GSA news & information

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A BRIEF LOOK AT THE INVESTMENT POLICY OF THE GEOLOGICAL SOCIETY OF AMERICA

In the May 1973 issue of *The Geologist,* Goldstein discussed in some detail the investment principles and practices of the Geological Society of America. Our investment policy has changed little since that time, but many new members are unfamiliar with the earlier study.

GSA has eleven funds which are managed by its Committee on Investments in consultation with its investment advisors, the Irving Trust Company. There are four medal and award funds: the Penrose Medal Fund, the Arthur L. Day Medal Fund, the Kirk Bryan Memorial Fund, and the Gilbert H. Cady Fund. These funds are invested for maximum income. The Kirk Bryan award and the Cady award are cash awards, whereas the other two funds are dedicated to generating funds for the cost of the medals, for remission of dues for the life of the recipients, and for paying the costs of bringing the medalist and spouse to the convention at which the award is given. The Harold T. Stearns Fund is used to support a research grant and is awarded by the Research Grants Committee at the same time as the Penrose Research Grant awards are made.

The Major Repairs Fund is set up to provide a source of capital for major repairs to the headquarters building and grounds. About 10 percent of this fund is invested in short-term investments, about 40 percent is in intermediate-term bonds (5 to 8 years), and about 50 percent is in long-term bonds. Maximum income is the objective of this fund.

The Income Stabilization Fund is designed to be drawn upon to smooth out fluctuations in revenue and to provide a source of funds for expenses of a critical nature that were not forecast when the budget was prepared. In simpler words, it is a back-up fund to provide for unforeseen contingencies. Investments in this fund are limited to short-term U.S. Government and Agency obligations and to commercial paper such as GMAC notes.

The General Reserve Fund, or as it is sometimes called, the Penrose Reserve Fund, has been the Society's main source of readily spendable *capital* as opposed to spendable income. Money is transferred to this fund by Council action and can be spent from this fund only by Council action. In normal times, this fund is devoted primarily to capital appreciation, with income a secondary consideration. At present, owing to the recent recession, this fund is completely depleted. It should be built up by appropriations of net realized capital gains from the Penrose Endowment for the better part of a decade before it can again serve its proper purpose in GSA finances.

Income from the Retirement Reserve Fund is used to provide funds for retirement for employees of the Geological Society of America. Primarily, these monies are used to buy participations for employees in the TIAA-CREF system, which combines a fixed annuity (TIAA) with a variable annuity (CREF). The investments in the Retirement Reserve Fund are designed to provide the maximum income that can be achieved safely with minimum risk of capital loss. More than half the portfolio of this fund is invested in bonds. Any realized capital gains are reinvested.

The Current Operating Fund or Current Fund is the source of capital for the day-to-day operations of the Society. Income from the Penrose Endowment Fund is transferred to this fund on a regular basis. Because of our need for readily available funds on short notice, this fund is invested largely in short-term investments that are highly liquid. The income varies with the yield on debt obligations of this type.

The Penrose Endowment Fund is the largest of GSA's funds, containing nearly three-fourths of our total investments and providing nearly three-fourths of our dividend and interest income. It is invested in a highly diversified list of bonds, convertible securities, and common stocks. Some holdings of bonds and convertible securities are always maintained; this fund is never 100 percent in common stocks. The bonds are purchased for maximum income and safety; most bonds are rates "A" or better, although there are a few of lower grade or nonrated (such as private placements). In the common stock portion of this portfolio, we emphasize the "total return" concept. By total return, we mean the sum of dividend yield plus the capital appreciation. In this fund we aim at a total return of at least 12 percent annually, and we ordinarily do not buy a stock on which the anticipated total return is 10 percent or less. If two prospective investments seem to promise the same total return, we pick the safer stock of the two.

The recent recession was devastating to GSA. Before we could balance our budget, our General Reserve Fund was wiped out and actually borrowed $136,000 from the Current Fund. In 1975 we balanced our operating budget and now anticipate a slight net operating surplus in 1976. If all goes as anticipated, we will realize sizable capital gains in the Penrose Endowment Fund in 1976. We plan to transfer enough net realized capital gains to the General Reserve Fund at the end of the year so that it can pay back its debt to the Current Fund and still show a slight favorable balance. However, both of us feel that the General Reserve Fund should be built up to such a size that the Society could operate for a year from this fund if it became necessary. To do this may take a decade or more.

Some of our readers may ask why we do not sell all of our common stocks and maximize our income. There is no doubt that we could legally adopt such a procedure and increase our income from investments very sizably over what it is now. We do not believe, and Council concurs, that it would be morally correct. Investment in high-growth, low-yield common stocks now means gradually increasing income from these investments in the future. We have a commitment to future generations of geologists to turn over to them a portfolio balanced between income and growth, and readily adaptable to the changing needs of the Geological Society of America.

William B. Heroy, Jr., *Chairman*
Committee on Investments

August Goldstein, Jr.
Treasurer

September BULLETIN briefs

Brief summaries of articles in the September 1976 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.*

☐ 60901—Age of emplacement of the Okanogan gneiss dome, north-central Washington. *K. F. Fox, Jr., C. D. Rinehart, U.S. Geological Survey, Menlo Park, California 94025; J. C. Engels, 348 Waverly Street, Menlo Park, California 94025; T. W. Stern, U.S. Geological Survey, Reston, Virginia 22092.* (8 p., 3 figs., 3 tbls.)

Contact relations and internal fabric suggest that penetrative metamorphism and deformation of parental rocks of the Okanogan gneiss dome culminated in their mobilization and diapiric intrusion into the country rocks. The gneiss dome cuts both plutonic rocks and eugeosynclinal low-grade metamorphic rocks, including rocks as young as Late Triassic, but not adjacent sedimentary deposits and associated volcanic rocks of Eocene age. The gneiss dome is itself cut by the Swimptkin Creek pluton, an epizonal quartz monzonite body that yields concordant biotite and hornblende K-Ar ages of 48.0 and 48.2 m.y. (Eocene), respectively. Thus, the field relations bracket the age of emplacement of the gneiss dome between Late Triassic and Eocene time.

A total of 21 age determinations were made using samples from seven localities within the gneiss dome. Zircon dated by U-Th-Pb methods gave the oldest ages, including Pb^{206}/U^{238} and Pb^{207}/U^{235} ages of 87.3 and 100.0 m.y., respectively. Fission-track ages of 66 m.y. (sphene), 63 m.y. (epidote), 59 m.y. (allanite), 53 m.y. (apatite), and 51 m.y. (apatite) were obtained, along with K-Ar ages ranging from 58 m.y. (hornblende) to 46 m.y. (biotite).

These data suggest that the gneiss dome was emplaced in Late Cretaceous time—probably between $\sim$ 87 and 65 m.y. ago—then cooled slowly through the successive temperature thresholds for sphene, epidote-allanite, hornblende, and finally apatite-muscovite-biotite, below which either loss of argon or erasure of fission tracks ceased.

☐ 60902—Partial fusion along the Alpine Fault Zone, New Zealand. *R. C. Wallace, Department of Geology, Otago University, Dunedin, New Zealand. (Present address: Geological Survey, Private Bag X112, Pretoria, South Africa.* (4 p., 5 figs.)

Fusion products of breccia and mylonite along the Alpine Fault Zone are locally hyalomylonite. Chemical data from this hyalomylonite and those from the Himalayas suggest that they are not the products of preferential melting of a low-melting point fraction, nor in most cases are they produced by total melting. The evidence suggests that progressive melting of the country rock occurred, probably in the presence of water, until the fault was lubricated. The composition of the melt is controlled by the rock mineralogy, temperature, and the time between initial melting and final chilling. A friction temperature of 750°C is estimated to have developed in parts of the Alpine Fault Zone; stresses on the order of 250 b could produce this temperature.

☐ 60903—Alpine structures in northwestern Calabria, Italy. *A. Carrara, G. G. Zuffa, Consiglio Nazionale delle Richerche-IRPI, 87030 Castiglione Scalo, Cosenza, Italy.* (18 p., 6 figs., 1 tbl.)

The Tyrrhenian Coastal Chain of northwestern Calabria is underlain by five tectono-stratigraphic units that represent large thrust sheets originating in the Tyrrhenian area and emplaced in Calabria before late Miocene time. Rocks of these nappe structures were originally Mesozoic-Tertiary platform-type carbonates, Jurassic-Cretaceous oceanic crust, and segments of a Hercynian Paleozoic microcontinent.

Calcareous-dolomitic, metavolcanic, and metasedimentary rocks of the three geometrically lowest units exhibit similar structural successions and comparable metamorphic patterns. The first deformational event recognized in such terranes generated recumbent, isoclinal, intrafolial folds with an axial-surface schistosity or slaty cleavage virtually parallel to bedding or volcanic layering. This was accompanied by metamorphism in the blueschist and lower greenschist facies and was followed by a second main deformational phase, which formed tight, inclined to recumbent folds with various types of axial-plane crenulation cleavages. Deformation and metamorphism are interpreted to have occurred before nappe emplacement, whereas during overthrusting, previous linear features such as L_2 lineations underwent reorientation toward parallelism, with the stretching direction generating a structural pattern that was radial in relation to the Calabrian arc.

The uppermost tectono-stratigraphic units made of Hercynian gneissic terranes display early structures largely obliterated by Alpine cataclasis and retrograde metamorphism. Two minor deformational phases occurred throughout the nappe pile and predated the late Miocene postorogenic transgression. The Pliocene-Quaternary arching of this fold belt was accompanied by widespread normal faulting, which determined the present outcrop pattern.

☐ 60904—Timing of late Tertiary deformation in the Andes of Peru. *Edward Farrar, Department of Geological Sciences, Queen's University, Kingston, Ontario K7L 3N6, Canada; Donald C. Noble, Department of Geology and Geological Engineering, Michigan Technological Univer-*

sity, Houghton, Michigan 49931, and Mackay School of Mines, University of Nevada, Reno, Nevada 89507. (4 p., 1 fig., 1 tbl.)

Radiometric (K-Ar) dating of a reconnaissance nature conservatively brackets late Tertiary deformation throughout Peru between about 20 and 5 m.y. ago. Folding appears to have begun about 15 to 17 m.y. ago. If the timing for Huancavelica Department, central Peru, is applicable to other parts of the country, then deformation and considerable uplift and erosion had taken place by 10.5 m.y. ago.

Intense deformation and uplift in Peru is one of many major igneous and tectonic events that affected the western parts of North, Central, and South America and other parts of the globe during middle Miocene time. These events appear to be associated with first-order changes in the movement patterns of lithospheric plates and thus may reflect a major perturbation of the lithosphere-asthenosphere system.

☐ 60905—Evidence of eolian activity in north-central Minnesota 8,000 to 5,000 yr ago. *D. F. Grigal, Department of Soil Science, University of Minnesota, St. Paul, Minnesota 55108; Ronald C. Severson, U.S. Geological Survey, Denver Federal Center, Denver, Colorado 80225; G. E. Goltz, U.S. Forest Service, Cass Lake, Minnesota 56633.* (4 p., 3 figs., 2 tbls.)

Soil morphology and radiocarbon dates from a sequence of buried soils, exposed by wave action along the shores of Lake Winnibigoshish, north-central Minnesota, provide evidence for a period of vegetation change and landscape instability in that area between about 8,000 and 5,000 yr ago. These data correlate well with interpretations from pollen diagrams of climatic and vegetational changes during the same period. The evidence indicates that a large dune field was active in the area during this time. Conditions that led to that activity could also have been responsible for other dune movement in Minnesota, such as on the Anoka Sand Plain.

☐ 60906—Colombian Basin magnetism and Caribbean plate tectonics. *Eric Christofferson, Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island 02881. (Present address: Department of Geology, Rutgers University, New Brunswick, New Jersey 08903.)* (4 p., 2 figs.)

A shipboard magnetic survey of the central Caribbean Sea has detected certain Late Cretaceous magnetic anomalies predicted in the northern Colombian Basin by a sea-floor spreading model of the region. The locations, trends, widths, lengths, shapes, polarities, and amplitudes of index anomalies 33 and 34 were specified by models derived earlier. All of these dimensions have been observed except one, the width of reversed anomaly 34, which may point to a change in spreading rate or to a possible error in the magnetic reversal scheme used. The extended sea-floor spreading model is generally consistent with drilling results from the Caribbean Sea, but it could be specifically confirmed—or rejected—by drilling to basement in the Colombian Basin.

☐ 60907—Sedimentology, structural geology, and tectonics of the Shikoku subduction zone, southwestern Japan. *J. Casey Moore, Earth Sciences, University of California, Santa Cruz, California 95064; Daniel E. Karig, Department of Geological Sciences, Cornell University, Ithaca, New York 14850.* (10 p., 12 figs.)

The Shikoku subduction zone is developed along the Nankai Trough where the Philippine plate is underthrust beneath the Asian plate. The landward wall of the Nankai Trough consists of horizontal parallel ridges and basins that trend northeastward. A Deep Sea Drilling Project site (Leg 31, site 298) on the landward flank of the deepest ridge penetrated 525 m of beds in normal stratigraphic position and 86 m of overturned beds (all of Quaternary age), indicating an overturned anticline. The tight, overturned anticline, which trends parallel to the Nankai Trough, has an interlimb angle of 9°, an axial surface inclined 9° to 14° landward, and a convergently fanning axial plane fracture cleavage. A coarsening-upward turbidite sequence defines a trench facies and demonstrates direct accretion of deposits from this environment.

The convergence rate in the Shikoku subduction zone is estimated to be from 1 to 2 cm/yr, with a strain rate of about 10^{-13}/sec. Tectonic consolidation has reduced the volume of the subducted and accreted rocks at least one-third. Olistostromes form as a direct consequence of fold evolution in the submarine environment and can be immediately underthrust, thereby developing a structural fabric.

☐ 60908—Trace elements in tephra as indicators of magmatic composition in the Aleutian arc. *Douglas Wayne Edsall, Department of Environmental Sciences, U.S. Naval Academy, Annapolis, Maryland 21402.* (4 p., 6 figs., 1 tbl.)

The Sr, Rb, Ti, and Zr concentrations of 16 volcanic ash samples from Leg 19 of the Deep Sea Drilling Project were determined by x-ray fluorescence. The age of each ash sample had been established previously by faunal criteria and had been confirmed by fission-track dating. Variations in the trace-element concentrations through the past 8 m.y. are clearly seen. Seven of the ashes are older than 4 m.y., have low TiO_2 contents, and have Sr concentrations of less than 200 ppm; they are thus similar to tholeiitic basalts of island arcs. Nine ashes are younger than 4 m.y. and are similar in trace-element content to andesite. Magmatic evolution of the Aleutian arc during the past 8 m.y. is clearly shown.

☐ 60909—Biogenic opal preservation in pelagic sediments of a small area in the eastern tropical Pacific. *Thomas C. Johnson, Geological Research Division, Scripps Institution of Oceanography, La Jolla, California 92037. (Present address: Department of Geology and Geophysics, 108 Pillsbury Hall, University of Minnesota, Minneapolis, Minnesota 55455.)* (10 p., 14 figs., 3 tbls.)

A 630-km^2 area of the sea floor near 14°N, 117°W in the eastern Pacific was surveyed and sampled extensively to determine the pattern of siliceous microfossil preservation, silica concentrations in the sediments and interstitial waters, and clay mineralogy. Siliceous microfossil preservation is uniformly excellent in the surface sediments throughout the area, but deteriorates markedly with depth, to the point where biogenic opal is totally absent within 1 to 2 m below the sea floor. Sediment redistribution by bottom currents concentrates siliceous microfossils in topographic depressions, causing good preservation to extend to greater depths beneath the sea floor in these areas than on surrounding topographic highs. The down-core change in preservation may be due to both an ever-increasing input rate of biogenic opal to the sea floor over the past one-half million years, and to postburial dissolution. Chemical and mineralogical analyses of the sediments indicate that some silica released by postburial dissolution may be used in the formation of authigenic smectite.

☐ 60910—Low-grade metamorphic belt in Jamaica and its tectonic implications. *G. Draper, Geology Department, University of the West Indies, Mona, Kingston 7, Jamaica; R. R. Harding, Institute of Geological Sciences, Exhibition Road, London SW7 2DE, England; W. T. Horsfield, Koninklijke/Shell Exploratie en Produktie Laboratorium, Volmerlaan 6, Rijswijk, Holland; A. W. Kemp, College of the Bahamas, Nassau, Bahamas; A. E. Tresham, Institute of Geological Sciences, Exhibition Road, London SW7 2DE, England.* (8 p., 4 figs., 3 tbls.)

The regionally metamorphosed rocks of Jamaica consist of parallel high- and low-grade belts that trend northwest. The low-grade belt—the Mount Hibernia Schist complex—consists of fine-grained schist and marble containing tremolite and actinolite, chlorite, and epidote. At the eastern end of the low-grade belt, crossite- and stilpnomelane-bearing schists are found. The low-grade belt is separated from the high-grade belt—the Westphalia Schist complex—by a major fault zone. The mineralogy of the low-grade belt and its position relative to the high-grade belt may suggest that a southwest-dipping subduction zone existed in eastern Jamaica in Cretaceous time. The position of these rocks is anomalous with resepct to similar occurrences in the other islands of the Greater Antilles and is not explained by any existing tectonic models of the evolution of the Caribbean.

☐ 60911—Characteristics of three turbidites: Hispaniola-Caicos Basin. *Kim R. W. Bennetts, Orrin H. Pilkey, Department of Geology, Duke University, Durham, North Carolina 27708, and Duke University Marine Laboratory, Beaufort, North Carolina 28516. (Present address, Bennetts: Department of Oceanography, University of Washington, Seattle, Washington 98015.)* (10 p., 10 figs., 3 tbls.)

The absence of analyses of complete sedimentary units resulting from single turbidity currents has been a major shortcoming of turbidite studies. Previous studies have extrapolated single-flow characteristics by averaging attributes of groups of flows. Distinctive source areas surrounding the 9,500-km^2, 4,100-m-deep Hispaniola-Caicos Basin allow long-distance correlation of beds and afford an unusual opportunity to study turbidites resulting from single-flow events.

On the basis of data from closely spaced piston cores, three individual turbidites have been mapped in their entirety. Two of the flows contain abundant terrigenous material; they originated from Hispaniola or Cuba. The third flow is almost exclusively bioclastic; it originated from Great Inagua Carbonate Bank. All of the flows traveled about 100 km across the flat basin floor. They range in total volume from 8.9×10^8 m^3. The flows cover areas ranging from 3,500 to 5,200 km^2, indicating the importance of lateral spreading on the basin floor. Maximum thicknesses, including upper pelitic intervals, are well over 200 cm.

The flow deposits generally thin away from their basin entry points but thicken by ponding in basin depressions. Marked horizontal sorting occurs on the basis of constituent particle density and size. In two flow deposits, Bouma interval structure units A through E are present everywhere. In the third turbidite, the complete Bouma sequence is present only near the basin entry point, and the upper flow regime units (A and B) disappear within 30 km of the basin edge.

☐ 60912—Hydrogeochemistry of Bermuda: A case history of ground-water diagenesis of biocalcarenites. *L. N. Plummer, U.S. Geological Survey, National Center, Mail Stop 432, Reston, Virginia 22092; H. L. Vacher, Department of Geology, Washington State University, Pullman, Washington 99163; F. T. Mackenzie, Department of Geological Sciences, Northwestern University, Evanston, Illinois 60201; O. P. Bricker, Maryland Geological Survey, 33rd and Charles Street, Baltimore, Maryland 21218; L. S. Land, Department of Geological Sciences, University of Texas, Austin, Texas 78712.* (16 p., 13 figs., 4 tbls.)

Bermuda is composed of relatively young skeletal limestones currently undergoing diagenesis by the ground water passing through them. The saturated zone consists of separate fresh-water bodies laterally surrounded and underlain by extensive brackish aureoles, in which the meteoric water is mixed with sea water. The meteoric water enters the aquifer after passing through the soil or through marshes (outcrops of the ground-water bodies), in each case causing an influx of CO_2 to the saturated zone.

Examination of the ground-water chemistry enables mapping of (a) the extent of mixing of meteoric ground water and sea water; (b) P_{CO_2}; (c) the extent of saturation with calcite and aragonite; (d) concentration of Sr; and (e) the amount of calcium and magnesium derived from the limestones.

It is concluded that three processes control the chemistry of Bermudian ground water: (a) generation of elevated CO_2 partial pressures in soils and marshes; (b) dissolution of metastable carbonate minerals (principally aragonite); and (c) mixing with sea water. Bermuda ground water apparently approaches a steady state of aragonite dissolution (at slight subsaturation) and concurrent precipitation of calcite cement. Large Sr/Ca ratios in the ground water indicate that the dissolution of aragonite is incongruent. Dissolution is most pronounced near the marshes where CO_2 content is highest. Mixing with sea water is not significant in controlling calcite saturation.

Only small amounts of magnesium enter the ground water by incongruent dissolution of magnesium calcite, an apparently slow process on the time scale of passage of the ground water through the saturated zone. All of the waters are well undersaturated with respect to dolomite. It is estimated that the present rate of recrystallization of aragonite to calcite is about 0.32 cm^3 of aragonite to calcite per cubic metre of the saturated zone per year. At the present rate of chemical weathering, 360 m^3 of the saturated zone is lost each year through solution and transported to the sea by ground water.

□ 60913—Southeastern margin of the northeastern Appalachians: Late Precambrian orogeny on a continental margin. *Michael J. Kennedy, Department of Geology, Memorial University of Newfoundland, St. John's, Newfoundland A1C 5S7, Canada.* (9 p., 4 figs.)

The evidence for a continental margin on the southeastern side of the Appalachians, analogous to that recognized on the northwestern side, and the nature of the margin are described. Remnants of such a margin are probably best preserved in Newfoundland as a thick wedge of complexly deformed dominantly metasedimentary rocks (Gander Group) resting on a gneissic continental basment. These rocks separate the Avalon zone to the southeast from an oceanic terrane to the northwest, now represented by a Lower Ordovician ophiolite suite and overlying volcanic and sedimentary rocks. The Gander Group suffered orogenic deformation, plutonism, and metamorphism, probably in late Precambrian time. Unconformable relationships in the Avalon zone can also be interpreted as the result of this orogenic episode, termed the Ganderian orogeny. Probable equivalents of the Gander Group are locally preserved in northeastern Cape Breton Island and central New Brunswick, but farther southwest they have not been recognized, although continental basement is preserved. Late Precambrian granitic rocks may represent the Ganderian orogen in southeastern Connecticut and eastern Massachusetts, and possible equivalents of the Gander Group are present in Rhode Island and in the British Isles. These occurrences suggest a widespread orogenic episode or episodes of late Precambrian age on the southeastern side of the Caledonian-Appalachian belt. This orogenic activity is interpreted to have devleoped at and within a continental margin on the northwestern side of a continental mass and is distinct from later orogenic episodes within the system. The ocean, on one of whose margins this orogenic belt was developed, must have opened considerably before Cambrian time, in contrast to the present northwestern margin of the Appalachians.

□ 60914—Kinetics of illite formation. *Dennis Eberl, Department of Geology, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801; John Hower, Department of Geology, Case Western Reserve University, Cleveland, Ohio 44106.* (5 p., 4 figs., 5 tbls.)

An activation energy of 19.6 ± 3.5 kcal/mole was found for conversion of synthetic beidellite with the composition $Al_2Si_{3.66}Al_{0.34}O_{10}(OH)_2K_{0.34}$ to mixed-layer illite/smectite. The size of this activation energy and the rate constants suggest that (1) the alteration of smectite to illite during diagenesis involves the breaking of chemical bonds in the 2:1 layers; (2) either an equilibrium or a kinetic interpretation for the range of mixed layering found in burial diagenetic sequences is compatible with the kinetic data; and (3) the formation of illite from smectite on the ocean floor will not be seen, even if the reaction is favored thermodynamically, because the reaction rate is too slow.

□ 60915—Upper Cambrian stromatolitic biostrome, Clinetop Member of the Dotsero Formation, western Colorado. *John A. Campbell, U.S. Geological Survey, Federal Center, Denver, Colorado 80225.* (5 p., 11 figs.)

The Clinetop Member of the Dotsero Formation consists of carbonate pebble conglomerate and stromatolitic algal heads as much as 1.5 m thick. Isopach maps indicate that the Clinetop Member occupies an area 24 to 32 km wide and 64 to 80 km long (1,500 to 2,600 km^2) and trends ~ N60°W.

The member consists of three stratigraphic units composed of 3 to 43 cm of basal carbonate pebble conglomerate, 0 to 91.4 cm of algal heads, and 0 to 2.1 cm of upper bioclastic and carbonate pebble conglomerate. The lower one-half to two-thirds of the algal heads are of the SH-V (cryptozoon) structural type, whereas the upper one-half to one-third are of the LLH-C (collenia) structural type. Channels filled with clastic carbonate as deep as 68 cm cut the algal-head unit. The orientation of the channels averages N46°E.

Comparison of the algal heads to modern stromatolitic heads suggests that they formed in the intertidal environment of a tropical to subtropical sea. The SH-V algal structures formed in a high-energy, seaward, intertidal environment, whereas the LLH-C structures formed in a low-energy, landward, intertidal environment. Channels were formed by tidal runoff. A gradual regression of the sea across a stable platform is suggested to explain the distribution of the Clinetop Member.

□ 60916—Phenocryst interactions and the velocity profile of magma flowing through dikes or sills. *Paul K. Komar, School of Oceanography, Oregon State University, Corvallis, Oregon 97331.* (7 p., 5 figs., 1 tbl.)

Mechanical interactions between phenocrysts during magma flow give rise to a grain dispersive pressure. Considerations of the balance of the dispersive pressure are utilized to deduce the velocity profile of the magma flowing through a picritic dike from the observed distribution of olivine phenocrysts. The dike, from the Isle of Skye, Scotland, has a gradual increase in phenocryst concentration from the walls to the center. The analysis of this dike yields a pluglike velocity profile in which the velocity is within 1 percent of the maximum velocity throughout the central half of the dike, with large velocity gradients near the walls.

Factors such as a viscosity increase toward the walls due to cooling and variations in the proportionality coefficient in the grain dispersive relationship are considered in the analysis. Other possible corrections required to improve the results are indicated. The velocity profile obtained in the analysis is first compared to profiles for pseudoplastic and Bingham-plastic non-Newtonian fluids. Poor agreement is found, and it is concluded that non-Newtonian fluid models are unsatisfactory. The data are then compared to a model in which the pluglike velocity profile results from the simultaneous requirement of a constant grain dispersive pressure and a balance between the pressure gradient producing the magma intrusion and the viscous dissipation of its momentum. This comparison was successful, and I concluded that such balances cause the pluglike velocity profile as well as the increase in phenocryst concentration toward the dike center.

☐ 60917—The Yukon Crystalline Terrane: Enigma in the Canadian Cordillera. *D. J. Tempelman-Kluit, Geological Survey of Canada, Vancouver, British Columbia, Canada.* (15 p., 12 figs.)

The Yukon Crystalline Terrane, an area of Proterozoic and Paleozoic metamorphic rocks intruded by Mesozoic and Tertiary plutons and covered by Tertiary volcanic strata, has been one of the least understood tectonic elements in the Canadian Cordillera. It incorporates characteristics of the Omineca Crystalline Belt, Intermontane Belt, and Coast Plutonic Complex. The metamorphic rocks are not part of a single time-stratigraphic assemblage as the term "Yukon Group" has implied. They can be divided into gross lithologic assemblages which are correlated with Proterozoic and Paleozoic strata of the Omineca Crystalline Belt, and the metamorphic rocks of the Yukon Crystalline Terrane are therefore the continuation of the Omineca Crystalline Belt.

Four plutonic suites are recognized in the Yukon Crystalline Terrane. The two oldest (Late Triassic and mid-Jurasssic) are related to similar plutons in the Intermontane Belt and mark its continuation through the central part of the Yukon Crystalline Terrane. The mid-Cretaceous suite in the northern part of the Yukon Crystalline Terrane is a westward continuation of plutonic rocks of the Omineca Crystalline Belt. Early Eocene alaskite marks the superposition of Coast Plutonic Complex igneous rocks on the southern part of the Yukon Crystalline Terrane.

Tertiary tholeiitic basalts, which cover part of the Yukon Crystalline Terrane, lie on an eroded plateau whose relief and physiography approximate the present terrane.

☐ 60918—Pb and Sr isotopic data bearing on the origin of volcanic rocks from the Mariana island-arc system. *Arend Meijer, Department of Geological Sciences, University of California, Santa Barbara, Santa Barbara, California 93016. (Present address: Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California 91125.)* (12 p., 5 figs., 3 tbls.)

Analyses of the isotopic composition of Pb in (1) western Pacific Ocean sediments [Jurassic(?) to Pleistocene in age, including clays and biogenic oozes], (2) Pacific Ocean basaltic rocks, (3) Mariana frontal arc volcanic rocks (Eocene to Miocene), and (4) Mariana active arc volcanic rocks [Pliocene(?) to Holocene] indicate that Pacific Ocean sediments could not have been a significant component of the source material for the Mariana arc volcanic rocks. Calculations involving the average concentrations and isotopic

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(from other issues)

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compositions of Pb in oceanic sediments, sea-floor basaltic rocks, and the Mariana arc volcanic rocks suggest that the sediment component must have been less than 1 percent of this source material.

The Pb isotopic compositions of the Mariana arc volcanic rocks lie, within experimental error, along the trend of available Pacific Ocean basalt analyses in $^{207}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ diagrams. Isotopic analyses of Pb in Pacific Ocean sediments do not lie along this trend; they have higher $^{207}Pb/^{204}Pb$ and $^{208}Pb/^{204}Pb$ values for comparable $^{206}Pb/^{204}Pb$ ratios. Clayey sediments generally have higher $^{208}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios than biogenic oozes regardless of the age of the sediment.

Comparison of combined Sr and Pb isotopic analyses for (1) mantle-derived materials erupted through oceanic crust, (2) altered ocean-floor basaltic rocks, and (3) volcanic rocks from oceanic island arcs suggests that the Mariana arc volcanic rocks were derived, at least in part, from altered Pacific lithosphere subducted beneath the Mariana arc.

Unaltered basalts from the Mariana interarc basin (Mariana Trough) have Pb and Sr isotopic compositions that are very similar to those reported for some Hawaiian volcanic rocks but distinct from Mariana active- and frontal-arc compositions. These observations, in addition to existing major- and trace-element data, support a mantle origin for the interarc basin volcanic rocks. Dacites dredged from the Mariana remnant arc (South Honshu Ridge) have Pb isotopic compositions that are within experimental error of the active-arc analyses, consistent with a genetic relation.

☐ 60919dr—Bathymetry and sediment geometry of the Greater Antilles Outer Ridge and vicinity: Discussion and reply. (5 p., 1 fig.)

Discussion: Peter H. Mattson, Department of Earth and Environmental Sciences, Queens College, City University of New York, Flushing, New York 11367.

Reply: Brian E. Tucholke, John I. Ewing, Lamont-Doherty Geological Observatory, Columbia University, Palisades, New York 10964. (Present address, Ewing: Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.)

☐ 60920dr—Gravity and magnetic investigation, Eastern Shore area, Virginia: Discussion and reply. (2 p.)

Discussion: Nelson C. Steenland, Geophysical Exploration Corporation, 6101 Southwest Freeway, Houston, Texas 77057.

Reply: M. A. Sabet, Department of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

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