneer Village, an authentic re-creation of life in Upper Canada during the 19th century. Experience the sights and sounds of a rural Ontario village of 100 years ago; see and meet the inhabitants in their period costumes and visit the general store, blacksmith shop, fire house, and the Dalziel Barn Museum built in 1809, containing a large collection of 19th-century toys.

Those seeking cultural attractions should visit the O'Keefe Center for the Performing Arts—the home of the renowned National Ballet of Canada, the Canadian Opera Company, and many of the world's other famous ballet and opera companies.

Of course, a trip to Toronto is not complete without a visit to the CN (Canadian National) Tower, the world's tallest free standing structure, rising 1,815 feet above the metropolitan skyline. The tower has observation levels with the potential for a panoramic 75-mile view of the city sights, as well as a spectacular view across Lake Ontario and beyond Niagara Falls.

In all, Toronto affords a broad variety of attractions and activities suitable to satisfy the interests of all meeting participants. For further information about the annual meeting, see the second announcement in the July issue of *GSA News & Information*.

If you're planning to attend the 1978 Joint Annual Meeting in Toronto, listed below are some travel hints, which you might find helpful, from the Canadian government:

Entry into Canada from the U.S. Citizens and legal residents of the U.S. do not need passports or visas to enter Canada as visitors. Native-born U.S. citizens should carry some identifying paper such as a birth, baptismal or voter's certificate which shows their citizenship. Naturalized U.S. citizens should carry a naturalization certificate or some other evidence of citizenship, in case they are asked for it. Permanent residents of the U.S. who are not U.S. citizens are advised to have their Alien Registration Receipt Card (U.S. Form 1-151).

Personal Possessions of Commercial Value. Visitors to Canada may bring in personal possessions with commercial value, such as cameras, typewriters, etc., by declaring them at entry. Although not a requirement, it may facilitate entry if visitors have a list (in duplicate) of all durable items carried, with a description of each item, including serial numbers where possible. *All such articles must be identified and reported when leaving Canada.* NOTE: While such items are normally admitted free of duty and tax, a deposit may be requested to ensure exportation. This deposit will be forwarded to the non-resident's home address by check upon proof of exportation of goods.

Money. The currency system in Canada is based on dollars and cents. Because of current monetary exchange rates, there may be a difference in value between the two currencies. Although U.S. currency is accepted in Canada, visitors are urged to exchange their funds for Canadian dollars at a bank where they will receive the prevailing rate of exchange. By using Canadian money during their travels in Canada, they avoid exchange problems. NOTE: There are exchange facilities at the Toronto airport. Most U.S. credit cards are honored in Canada, including the principal bank cards. *Visitors are advised to check with their own banks before leaving home concerning credit cards and currency exchanges.*

For further information regarding travel in Canada contact either a local Canadian consulate or trave agent.

Preregistration deadline September 22, 1978

(Preregistration forms are in July 1978 issue).

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

SOUTH-CENTRAL SECTION, GSA, 13th Annual Meeting
Mountain View, Arkansas, April 9–10, 1979

The **South-Central Section** of the Geological Society of America will hold its 13th annual meeting in Mountain View, Arkansas, on April 9 and 10, 1979. The headquarters for the meeting will be at the Ozark Folk Center. This meeting is under the sponsorship of the Arkansas Geological Commission, Little Rock, Arkansas, Norman F. Williams, State Geologist.

TECHNICAL SESSIONS. Two days of technical sessions will be held on April 9 and 10, with premeeting and postmeeting field trips on April 8 and 11, respectively. Field trips will be announced at a later date. Technical sessions will be arranged after abstracts of proposed papers have been reviewed by the Program Committee.

PLEASE HELP US FIND GOOD PAPERS. The quality of submitted abstracts has been excellent for previous meetings. If you are thinking about preparing a paper, do it now! A postal card to Norman F. Williams or Melvin C. Schroeder will get an abstract form to you. The use of the GSA section meeting abstract form, completed according to the instructions, is mandatory.

STUDENT PAPERS are welcome and encouraged. The Section awards $25.00 for the best student paper. To be eligible, the paper must be by a single author and identified to the Program Chairman. Please announce this policy to all students associated with you.

ABSTRACTS ARE DUE November 17, 1978.

Send one original and four copies to

Norman F. Williams
Program Chairman
South-Central Section, GSA
Arkansas Geological Commission
3815 West Roosevelt Rd.
Little Rock, AR 72204

PROJECTION EQUIPMENT in each room will include two projectors for 2" x 2" slides and two screens.

FIELD TRIPS will be announced at a later date, but they will be in the Ozarks and along the Buffalo River.

ANNOUNCEMENTS concerning registration, motel accommodations, and events for guests will appear in a later issue of *GSA News and Information* and as part of the *Abstracts with Programs* for 1979.

ABSTRACT FORMS may be obtained from the following persons:

Norman F. Williams, State Geologist
Program Chairman
South-Central Section, GSA
Arkansas Geological Commission
3815 West Roosevelt Rd.
Little Rock, AR 72204
(501) 371-1488

Melvin C. Schroeder
Secretary
South-Central Section, GSA
Department of Geology
Texas A & M University
College Station, TX 77843
(713) 845-2451

or
Abstracts Coordinator
Geological Society of America
3300 Penrose Place
Boulder, CO 80301
(303) 447-2020

CALENDAR OF SECTION MEETINGS FOR 1979

NORTHEASTERN
Hershey Motor Lodge, Hershey, Pennsylvania
March 1–3, 1979
Abstract Deadline: November 1, 1978

SOUTH-CENTRAL
Folk Center, Mountain View, Arkansas
April 9–10, 1979
Abstract Deadline: November 17, 1978

CORDILLERAN
San Jose State University, San Jose, California
April 9–11, 1979
Abstract Deadline: November 9, 1978

SOUTHEASTERN
Virginia Polytechnic Institute and State University
Blacksburg, Virginia, April 26–27, 1979
Abstract Deadline: December 7, 1978

NORTH-CENTRAL
Normandy Inn, Duluth, Minnesota
May 10–11, 1979
Abstract Deadline: December 21, 1978

ROCKY MOUNTAIN
Colorado State University, Fort Collins, Colorado
May 24–25, 1979
Abstract Deadline: December 21, 1978

PRELIMINARY ANNOUNCEMENT AND CALL FOR PAPERS

CORDILLERAN SECTION, GSA, 75th Annual Meeting San Jose, California, April 9–11, 1979

The **Cordilleran Section** of the Geological Society of America will hold its 75th annual meeting with the annual meeting of the Paleontological Society, Pacific Coast Section, on the campus of San Jose State University, San Jose, California, on April 9-11, 1979.

WELCOMING PARTY. A no-host cocktail party will be held from 1930 to 2300 hours on Sunday evening, April 8. Location to be announced later.

REGISTRATION. Registration will be by preregistration and also at the location of the welcoming party, Sunday, April 8, from 1600 to 2100 hours, and during the meeting at the Student Union at San Jose State University. Preregistration costs are $15.00 for professionals, $2.00 for GSA Student Associates, and $5.00 for other students. On-site registration is $25.00 for professionals and $5.00 for all students. All are urged to take advantage of the lower preregistration rates. **Preregister before March 15, 1979.** Refunds on cancelled preregistration will be made in full until April 1, 1979.

SYMPOSIA (In honor of the U.S. Geological Survey Centennial). The G. K. Gilbert Symposium: *Quaternary History of the San Francisco Bay Region* (Ray Pestrong); The W. H. Dall Symposium: *The Quick and the Dead—Studies of Living and Fossil Organisms* (Judy Smith); The W. C. Mendenhall Symposium: *Glacial Geology of the Arctic* (Mort D. Turner); The W. T. Lee Symposium: *Geologic and Hydrologic Effects of Southwestern Storms, 1976-1978* (William M. Brown III); The Clarence King Symposium: *Stratigraphy and Structure of Wall Rocks of the Sierra Nevada Batholith* (Warren Nokleberg and Elwood Brooks); The John Wesley Powell Symposium: *Human Impact on Arid Lands* (John Nakata and Howard Wilshire); The J. P. Pardee Symposium: *Worldwide Quaternary Faulting* (Lloyd Cluff); The C. C. Birdseye Symposium: *The Southern California Uplift Revisited* (Thomas E. Gay); The Ralph Arnold Symposium: *Famous Fossil Fields Revisited* (Stephen M. Rowland); The C. A. Anderson Symposium: *Cenozoic Volcanic Rocks of the Northwest* (Edwin H. McKee). Papers are invited for all the above symposia.

FIELD TRIPS

Premeeting: (1) Geology of the Tres Pinos-Vallecitos area, April 7-8; (2) Recent deformation and landsliding related to the Hayward and Calaveras faults and the Diablo piercement, April 8; (3) Effects of December 1977 windstorm in San Joaquin Valley, April 7-8; (4) Environmental and engineering geology of the Santa Clara Valley, April 8; (5) San Andreas fault—Trace features and monitoring, April 7-8; (6) Crystalline basement of the Salinian block, April 8.

Postmeeting: (7) Geology of the La Honda Basin, Santa Cruz Mountains, April 12-13; (8) Tectonics of coastal area north of Monterey Bay, April 12; (9) Calaveras fault, April 12; (10) Lower Eocene Meganos Canyon fill and fan facies, April 12; (11) Modern coastal sedimentary processes and ancient examples, April 12-13; (12) Kings Canyon, April 12-13; (13) Erosion and land-use near Redwood National Park, April 12-13; (14) Following in the footsteps of our forefathers: Early fossil localities in the San Francisco Bay area, April 12.

ABSTRACTS, which are limited to 250 words, **MUST be submitted camera-ready on official abstract forms available from:**

Mary Hill U.S. Geological Survey 345 Middlefield Road Menlo Park, CA 94025	or	Abstracts Coordinator Geological Society of America 3300 Penrose Place Boulder, CO 80301

Abstracts are due November 9, 1978. Acceptance or rejection of an abstract will be based on the abstract as submitted by the author.

Send one original and four copies to	Mary Hill U.S. Geological Survey 345 Middlefield Road Menlo Park, CA 94025

All papers in ordinary sessions will be 15 minutes, plus 5 minutes for discussion.

All abstracts will be reviewed by an Abstract Review Committee for informative content, correct structure, reliability of data, Cordilleran Section geographic coverage and originality. Only one paper will be accepted from a single author; if papers are co-authored, no more than one paper may be presented by an author. Authors will be notified of acceptance well in advance of the meeting.

CAROUSEL PROJECTION EQUIPMENT will be provided for 2" x 2" (35-mm) slides only *(dual projectors by prior request only)*. Please bring your own loaded carousel trays if possible.

BUSINESS MEETING. The business meeting and luncheon will be in the Student Dining Commons at 1200 hours on Tuesday, April 10.

HOUSING. Housing will be in local motels. Additional information available later.

DETAILED INFORMATION concerning registration and other activities will appear in a later issue of *GSA News & Information* and as a part of the *Abstracts with Programs* for 1979.

Direct additional information, requests, or suggestions to

Calvin H. Stevens, Local Committee Co-chairman
Department of Geology, San Jose State University
San Jose, California 95192 (408-277-2386)

Report of the Treasurer

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

This report is for the calendar year 1977. For the second year in a row, the Society was in the black, a significant factor when the full impact of inflation is taken into consideration. Not many costs have risen faster than those related to publications, which is the major part of our budget.

With one or two minor adjustments, the figures used in this report are taken from the report of our public accountants, Peat, Marwick, Mitchell & Co. During the year, Council voted to establish an Audit Committee of the Council whose responsibility will be to both instruct the auditors and to review their report with the Society Treasurer and Society administrators. This includes reviewing accounting procedures and financial controls.

As of December 31, 1977, current assets of the Society were $10,198,959, and current liabilities were $1,361,167, a current ratio of 7.7:1, a very healthy condition.

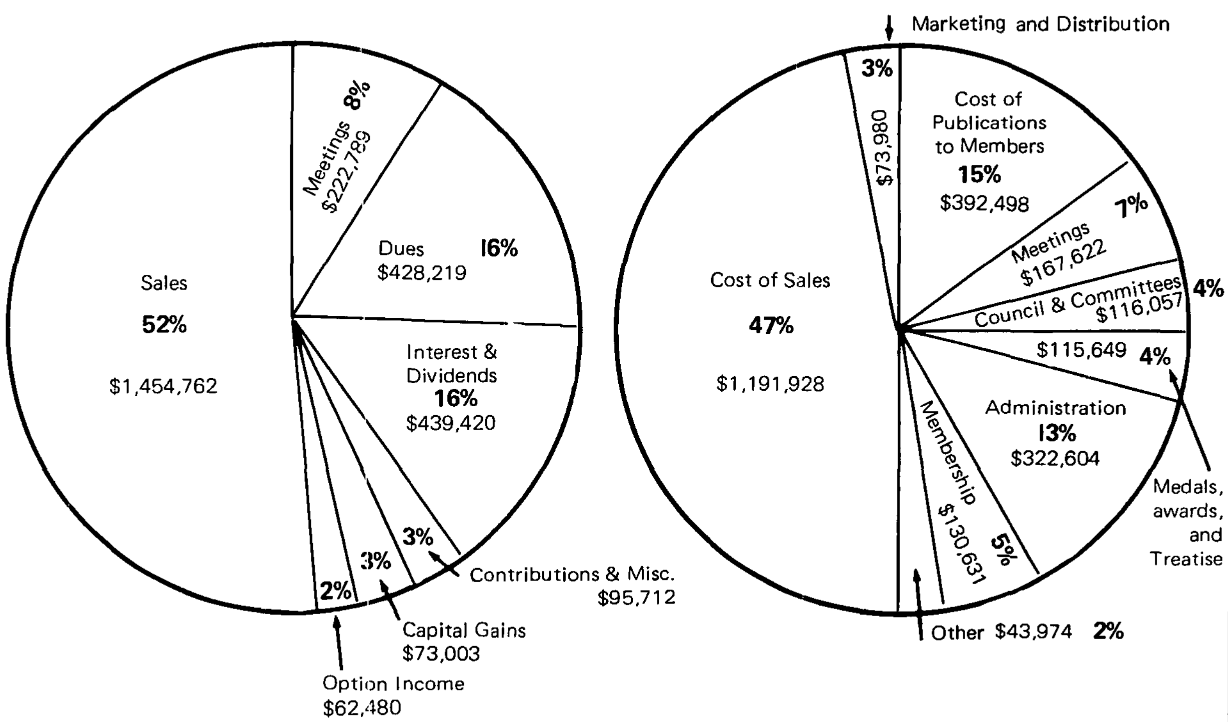
Total operating revenue for 1977 was $2,201,482, and total operating expenses were $2,554,943, an operating deficiency of $353,461. This deficiency was increased by $47,000 due to write-offs from prior years related to costs of Treatise grants, giving a total operating loss of $400,461. However, the operating loss was more than offset by income from investments of $574,903, giving a final excess of income over expenses of $174,442. The reduction in income and expenses compared to the calendar year of 1976 was largely due to the record size of the Denver convention.

Below are pie diagrams showing the distribution of revenue and expenses. It should be noted that along with the transfer of the full responsibility for the GeoRef program to AGI next year will come a major change in our cash flow, a figure of approximately $800,000 per year.

Respectfully submitted,
William B. Heroy, Jr.

THE GEOLOGICAL SOCIETY OF AMERICA SOURCE AND APPLICATION OF FUNDS, 1977

REVENUE $2,776,385 **EXPENSE $2,554,943**



Annual Report for 1977
The Geological Society of America

International Geological Correlation Program
PROJECT 163 – IGBA

IUGS UNESCO IGCP

International Data Base for Igneous Petrology

AN INVITATION TO PARTICIPATE

R.S.V.P.

Felix Chayes
Geophysical Laboratory, Carnegie Institution of Washington
2801 Upton Street, N.W., Washington, D.C. 20008
Felix Mutschler
Department of Geology, Eastern Washington University
Cheney, Washington 90004

It is coming to be recognized by petrologists in general that the study of igneous rocks is in large part the study of silicate solutions and their equilibria, often complicated by the presence of volatile components, and is thus to be regarded as essentially a special branch of physical chemistry . . . For this rock analyses are all-important—indeed, indispensable.

H. S. Washington **(1917, p. 10)**

When Washington's compilation of 8,602 analyses was published in 1917, petrologists had rapid access to perhaps 90% of the existing stock of whole-rock chemical analyses of igneous rocks published after 1883. For a few years the petrochemist could readily compare analytical data he produced with almost the entire data base of his science. Unfortunately, Washington's tables were never either updated or replaced. Today there are probably more than 100,000 published whole-rock chemical analyses that would qualify for inclusion. We estimate that these analyses are scattered through more than 12,000 individual papers and monographs, so it is a nearly impossible task for the scientist to find, collect, and evaluate all the "available" analytical data that might be relevant to a particular problem.

Few of us are aware of the size of the public corpus of our subject, although in specific situations most of us realize that we have lost ready command and control of it. As we generate and publish data at an ever increasing rate, in an ever increasing number of journals, we are more and more vulnerable to the dangers of over-specialization and undocumented speculation. A publicly available computerized data base and appropriate software could easily alleviate this rapidly worsening situation, allowing us to utilize existing information efficiently, both for hypothesis testing and in the planning of further data acquisition. In the last decade, experience with information systems designed to exploit independently compiled data bases (see, for instance, Chayes, 1975; Le Maitre, 1976; or Mutschler and others, 1976), has repeatedly demonstrated the enormous potential of the approach. It has also revealed limitations inherent in every information system tied to a data base characterized by incomplete coverage and inadequate information content, afflictions from which, to varying extents, all existing petrological and petrochemical bases suffer.

International Geological Correlation Project 163—IGBA (IGneous BAse) has been established by UNESCO and the International Union of Geological Sciences to compile a comprehensive retrospective data base for igneous petrology. It is hoped that this computerized "library," to be compiled by volunteer contributors, will ultimately include data on each rock specimen for which a chemical analysis has been published in a journal, serial, monograph, or other reference work postdating 1917. At a 1977 meeting in Bochum, West Germany,

CONTRIBUTOR S NAME *FELIX*

CONTRIBUTION NO *F 78*

A. HEADING INFORMATION

ROCK NAME *GRANITE*

LOCATION LATITUDE *39.16* LONGITUDE *105.44*

GEOLOGIC UNIT *PIKES PEAK GRANITE*

REFERENCE NO *1*

B ESSENTIAL OXIDES

SIO2	TIO2	AL203	FE203	FEO	MNO	MGO	CAO	NA2O	K2O	P2O5	CO2	H2O+	H2O-	TOTAL
74.38	.17	12.79	.51	1.60	.04	.06	.88	3.29	5.27	.03	.01	.39	.06	100.18

C. TRACE ELEMENTS OR COMPONENTS

..1A
..1B
..1C
..1D

NAME	CL	F		AG	BA	BE	CE	CO	CR	CU	GA	LA
AMOUNT	H 3	H 67		0	500	3	200	0	1	2	30	200
REFERENCE												

..2A
..2B
..2C

NAME	LI	MO	NB	ND	NI	PB	RB	SC	SR	Y	YB	ZR
AMOUNT	100	0	70	0	0	30	860	7	70	200	20	200
REFERENCE												

..2D
..2E
..2F
..2G
..2H
..2I

NAME												
AMOUNT												
REFERENCE												

D. AGE

..3A STRATIGRAPHIC *PRECAMBRIAN* REFERENCE NO.

..3B ISOTOPIC OR PHYSICAL

..3C
..3D
..3E
..3F
..3G

YEARS	1.04 BY						
METHOD	RB-SR						
MATERIAL	WHOLE ROCK						
REF NO							

..3H
..(3I) E. PETROGRAPHIC DESCRIPTORS

..4A
..4B
..4C
..(4D)
..(4E)
..4F
..4G
..4H
..4I

ERUPTIVE TYPE, MODE OF OCCURRENCE

AA NO INFORMATION

AB AA
AC AGGLOMERATE
AD ASH
AE ASH FLOW
(AF) BATHOLITH
AG BLOCK LAVA
AH BOMB
AI BOSS
AJ BRECCIA
AK CONE SHEET
AL DIATREME
AM DIKE (DYKE)
AN DOME
AO EXTRUSIVE
AP FLOW
AQ FLOW BRECCIA
AR HYALOCLASTITE
AS HYPABYSSAL
AT IGNIMBRITE
AU INTRUSIVE
AV INTRUSIVE (INTRUSION) BRECCIA
AW LACCOLITH
AX LAPILLI
AY LAVA
AZ LAVA LAKE
BA LAYERED INTRUSION
BB LOPOLITH
BC NECK
BD NUEE ARDENTE
BE NODULE
BF PAHOEHOE
BG PHACOLITH
BH PILLOW LAVA
BI PIPE
BJ PLUG
BK PLUTON
BL PLUTONIC
BM PUMICE
BN PYROCLASTIC
BO RING DIKE
BP ROPY LAVA
BQ SCORIA
BR SEGREGATION
BS SILL
BT SPATTER
BU STOCK
BV SUBAERIAL
BW SUBAQUEOUS
BX SUBMARINE
BY TEPHRA
BZ TUFF
CA TUFF BRECCIA
CB VEIN
CC VOLCANIC
CD VOLCANICLASTIC
CE WELDED TUFF
CF XENOLITH

DP OTHER (ADD IN BLOCK G)

TEXTURE, STRUCTURE, GRAIN SIZE

DQ NO INFORMATION

DR AMYGDULAR
DS APHANITIC
DT APHYRIC
DU APLITIC
DV BANDED
(DW) COARSE
DX CRYPTOCRYSTLN
DY CUMULATE
DZ DEVITRIFIED
EA DISCRYSTALLINE
EB DOLERITIC
EC EUCRYSTALLINE
ED EQUIGRANULAR
EF FELSITIC
EG FINE
EH GLASSY
EI FOLIATED
EJ GLOMEROPORPH
EK GNEISSIC
EL GRANITIC
EM GRANOPHYRIC
EN GRANULITIC
EO GRAPHIC
EP HOLOCRYSTALLINE
EQ HOLOHYALINE
ER HYALINE
ES HYALOPILITIC
ET HYPOCRYSTALLINE
EU INTERSERTAL
EV LAMPROPHYRIC
EW LINEATED
EX MASSIVE
EY MEDIUM
EZ MICROCRYSTALLINE
FA MICROGRAPHIC
FB MICROLITIC
FC MICROPEGMATITIC
FD MICROPOIKILITIC
FE MICROPORPHYRITIC
FF MICROSPHERULITIC
FG MYRMEKITIC
FH OPHITIC
FI ORBICULAR
FJ PEGMATITIC
FK PERLITIC
FL PHANERITIC
FM PILOTAXITIC
FN PLATY
FO POIKILITIC
(FP) PORPHYRITIC
FQ PUMICEOUS
FR RECRYSTALLIZED
FS SCHISTOSE
FT SCORIACEOUS
(FU) SERIATE
FV SPHERULITIC
FW SPINIFEX
FX SUBOPHITIC
FY TRACHYTIC
FZ VARIOLITIC
GA VESICULAR
GB VITREOUS
GC VITROPHYRIC
GD XENOCRYSTIC

HY OTHER (ADD IN BLOCK G)

STATE OF PRESERVATION

IA NO INFORMATION
(IB) FRESH
IC ALTERED
ID SLIGHTLY
IE MODERATELY
IF EXTENSIVELY

IJ OTHER (ADD IN BLOCK G)

TYPE OF ALTERATION

IK NO INFORMATION

IL ARGILLITIC
IM CHLORITIC
IN DEUTERIC
IO FENITIC
IP HYDRATED
IQ HYDROTHERMAL
IR LEACHED
IS METAMORPHIC
IT METASOMATIC
IU OXIDATION
IV PALAGONITIC
IW PROPYLITIC
IX PYRITIC
IY SAUSSURITIC
IZ SERICITIC
JA SERPENTINIZED
JB SILICIFICATION
JC SOLFATARIC
JD WEATHERED

JJ OTHER (ADD IN BLOCK G)

F. MINERAL ASSEMBLAGE

NA NO INFORMATION

FELDSPARS, FOIDS

NB FELDSPAR

NC ALKALI FELDSPAR
ND ANORTHOCLASE
NE K-FELDSPAR
NF 467 MICROCLINE
NG MICROPERTHITE
NH ORTHOCLASE
NI 47 PERTHITE
NJ SANIDINE

NK ANTIPERTHITE

NL PLAGIOCLASE
NM 346 NA PLAGIOCLASE
NN INTERMED PLAG
NO CA-PLAGIOCLASE
NP ALBITE
NQ ALBITE-OLIGOCLASE
NR OLIGOCLASE
NS OLIGOCL -ANDESN
NT ANDESINE
NU ANDSN -LBRDRT
NV LABRADORITE
NW LBRDRT -BYTWNT
NX BYTOWNITE
NY BYTWNT -ANORTHITE
NZ ANORTHITE

N9 OTHER (ADD IN BLOCK G)

OA FELDSPATHOID
OB ANALCIME
OC CANCRINITE
OD HAUYNE
OE KALSILITE
OF LEUCITE
OG NEPHELINE
OH NOSEAN
OI PSEUDOLEUCITE
OJ SODALITE

O9 OTHER (ADD IN BLOCK G)

PHYLLOSILICATES, DOUBLE CHAIN SILICATES, AND AMPHIBOLOIDS

PA MICA
PB 4 BIOTITE
PC LEPIDOLITE
PD 4 MUSCOVITE
PE PHLOGOPITE
PF SERICITE

PG CHLORITE
PH SERPENTINE

P9 OTHER (ADD IN BLOCK G)

QA AMPHIBOLE
QB BASALTIC HNBLND
QC CUMMINGTONITE
QD HORNBLENDE

QE ALKALI AMPHIBOLE
QF ARFVEDSONITE
QG BARKEVIKITE
QH HASTINGSITE
QI KAERSUTITE
QJ KATOPHORITE
QK RIEBECKITE
QL SODIC

QM AENIGMATITE
QN COSSYRITE
QO RHONITE

Q9 OTHER (ADD IN BLOCK G)

PYROXENES, PYROXENOIDS, OLIVINES

RA PYROXENE

RB ORTHOPYROXENE
RC BRONZITE
RD ENSTATITE
RE HYPERSTHENE

RF CLINOPYROXENE
RG AUGITE
RH DIOPSIDE
RI DIOPSIDE-AUGITE
RJ CHROME DIOPSIDE
RK FERROAUGITE
RL HEDENBERGITE
RM HIGH-AL AUGITE
RN PIGEONITE
RO SUBCALCIC AUGITE
RP TITANAUGITE

RQ ALKALI PYROXENE
RR ACMITE
RS ACMITE-DIOPSIDE
RT AEGIRINE
RU AEGIRINE-AUGITE
RV AEGIRINE-DIOPSIDE
RW OMPHACITE
RX SODIC

RY PECTOLITE
RZ WOLLASTONITE
R1 SPODUMENE

R9 OTHER (ADD IN BLOCK G)

SA OLIVINE
SB FAYALITIC
SC FORSTERITIC
SD MONTICELLITE

S9 OTHER (ADD IN BLOCK G)

OTHER SILICATES

TA ALLANITE
ALUMINO-SILICATES
TB ANDALUSITE
TC KYANITE
TD SILLIMANITE
TE BERYL
TF CLAY MINERAL(S)
TG CORDIERITE
TH EPIDOTE
TI GARNET
TJ ALMANDINE
TK ANDRADITE
TL GROSSULAR
TM MELANITE
TN PYROPE
TO SPESSARTINE
TP MELILITE
TQ TITANITE, SPHENE
TR A TOPAZ
TS TOURMALINE
TT VESUVIANITE
TU ZEOLITE(S)
TV CHABAZITE
TW HEULANDITE
TX LAUMONTITE
TY NATROLITE
TZ PHILLIPSITE
T1 A ZIRCON
T2 ZOISITE

T9 OTHER (ADD IN BLOCK G)

OXIDES

UA ANATASE
UB BROOKITE
UC CASSITERITE
UD CORUNDUM
UE HEMATITE
UF ILMENITE
UG LIMONITE
UH PEROVSKITE
UI PSEUDOBROOKITE
UJ RUTILE

SILICA GROUP
UK CRISTOBALITE
UL CRYPTOCRYST
UM 346 QUARTZ
UN TRIDYMITE

UO SPINEL
UP CHROMITE
UQ HERCYNITE
UR MAGHEMITE
US MAGNETITE
UT PLEONASTE
UU TITANOMAGNETITE
UV ULVOSPINEL
UW A OPAQUES, ORES

U9 OTHER (ADD IN BLOCK G)

NON-OXIDES, NON-SILICATES

VA APATITE
VB CARBONATE(S)
VC CALCITE
VD DOLOMITE
VE SIDERITE
VF A FLUORITE
VG MONAZITE
UW OPAQUES, ORES
VH NATIVE ELEMENT(S)
VI SULFATE(S)
VJ SULFIDE(S)
VK CHALCOPYRITE
VL PYRITE
VM PYRRHOTITE

V9 OTHER (ADD IN BLOCK G)

MINERALOIDS

WA CHLOROPHAEITE
WB GLASS
WC IDDINGSITE
WD LEUCOXENE
WE PALAGONITE
WF SIDEROMELANE

W9 OTHER (ADD IN BLOCK G)

G. ADDITIONAL NOTES S. M3-156

Figure 1. (Left and above) Example of a completed IGBA coding form (reduced from original 21.5 cm by 35.7 cm sheet). Reference for coded specimen is Hawley and Wobus (1977).

petrologists from nine nations edited and approved a one-sheet form for use in coding the geographic, geologic, petrographic, mineralogic, and chemical attributes reported for each specimen. A completed coding form is reproduced as Figure 1 here.

When the data base is available to the scientific public, petrologists will be able to retrieve promptly all or any part of it in any of a variety of formats and output media. Imagine placing an esoteric request such as, "Give me all the analyses of igneous rocks of Eocene to Holocene age, occurring between latitudes 64°00′ and 66°30′N, and between longitudes 13°00′ and 24°30′W, that contain molecular $Na_2O + K_2O >$ molecular Al_2O_3, and have quartz phenocrysts," and getting the answer in seconds! Clearly, access to such a computerized index would allow petrologists to evaluate routinely many formidable problems in rock nomenclature and classification, relationships between tectonic style and magma chemistry and genesis, petrochemical constraints for geophysical crustal models, and geochemical prospecting guides for ore and energy resources.

Successful development of IGBA will depend on how rapidly and accurately we are able to code data from the literature into machine-readable form. Except for the analyses themselves that are usually given in tables, the information to be coded is of a kind ordinarily embedded in the texts of the reference papers, so that coding must be done by professional petrologists able and willing to spend time searching out data from papers and monographs in the world's major languages. *IGBA invites all interested petrologists to join in this endeavor.* If there are no contributors, there will be no data base.

Our central office will (1) distribute coding forms and instructions to contributors, (2) arrange for keypunching coded data forwarded by contributors, (3) return listings of punched data to contributors for proofing, (4) distribute machine-readable copies of data files to contributors, and (5) to avoid duplication, confirm responsibility for coding, by journal or by area, with contributors.

The only rewards IGBA can offer volunteer contributors are citation in the base and early access to it during the few years before it is large enough to release to the public. Each contributor will be entitled to request, at the cost of reproduction and postage, a computer-readable magnetic tape copy of the entire current IGBA file at the end of each calendar year during which he has submitted copy included in it. We hope that within five years IGBA will constitute a viable, growing file of sufficient size to justify completely public operation. We shall attempt to make stable arrangements so that any interested person may then routinely order copies of, or partial data retrievals from, the data base.

National IGBA groups have been organized, or are being organized, in Australia, Bulgaria, India, Spain, Turkey, the United States of America, Venezuela, and Yugoslavia, and there is active interest also in Belgium, Cyprus, Czechoslovakia, Denmark, France, Great Britain, Iceland, Italy, and the Netherlands. Some groups plan to establish offices to coordinate the work of contributors in regional or national areas, and to provide keypunching and other services for their associated contributors. Several national groups are applying for funding from agencies in their own nations.

If you are able to contribute some of your time and skill to the coding of data for IGBA, please let us know. The sooner you act, the more likely is it that the journals, areas, or rocks that particularly interest you will still be available for assignment.

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	Member Rate	Nonmember Rate
Journal of Applied Physics	$24.50	$112.00
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Physics Today	10.00	24.00
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September BULLETIN briefs

Brief summaries of articles in the September 1978 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.*

* * *

• 80901—Basaltic ring structures of the Columbia Plateau.

Carroll Ann Hodges, U.S. Geological Survey, Menlo Park, California 94025. (9 p., 14 figs.)

Circular structures, defined by arcuate, concentric ridges and scraps that surround hills, mesas, or crater-like depressions, are localized in an exceptionally thick section of the Roza Member of the Yakima Basalt on the Columbia Plateau. Autointrusive dikes are conspicuous in most ridge segments. Palagonite discovered in a few central hills appears genetically related to the ring structures and suggests an origin involving interaction of water and lava. The dikes intruded a crust about 30 m thick, however, so that substantial cooling must have occurred prior to formation of the rings.

A plausible explanation for these unusual features may hinge on the disruption of drainage that occurred as a result of the voluminous basalt extrusion. If, after partial cooling, the molten interior of this thick ponded Roza flow were intersected by a rising ground-water table, rapidly accumulating volatiles could have caused explosive venting as well as doming and cracking of the crust, with concurrent emplacement of granulated sideromelane (later palagonitized) and tephra in craters and fractures. Subsidence of the crust after initial venting could have permitted intrusion of melt into fractures predominantly concentric to the focus of pressure release. Subsequent catastrophic erosion by the Missoula floods effectively removed most of the surficial clues to original structure and morphology, leaving the roots of these enigmatic features partly exposed.

• 80902—Older Guiana basement south of the Imataca Complex in Venezuela, and in Suriname.

Henri E. Gaudette, Department of Earth Sciences, University of New Hampshire, Durham, New Hampshire 03824; Patrick M. Hurley, Harold W. Fairbairn, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139; Anibal Espejo, Ministry of Mines and Hydrocarbons, Caracas, Venezuela; E. Henk Dahlberg, Geological and Mining Service, Paramaribo, Suriname. (5 p., 5 figs., 3 tbls.)

Older basement rocks of the northeastern Guiana shield in South America underlie supracrustal sequences in Venezuela, Guyana, Suriname, and French Guiana. The supracrustal rocks are believed to be coeval and of early Proterozoic age and have been correlated with the upper and lower Birrimian rocks of West Africa. In West Africa the Birrimian sequence is underlain by basement rocks of the 2,700 m.y. B.P. Liberian event. These supracrustal rocks in both South America and West Africa are intruded by granites related to the Trans-Amazonian–Eburnean thermotectonic event.

Rb-Sr and U-Pb isotopic age measurements of the basement rocks of the Pastora province, Venezuela, and the Bakhuis Mountains, Suriname, yield ages of 2,600 to 2,800 m.y. The isotopic ages of these rocks in South America reinforce correlation of this older basement with the Imataca province in Venezuela, and the 2,700 ± 100 m.y. old Liberian orogeny basement in West Africa.

A unified pre-drift Precambrian stratigraphy extending throughout the entire West African–Guiana shield area is strongly suggested.

• 80903—Cyclic fracture mechanisms in cooling basalt.

Michael P. Ryan, Charles G. Sammis, Department of Geosciences, Pennsylvania State University, University Park, Pennsylvania 16802 (present addresses, Ryan: Department of Mineral Sciences, Smithsonian Institution, Washington, D.C. 20560; Sammis: Department of Geological Sciences, University of Southern California, Los Angeles, California 90007). (14 p., 22 figs., 1 tbl.)

Striae on the fracture surface of columnar joints in basalt may be rationalized in the light of experimental fracture mechanics. Morphologic similarity between experimentally produced and natural fracture surfaces suggests that the striae in basalt were formed during incremental crack advances accompanying cyclic stress buildup and release in the cooling body. Fracture surfaces in a Hawaiian flow (Boiling Pots) are striated by alternating smooth ($\sim$2.5 cm wide) and rough ($\sim$1.0 cm wide) zones normal to the column axis, which suggest elastic and nonelastic failure, respectively. By analogy to laboratory studies of cyclically fatigued samples, the rough band is interpreted as representing successive stopping positions of the crack tip during fracture. Seismic studies of thermal cracking in Kilauea Iki lava lake (Hawaii) indicate that thermal fracture in cooling basalt is a discrete event, characterized by a sudden period of crack advance. Comparison between cooling units shows that thin bodies have narrow striae and column faces, while thick bodies have wide striae and column faces. This suggests the importance of relative temperature gradients (that is, cooling rates) in driving the crack advance. Observations of the sense of shear on column faces [as revealed by orientations of small platelets (fracture lances) within striae] permit a kinematic interpretation of polygon development and suggest that purely tensile opening frequently is coupled with antiplane shear during crack propagation. Striations are thus a record of the crack advance in cooling basalt; not only should they provide a new tool for the field geologist, but their interpretation should lay the basis for models that examine the coupling of the thermal and mechanical behavior in subsolidus cooling basalt.

• 80904—Geology, petrology, and geochemistry of Isla Tortuga, a recently formed tholeiitic island in the Gulf of California.

R. Batiza, University of California, San Diego, Scripps Institution of Oceanography, La Jolla, California 92093 (present address: Department of Earth and Planetary Sciences, Washington University, and McDonnell Space Center, St. Louis, Missouri 63130). (16 p., 13 figs., 5 tbls.)

Isla Tortuga is a recently formed volcanic island located on a fracture zone of an active spreading trough in the Gulf of California. The volcano is composed of tholeiitic basalt lava flows and vitric tuffs and minor volumes of tholeiitic andesite. It was built in at least two stages by a northward-migrating point source of volcanism. The latest stage of activity culminated in caldera collapse, extrusion of the surficial flows, and the formation of a lava lake. The suite of basalts and Fe-Ti–rich basalts on Tortuga is chemically very similar to suites of ocean-ridge tholeiite. The chemical variation observed in the Tortuga basalts can be explained by removal of the low-pressure phase assemblage Pl + Cpx + Ol from a relatively "primitive" (high Mg/Fe) tholeiitic basalt parental magma. The chemical variation of coarse-grained basaltic pegmatoidal segregations, which occur in thick flows on Tortuga, is similar to that of the basaltic lavas. These pegmatoids have fractionated in situ and have produced SiO_2-rich liquids (interstitial glass) by the separation of Pl + Cpx + Ol + ilmenomagnetite and/or ilmenite from basaltic liquids. The most primitive Tortuga basalts are similar to ocean-ridge tholeiite in $^{87}Sr/^{86}Sr$ ratio and large-ion lithophile element abundance, but have higher sodium contents. This may be due to halite assimilation by the Tortuga basalt liquids.

• 80905—Rb-Sr and U-Pb isotopic studies of the northeastern Idaho batholith and border zone.

Ronald B. Chase, Department of Geology, Western Michigan University, Kalamazoo, Michigan 49008; M. E. Bickford, Department of Geology, University of Kansas, Lawrence, Kansas 66045; Steven E. Tripp, Department of Geology, Western Michigan University, Kalamazoo, Michigan 49008 (present address: Tyler Combustion Engineering, 8200 Tyler Boulevard, Mentor, Ohio 44060). (10 p., 10 figs., 5 tbls.)

Border-zone rocks of the northeastern Idaho batholith have been subjected to multiphase penetrative deformation, regional metamorphism up to sillimanite-orthoclase grade, and multiple intrusion. Intrusion was accompanied by diapiric uprise of the plutonic-metamorphic complex, with extensive cataclasis and flow folding along the eastern margin of the rising gneiss dome. Normal faulting followed, with mylonitization and greenschist-grade metamorphism in local shear zones.

Ages of some thermal events are estimated as follows: 85 ± 35 m.y. for a metamorphic event that affected quartzofeldspathic gneiss (Rb/Sr whole-rock line of best fit); 82 ± 10 m.y. for the emplacement of a quartz-diorite orthogneiss (estimate based on U/Pb isotopic ratios from a single zircon fraction); 66 ± 10 m.y. for the main stage of batholithic emplacement (U-Pb concordia–lower intercept age); 46 ± 5 m.y., 42 ± 8 m.y., and 39 ± 2 m.y. for Rb/Sr isotopic equilibration late in the thermal evolution of the plutons (Rb/Sr mineral isochrons).

The older dates conform generally to the range of intrusive ages assigned to the Flint Creek plutons and the Boulder batholith to the east. The younger dates reflect the igneous-hydrothermal-tectonic event of Eocene-

Oligocene time which has reset K-Ar and fission-track (apatite) dates within the general Idaho batholith igneous complex.

Magmas that formed the northeastern Idaho batholith were derived from, or contaminated with, older crustal material. This statement is supported by a 1,900- to 2,250-m.y. upper intercept age for batholithic zircons, some of which show euhedral overgrowths on anhedral cores, and by relatively high whole-rock Sr^{87}/Sr^{86} ratios from samples with low Rb^{87}/Sr^{86} ratios.

• 80906—Geology and age of the Parguaza rapakivi granite, Venezuela.

Henri E. Gaudette, Department of Earth Sciences, University of New Hampshire, Durham, New Hampshire 03824; Vicente Mendoza, Direccion de Geologia, Ministerio de Minas e Hidrocarburos, Caracas, Venezuela; Patrick M. Hurley, Harold W. Fairbairn, Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139. (6 p., 5 figs., 3 tbls.)

The 1,550-m.y.-old Paraguaza granite of the northwestern Guayana Shield in Venezuela represents one of the larger, apparently anorogenic rapakivi intrusive rocks of the world. The massive rapakivi granite intrudes foliated granitic rocks and associated volcanic rocks of trans-Amazonian age in a structural setting transcurrent to the general northeast-southwest trend of the older basement rocks of the Guayana Shield. Age relations and the geochemistry of the rapakivi suggest an anatectic origin from tensional effects developed by internal distortions within a continental mass.

The extensive 1,550-m.y.-old Parguaza intrusion in Venezuela is correlated with 1,550-m.y.-old basement rocks underlying the Amazon Basin in Brazil and suggests a widespread "Parguazan" event 1,500 to 1,600 m.y. ago which affected a large part of the northwestern and southern Guayana Shield, extending as far south as the Guapore craton of Brazil. The Parguazan event therefore marks an important Proterozoic episode in the tectonic evolution of the widespread Precambrian Shield area of northern South America.

• 80907—Terrestrial heat flow and crustal radioactivity in northeastern New Mexico and southeastern Colorado.

C. L. Edwards, Marshall Reiter, Charles Shearer, Wesley Young, Geoscience Department and New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, New Mexico 87801 (present address, Edwards: Los Alamos Scientific Laboratory, University of California, P.O. Box 1663, Los Alamos, New Mexico 87545). (10 p., 5 figs., 2 tbls.)

New heat-flow data obtained in northeastern New Mexico and southeastern Colorado show three regional trends: (1) A broad heat-flow anomaly associated with the southern Rocky Mountains contrasts with a narrow heat-flow anomaly between lat 35.5° and 34°N, apparently associated only with the Rio Grande rift. (2) The high heat-flow anomaly apparently associated with the southern Rocky Mountains extends 200 to 300 km onto the Great Plains of northeastern New Mexico and southeastern Colorado. (3) Areas of extensive volcanic activity do not necessarily have high heat flow. In addition, measurements of crustal radioactivity in the vicinity of the Rio Grande rift suggest that the radioactive heat generation contributes uniformly to the surface heat flow. This implies that the heat-flow anomaly observed along the Rio Grande rift is caused by tectonic and volcanic sources and not by anomalously high crustal radioactivity.

• 80908—Geology, geochemistry, and tectonic setting of the Ben Ghnema batholith, Tibesti massif, southern Libya.

Mohamed A. Ghuma, Department of Geology, Faculty of Science, Fatih University, P.O. Box 656, Tripoli, Libyan Arab People's Socialist Jamahiriya; John J. W. Rogers, Department of Geology, University of North Carolina at Chapel Hill, Mitchell Hall 029A, Chapel Hill, North Carolina 27514. (8 p., 13 figs., 1 tbl.)

The Precambrian Tibesti massif of southern Libya and northern Chad is separated from other massifs to the east and west by relatively deep basins of Paleozoic and younger sedimentary rocks. It is also bordered on the north by a northward-thickening wedge of Phanerozoic sedimentary rocks and connects southward, under shallow sedimentary cover, with the older Precambrian terranes of central Africa.

The northwestern part of the Tibesti massif contains the Ben Ghnema batholith, a complex assemblage of plutons intruded along a north-south axis between metamorphic wall rocks. To the west, the wall rocks are felsic, platformal, and metasedimentary; to the east is a more intensely folded, mafic basinal sequence of metasedimentary and metavolcanic rocks. The northern part of the batholith, about 40 by 120 km, contains a typical calc-alkalic plutonic assemblage. AFM and other variation diagrams for the Ben Ghnema batholith are virtually identical to those for the Sierra Nevada and Southern California batholiths. Furthermore, the Ben Ghnema batholith exhibits compositional variations from tonalite and granodiorite in the east to adamellite and granite in the west, identical to the west-to-east variation in the Sierra Nevada. The age of the Ben Ghnema batholith is 550 m.y. (Pan-African) by K-Ar and Rb-Sr methods.

By analogy with the Sierra Nevada batholith, the Ben Ghnema batholith may have formed above a subduction zone carrying oceanic crust westward under a continental margin located in the northwestern Tibesti massif. This conclusion probably implies eastward extension of the West African craton across areas now occupied by the Ahoggar massif and the Murzuk basin. Events of Pan-African time in these areas were probably related to intracratonic reactivation. It is also possible that an oceanic basin extended eastward from the Tibesti massif to the western margin of the Arabian shield in Saudi Arabia, where Greenwood and others (1976) have postulated northeastward subduction of oceanic crust before and during Pan-African time.

• 80909—Study of heterogeneous fabric and texture within a quartz-feldspar mylonite using the photometric method.

Graham P. Price, Commonwealth Scientific and Industrial Research Organization, Division of Applied Geomechanics, Syndal, Victoria, Australia. (14 p., 11 figs., 1 tbl.)

In a quartz-feldspar mylonite specimen from the Darling fault zone, Western Australia, the quartz *c*-axis fabrics were analyzed using a combination of the conventional universal-stage methods and the photometric method of determining fabric variations. Previously existing techniques for gauging fabric homogeneity proved laborious; therefore, detailed analysis was performed using the photometric approach. The results were considered in relation to grain morphological characteristics, and three types of quartz grains were recognized. Domains of each of these types of grains exhibited different *c*-axis fabrics. Spatial distribution of fabric parameters determined from the photometric data revealed the degree and nature of fabric heterogeneity. It is suggested that these variations in fabric are the result of variable strain produced by the action of a uniform stress on a layered material in which alternate layers have different rheological properties related to the proportion of quartz and feldspar.

• 80910—Seismotectonics of the Arthur's Pass region, South Island, New Zealand.

John M. W. Rynn, Christopher H. Scholz, Lamont-Doherty Geological Observatory and Department of Geological Science, Columbia University, Palisades, New York 10964 (present address, Rynn: Research School of Earth Sciences, Australian National University, Canberra, Australia 2600). (16 p., 9 figs., 2 tbls.)

The spatial distribution of the seismicity of the Arthur's Pass region in South Island, New Zealand, shows that earthquakes occur within the crust in definite subparallel zones, each with an east-northeast trend. Composite focal mechanism solutions indicate that the compressive axis is oriented approximately west-northwest, with an average slip direction of N72°E. Comparisons between the 1973 study described here and one conducted in 1972 reveal no differences in the spatial and temporal distributions of the seismicity. Tectonically, the region can be considered as one in which transference of motion between the Alpine fault and the Hikurangi Trench is occurring. This tectonics situation, coupled with the shoaling of the Benioff zone associated with a southward migration of the Hikurangi Trench, suggests that the deformation in the Arthur's Pass region has occurred within the past 2 m.y. This region has marked similarities with the Transverse Ranges area of the San Andreas fault zone in southern California. Both regions are located where two different tectonic and seismic "styles" merge—namely, where a master fault, with its associated seismic activity consisting of infrequent great earthquakes separated by long periods of quiescence, branches into a system of splay faults having a moderate to high level of continuous activity, with the occurrence of large earthquakes. The regions do differ, however, in that the long quiet zone on the Alpine fault is oblique to the slip vector between plates, whereas similar zones of the San Andreas fault are both parallel and nonparallel to the slip vector. This suggests that long quiet zones of strike-slip faults are not a consequence solely of the orientation of a fault with respect to the direction of relative motion between plates.

• 80911—Relationship between eustacy and stratigraphic sequences of passive margins.

Walter C. Pitman III, Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964. (15 p., 8 figs., 2 tbls.)

It is commonly thought that transgressive or regressive events that may have occurred simultaneously on geographically dispersed continental margins have been caused by worldwide sea-level rise or fall, respectively. Instead, it is shown here that these events may be caused by changes in the rates of sea-level rise or fall. The subsidence of an Atlantic-type (passive) margin may be modeled as a bordering platform rotating downward about a landward hinge line. The rate of subsidence is greatest at the seaward side of the platform and decreases landward to zero at the hinge line. With the exception of sea-level changes due to glaciation, desiccation, and flooding of small ocean basins and other sudden events, the rate of subsidence at the seaward edge of the platform (shelf edge) is greater than the rate at which sea level may possibly rise or fall. Thus, if sea level is falling, the shoreline will seek that point on the subsiding platform at which the rate of sea-level fall is equal to the rate of subsidence minus the sedimentation rate. If the rate of sea-level fall decreases, the shoreline will move landward; if the rate increases, the shoreline will migrate seaward. If sea level is rising, the shoreline will move to that point where the rate of sea-level rise is equal to the sedimentation rate minus the subsidence rate. Thus, if the rate of sea-level rise decreases, the shoreline will move seaward; if the rate increases, the shoreline will move landward. The position of the shoreline is also a function of the sedimentation rate. These relationships have been quantified so that the position of the shoreline and the thickness of the sediments deposited during discrete time intervals may be computed as a function of the rate of sea-level change and the sedimentation rate. A sea-level curve, based on volume changes of the mid-oceanic ridge system, has been computed. Sea level is seen to fall persistently from Late Cretaceous to middle Miocene time, but transgressions occur in Eocene and early Miocene time because the rate of sea-level fall is slower for these periods. It is concluded also that the presence of the shoreline seaward of the shelf edge of an Atlantic margin should be symptomatic of events that may cause rapid sea-level fall, such as glacial build-up or the sudden flooding of large deep basins.

• 80912—Significance of chloritoid-bearing and staurolite-bearing rocks in the Picuris Range, New Mexico.

M. J. Holdaway, Department of Geological Sciences, *Southern Methodist University, Dallas, Texas 75275.* (11 p., 5 figs., 12 tbls.)

In the Picuris Range near Taos, New Mexico, the Precambrian Ortega Quartzite and Rinconada Formation are folded together and share a common history. The Ortega contains chloritoid-Al silicate and essentially no staurolite, and the Rinconada contains staurolite-almandine–bearing assemblages with minor graphite. Al silicate–bearing Rinconada rocks locally contain Mn-rich garnet.

All the rocks of the area crystallized at temperatures a little above the Al silicate triple point, as indicated by the paragenetic sequence kyanite → andalusite → sillimanite. Analysis of the assemblages in relation to chloritoid, staurolite, and Al silicate stability data, taking into account the mineral compositions and the effect of graphite on fluid composition, shows that all the rocks crystallized at 532 ± 20 °C and about 3,700 bP_{tot}, but P_{H_2O}/P_{tot} was 0.88 or less in the Rinconada rocks and near 1 in the Ortega rocks. This small difference in P_{H_2O} appears to be the most important factor in explaining the juxtaposition of chloritoid and staurolite in the two units.

• 80913—Origin of blueschist-bearing chaotic rocks in the Franciscan Complex, San Simeon, California.

Darrel S. Cowan, Department of Geological Sciences, University of Washington, Seattle, Washington 98195. (9 p., 8 figs.)

Chaotic rocks exposed in sea cliffs south of San Simeon, California, consist of subrounded to lens-shaped fragments of graywacke, greenstone, and less abundant blueschist and chert dispersed in a matrix of argillite. This nonbedded mélange has been deformed twice. An earlier deformation, D_1, produced a strong northwest-striking, northeast-dipping foliation defined by both tectonically flattened inclusions and a parallel penetrative cleavage in argillite. Most inclusions, even of blueschist, are imperfect oblate illipsoids or display pinch-and-swell structure and, locally, extreme necking and boudinage. Overall ductile behavior during D_1 was succeeded by the development of subparallel shear fractures that record a brittle deformation, D_2. Displacements on these fractures were generally small or negligible.

It is clear that neither D_1 or D_2 was responsible for the original lithologic heterogeneity and chaotic fabric of the mélange. Mixing of foliated, glaucophane-lawsonite blueschist with lower-grade graywacke and greenstone to yield a nonbedded diamictite composed of variously sized clasts in a mudstone matrix must have occurred prior to D_1, probably by sedimentary processes involving submarine sliding and downslope transport of debris flows. There is no evidence that the mélange was bedded or that the blueschist inclusions were tectonically introduced among lower-grade rocks, prior to D_1. The sequence of sedimentary and tectonic events suggests that as the subduction ultimately responsible for the Franciscan Complex as a whole proceeded, blueschists in elevated parts of previously accreted material were eroded, mixed with lower-

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grade rock, and deposited as olistostromes that were subsequently accreted and deformed.

• 80914—Textural and structural modification history in the Red Hill layered syenitic complex, New Hampshire.

William B. Size, Department of Geology, Emory University, Atlanta, Georgia 30322. (5 p., 5 figs.)

Textures and structures present in magmatic rocks represent the additive results of continuous activity from crystallization through post-solidification. Layered syenitic rocks from the Red Hill intrusive complex show deformed cumulate textures and structures that are used to determine the relative time sequence of their formation and development. Texture and structure formations are related to five phases of crystal-magma evolution: primary crystallization, early accumulation, intermediate accumulation, late accumulation, and post-solidification. Individual features are related to one of the phases and to the processes that were operating during the phase. By assembling all of the textures and structures into a relative order of appearance, it is possible to identify major whole-rock textural transformations. These grade from early-formed cumulate texture through tightly packed laminate, to hypidiomorphic-inequigranular, allotriomorphic-granular, and finally, recrystallized mosaic texture.

• 80915d—Gravity tectonic removal of cover of Blue Ridge anticlinorium to form Valley and Ridge province: Discussion. (1 p.)

Discussion: *Peter Geiser, Department of Geology, University of Connecticut, Storrs, Connecticut 08268.*

• 80916—Medals and Awards for 1977.

Presentation of the Penrose Medal to Robert P. Sharp. *Citation by Clarence R. Allen.*

Presentation of the Arthur L. Day Medal to Akiho Miyashiro. *Citation by W. G. Ernst. Response by Akiho Miyashiro.*

Presentation of the Kirk Bryan Award to Michael Church. *Citation by J. T. Andrews. Response by Michael Church.*

Presentation of the O. E. Meinzer Award to Jacob Rubin and Ronald V. James. *Citation by J. D. Bredehoeft. Response by Jacob Rubin and Ronald V. James.*

Presentation of the E. B. Burwell, Jr., Memorial Award to Richard E. Goodman. *Citation by Murray R. McComas. Response by Richard Goodman.*

Presentation of the Gilbert H. Cady Award to William Spackman. *Citation by Russell R. Dutcher. Response by William Spackman.*

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