PROCEEDINGS OF THE THIRTY-SECOND ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT DETROIT, MICHIGAN

C. S. HURLBUT, JR., *Secretary.*

The thirty-second annual meeting of the Society was held on November 8–10, 1951, at the Hotel Statler, Detroit, Michigan. Scientific sessions were held on each afternoon and on the morning of November 10th, at which forty-nine papers were presented. In addition, on the morning of November 9th the Society, in collaboration with the Geological Society of America, sponsored a symposium on *Distribution of Igneous Rocks in Space and Time.*

The annual luncheon of the Society on November 8th was attended by 150 fellows, members, and guests. Following the luncheon the first presentation of the *Mineralogical Society of America Award* was made to O. F. Tuttle. The Society was then addressed by the Retiring President, A. Pabst, on *Mineralogical Notes.*

The increase in membership and fellowship in the Society has brought about corresponding increase in the time required by the Council to transact the business of the Society. The Council met for over ten hours during November 7th and 8th, and debated twenty-six items of business. The following are of particular interest to the general membership:

1. *Special Publication Series.* The Council voted that the Society sponsor a Special Publication Series comprised of papers of mineralogical interest that are too long to be printed in *The American Mineralogist.* The series is to be guided by an Editorial Board composed of the following:

F. A. Bannister	E. F. Osborn
A. F. Buddington	A. Pabst
M. Fleischer	L. S. Ramsdell
C. Frondel (Chairman)	

2. *Suspension of Dues.* The Council voted to place the following resolution as an amendment to the By-laws on the ballot in 1952 to be voted upon by the general membership:

   Fellows and members who have reached the age of 70 years, or have reached the official retirement age of the institution in which they have been serving, and have paid annual dues for 30 years shall be exempt from further payment of dues but shall retain all rights and privileges.

3. *Editorial Board of The American Mineralogist.* The Council voted to appoint L. S. Ramsdell Assistant Editor of *The American Mineralogist* and to place the present Associate Editors on an Editorial Board without specific designation of fields.

The committee appointed by the Council to consider candidates for nomination to fellowship is given below. It is hoped that Fellows of the Society will suggest candidates to the committee members.

NOMINATING COMMITTEE FOR FELLOWS 1952

3 years—Herbert Insley (Chairman), and A. F. Buddington
2 years—Samuel Zerfoss and William Parrish
1 year—E. F. Osborn and George Faust

REPORT OF THE SECRETARY

To the Council of the Mineralogical Society of America:

ELECTION OF OFFICERS AND FELLOWS

Four hundred and thirty-four ballots were cast in the election of officers: 153 by fellows and 281 by members of the Society. The officers elected to serve in 1952 are:

President: Michael Fleischer, U. S. Geological Survey, Washington, D. C.
Vice-President: J. D. H. Donnay, The Johns Hopkins University, Baltimore, Maryland.
Secretary: C. S. Hurlbut, Jr., Harvard University, Cambridge, Massachusetts.
Treasurer: Earl Ingerson, U. S. Geological Survey, Washington, D. C.
Editor: Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.
Councilor (1952–55): Victor T. Allen, Institute of Geophysical Technology, St. Louis, Missouri.

According to the provisions of the Constitution, the following have been elected to fellowship:

Carl W. Correns, Universität, Göttingen, Germany.
Robert Marx Dreyer, University of Kansas, Lawrence, Kansas.
Wilhelm Hermann Julius Eitel, Electrotechnical Laboratory, Norris, Tennessee.
Wilfrid Raymond Foster, Champion Spark Plug Company, Detroit, Michigan.
Robert Alchin Hatch, Electrotechnical Laboratory, Norris, Tennessee.
Richard Henry Jahns, California Institute of Technology, Pasadena, California.
Richard Childs Mielenz, Bureau of Reclamation, Denver, Colorado
Werner Nowacki, Universität, Bern, Switzerland.
Hans Seifert, Westf. Landesuniversität, Münster, Germany.
Hugo Strunz, Mineralogisch-Geologisches Institut, Regensburg, Germany.
Helmut G. F. Winkler, Universität, Göttingen, Germany.

MEMBERSHIP STATISTICS

November 1, 1951

	1950	*1951*	*Gain*	*Loss*
Correspondents	5	5	0	0
Fellows	307	309	9	7
Members	747	797	140	90
Subscribers	632	735	156	53
	1691	1846	305	150

The above figures show a net gain of 2 fellows, 50 members, and 103 subscribers. Considering the four groups together, there is a gain of 155, giving a total of 1846.

The Society lost through death four fellows: Lloyd Fisher of Bates College, Lewiston, Maine; William T. Gordon of Kings College, London, England; William M. Myers of Pennsylvania State College; and Heinrich Ries of Cornell University, Ithaca, New York.

Respectfully submitted,
C. S. HURLBUT, JR., *Secretary*

REPORT OF THE TREASURER FOR 1951

To the Council of the Mineralogical Society of America:

Your treasurer submits herewith his annual report for the year beginning November 1, 1950 and ending October 31, 1951.

RECEIPTS

Dues and subscriptions	$ 7,495.30
Sale of back numbers	1,298.49
Authors' charges on reprints	1,830.31
Interest and dividends from endowment	4,098.73
Geological Society of America aid for printing the Journal	7,006.19
Advertising	744.09
Sale of Index, volumes 21–30	104.10
Sale of Index, volumes 1–20	5.90
Bonds called	4,200.00
Contribution to Larsen issue (September–October 1950)	1,944.00
	$28,727.11
Cash on hand, November 1, 1950	7,172.06
	$35,899.17

DISBURSEMENTS

Printing and distribution of the Journal (6 issues)	$14,942.57
Printing and distribution of reprints	1,972.08
To the Editor, Secretary and Treasurer	1,250.00
Clerical help	685.30
Postage and express	438.78
Printing and stationery	243.86
Office supplies and equipment	8.69
New securities purchased	9,678.67
Commission on securities	92.16
Taxes on securities	.30
Dividend adjustment on new stock	9.90
1950 program and abstracts	328.94
Expenses of officers to 1950 annual meeting	74.48
Expenses of committees	33.84
Safety deposit box	7.80
Back numbers purchased	27.70
Telephone and telegraph	4.04
Checks returned	8.00
Refunds	3.60
Exchange charges on checks	4.09
Contribution to America Geological Institute	400.00
Binding volumes of *American Mineralogist* for sale	82.50
	$30,297.30
Cash balance, October 31, 1951	5,601.87
	$35,899.17

The endowment funds of the Society as of October 31, 1951, consist of the following securities:

BONDS

6M	Atlantic Coast Line, $4\frac{1}{2}$	$5,257.50
5M	New York Central, 5	4,300.00
5M	Southern Railway, 5	5,743.75
4C	Great Northern, $5\frac{1}{2}$	400.00

$15,701.25

PREFERRED STOCKS

200 shares,	Southern California Edison, 4.88	$5,250.00
100 shares,	Union Pacific, 4	4,570.25
60 shares,	Jones & Laughlin, A, 5	4,987.50
55 shares,	United States Steel, 7	6,946.20
50 shares,	Virginia Electric & Power Co., 5	5,942.50
24 shares,	Public Service Electric & Gas Co	728.40
10 shares,	Consolidated Edison, 5	1,066.64

$29,491.49

COMMON STOCKS

288 shares,	Potomac Electric Power Co	$3,871.00
200 shares,	Greyhound Corp	2,300.00
100 shares,	Columbus and Southern Ohio Electric	2,087.50
80 shares,	Kroger Co	1,990.00
60 shares,	United Fruit Co	3,067.50
56 shares,	Standard Oil of New Jersey	1,444.84
50 shares,	Chesapeake & Ohio Railway	2,368.75
50 shares,	Pennsylvania Railroad	1,468.75
47 shares,	American Telephone & Telegraph	6,427.32
40 shares,	Plymouth Cord	2,050.00
30 shares,	U. S. Playing Card	2,411.25

$29,258.91

$74,451.65

Respectfully submitted,
EARL INGERSON, *Treasurer*

For Dana Fund Report, see next page.

DANA FUND

Disbursements are made to needy mineralogists in war areas and to needy families of deceased mineralogists in war areas.

<div align="center">RECEIPTS</div>

Available balance, November 1, 1950...................................	$212.75
Interest...	2.08
	$214.83

<div align="center">DISBURSEMENTS</div>

Disbursed...	$ 43.87
Available balance, October 31, 1951.................................	170.96
	$214.83

Respectfully submitted,
EARL INGERSON, *Treasurer*

REPORT OF THE AUDITING COMMITTEE

To the President of the Mineralogical Society of America:

The Auditing Committee has examined and verified the accounts of the Treasurer of the Mineralogical Society of America for the fiscal year ending October 31, 1951. The securities listed in the Treasurer's report, with all future coupons on the coupon bonds attached, are in the safety deposit box at the West End Branch of the Washington Loan and Trust Company in Washington, D. C.

Respectfully submitted,
MARIE L. LINDBERG
THEODORE BOTINELLY
GEORGE SWITZER, *Chairman*

REPORT OF THE EDITOR FOR 1951

To the Council of the Mineralogical Society of America:

In presenting the annual editorial report at this time, the same policy will be followed as that used in recent years. With five issues published and distributed and only the November-December issue in press, sufficient data are now available to give a general survey of the year's activity. When the editor's report appears in print in the March-April number certain data incomplete or not available at present will be incorporated so that the final printed report in April can be compared with those given for previous years.

From the standpoint of articles published and total pagination the activity of 1951 can be considered that of a normal year. Aside from the regular issues, attention might be called to one so-called special number, authorized by the Council, and sponsored by the Walker's Mineralogical Club. This particular issue continued the series of Contributions to Canadian Mineralogy, and appeared as the May-June issue under the editorship of L. G. Berry of Kingston, Ontario. In this number the guest editor assembled 16 interesting papers on varied mineralogical subjects and assumed full responsibility in seeing these contributions through the press. This policy, followed for the past three years, of devoting one issue each year to Canadian mineralogy and Canadian authors seems to have won universal approval, and it is hoped that the Council will approve its continuance in 1952.

The current volume will run about 950 pages and contain 68 leading articles. Thirty-one additional short papers, appearing under Notes and News, give an over-all total of 99 published manuscripts for the year. As an indication of the general service rendered by the Journal in 1951, it may be mentioned in passing that 24 contributions were published from contributors residing outside of the States: 17 from Canada, and one each from Australia, Bolivia, Holland, Japan, New Zealand, South Africa, and Spain. These contributions were received from 113 authors associated with 50 different Universities, research bureaus, and technical laboratories. Twenty-six critical book reviews and 84 abstracts of new mineral names comprise other items of general mineralogical interest. Six new minerals were described in detail for the first time—andersonite, bayleyite, ferrocarpholite, novacekite, sabugalite, and swartzite.

While it is impossible at this early date to state with any degree of accuracy the printing demands that will be made on the Journal in 1952, it would seem that the volume will at least reach the size of that issued this year. This estimate is based on the fact that as of November 1 the files contain 36 articles of various lengths on a wide range of subjects aggregating about 485 typed pages. If, however, as has been tentatively suggested, a special number dedicated to a renowned mineralogist be included in the offerings, the total size may well exceed that of the current volume.

As a matter of permanent record, recognition and appreciation is here expressed for the valiant service performed by Dr. Michael Fleischer who for the past 11 years has had charge of the New Mineral Names section of the Journal. His critical remarks and good judgment in evaluating the propriety of proposed new mineral names has been of inestimable service. Also appreciation is expressed for the continued liberal support received from the Geological Society of America toward defraying a substantial portion of the printing costs. For this assistance the Society is indeed very grateful as otherwise dues would have to be increased or restrictive measures applied to keep the costs within our established income.

A suggestion has been received that if followed would slightly decrease the size and cost of the March issue, namely the elimination of the reprinting of the abstracts of papers read at the annual meeting. Since these abstracts are mailed out separately prior to the meeting, their reprinting as part of the printed Proceedings may not be necessary. However, the saving would not be large as the type is held over. The reprinting does permit

corrections to be made as due to lack of time proof reading is not possible before the preliminary abstracts go to press. Also the reprinting makes it possible for the abstracts to become an integral part of a regular issue.

As a matter of convenience, starting with the January–February issue, each number will have a printed back bone carrying year, volume number and pagination. This bit of refinement should enable the reader to select more quickly the proper reference when the volumes are in a vertical position on the book shelves.

The accompanying Table 1 summarizes in detail the distribution of subject matter in volume 36.

TABLE 1. DISTRIBUTION OF SUBJECT MATTER IN VOLUME 36

Subjects	Articles	Pages	Per Cent of Total
Leading articles*			
Descriptive mineralogy	17		
Geochemistry	18		
Structural crystallography	14		
Petrography	8		
Geometrical crystallography	1		
Optical crystallography	5		
Memorials	2		
Miscellaneous	3		
	68	742	80.0
Shorter articles	31	$77\frac{1}{2}$	
Notes and news	21	$8\frac{1}{3}$	
Proceedings of Societies	5	$58\frac{1}{2}$	20.0
Book reviews	26	$26\frac{1}{2}$	
New mineral names	84	15	
Total entries	235	928	100.0
Illustrations	260		
Index, Title page, Table of contents		20	
Grand total		948	

* Leading articles average 10.9 printed pages each.

Respectfully submitted
WALTER F. HUNT, *Editor*

ABSTRACTS OF PAPERS PRESENTED AT THE THIRTY-SECOND ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT DETROIT, MICHIGAN, NOV. 8–10, 1951

IONIC RADII OF THE ELEMENTS

L. H. AHRENS

Massachusetts Institute of Technology, Cambridge, Massachusetts

Of the two sets of ionic radii in common use—(1) Goldschmidt and (2) Pauling—those of Goldschmidt are usually employed by crystallographers, mineralogists and geochemists. Their use in preference to the other set is not supported by the relationship between ionic radius and ionization potential.

Within an isoelectronic sequence, ionic radii vary regularly with ionization potential. This is particularly well developed when Pauling radii are employed and is interpreted as strongly supporting their use in preference to those derived purely from measured interatomic distances. Other regularities between radius and ionization potential, and between radius and charge, are also well developed when Pauling radii are used.

Deviations by measured (Goldschmidt) radii can usually be explained by:

(1) an assumed radius of 1.32 A for O^{2-} as too low,

(2) significant polarization of O^{2-} by cations of high polarizing power, and

(3) some inaccuracies in interatomic distance measurements.

Radii in the isoelectronic sequence, Li^+-Be^{2+}-B^{3+}-C^{4+}-N^{5+}-O^{6+}-F^{7+} have been revised on a basis of a radius of 0.68 A for Li^+ rather than 0.60 A as used by Pauling.

Hitherto unknown radii for W^{6+}, Po^{6+}, Re^{7+}, Tc^{7+} and At^{7+} have been determined graphically by means of the well-developed regularities between ionization potential, charge and radius.

SALITE AND ACTINOLITE AT IRON MOUNTAIN, MISSOURI*

VICTOR T. ALLEN AND JOSEPH J. FAHEY

Saint Louis University, Saint Louis, Missouri;
U. S. Geological Survey, Washington, D. C.

Salite, actinolite, dolomite, and fluorite at Iron Mountain, Missouri, are reported for the first time. Salite, an intermediate pyroxene of the diopside-hedenbergite series, occurs in a skarn formed by the action of iron-bearing solutions on andesitic lava of pre-Cambrian age. The salite occurs as grayish-green columns up to 10 inches long; it has the following chemical composition and optical properties: SiO_2, 52.76; Al_2O_3, 1.12; TiO_2, 0.16; Fe_2O_3, 1.73; FeO, 8.92; MnO, 0.47; CaO, 20.48; MgO, 13.43; Na_2O, 0.35; K_2O, 0.05; H_2O, 0.45; $\gamma = 1.715$; $\alpha = 1.695$; $2V = 60°$; positive; $Z \wedge c = 45°$; density, 3.350. At somewhat lower temperature salite was locally changed to actinolite, which has previously been called amphibole or tremolite, but optical properties of numerous grains fall within the range of actinolite with $\gamma = 1.645$; $\alpha = 1.625$; $Z \wedge c = 15°$. The iron garnet, andradite ($N = 1.88$), replaces actinolite, and euhedral, zoned dodecahedrons contain relict fibers of the actinolite. Calcite and quartz replace actinolite and are cut by veins of hematite. Purple fluorite occurs in quartz, but is not in contact with hematite, so its age relation to hematite is unknown. A pink carbonate, having the color of rhodochrosite, occurs in veins cutting the andesitic lava, but it contains only 1.45 per cent MnO and has the optical properties of dolomite with $\omega = 1.685$. Thus, doubt is raised concerning the rhodochrosite and manganocalcite reported in 1895 from this deposit.

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* Publication authorized by the Director, U. S. Geological Survey.

PHOSPHATE MINERALIZATION AT BOMI HILLS AND BAMBUTA, LIBERIA, WEST AFRICA

J. M. AXELROD, M. K. CARRON, C. MILTON AND T. P. THAYER
U. S. Geological Survey, Washington, D. C.

An interesting suite of iron phosphate minerals formed by biogeochemical processes has been found at Bomi Hills and at Bambuta in western Liberia. The phosphates at Bomi Hills form bouldery aprons on the slopes below two prominent cliffs and occur in caves and open fissures in cliffs of high-grade iron ore where they were formed by the interaction of bat dung, or substances derived from it, with exposed iron oxide. The substances thus formed include strengite and its dimorph, phosphosiderite; a member of the rockbridgeite group (formerly included with dufrenite); and most noteworthy of the suite, a complex substance, or possibly mixture of substances, apparently closely related to leucophosphite, described by Simpson (1932) from Western Australia.

The evidence, admittedly not conclusive, for regarding the Australian and African substances as constituting a mineral species is considered; their provisional acceptance as such rests on their similar and unique x-ray diffraction patterns, and essentially similar chemical composition—namely, potassium-ammonium-ferric hydrous phosphate. The paragenesis of the several phosphate minerals is discussed, based largely on petrographic study of the various specimens, with identification of the crystalline phases by x-ray diffraction patterns.

STUDIES OF METAMICT MINERALS (I): METHODS AND PROCEDURES*

JOSEPH BERMAN
U. S. Geological Survey, Washington, D. C.

Review of the literature reveals much confusion in the identification of metamict minerals and in interpretation of results obtained by x-ray powder studies. The need for standard methods of studying these minerals is urgent.

On the basis of x-ray powder patterns it is ascertained that many minerals containing radioactive elements show various degrees of "metamictization." Reproducible powder patterns are obtained after ignition of these minerals in certain gases under controlled temperatures. The current practice of heating a sample in a crucible over an open flame may lead to misinterpretation of resultant patterns.

Our studies have indicated that ignition of the noncrystalline specimens results in randomly oriented crystallized material. None of our samples recrystallized as single homogeneous crystals, although this phenomenon has been reported for gadolinite. The results also indicate that different gases have a marked influence on crystallization and on dissociation of some material.

The apparatus used for heating consists of a tube furnace that can be set up for heating in air or in any other atmosphere. The samples are first crushed and then heated at temperatures below their fusion points for a short time both in air and in uncontaminated helium. It was found that both helium and commercial nitrogen, which for a time was used as the inert gas, contain sufficient water to oxidize the specimen being heated.

The resulting x-ray powder patterns are strong with sharp diffraction lines indicating good crystallinity after ignition. Preliminary data on allanite, brannerite, davidite, fergusonite, samarskite, thorite and zircon are given.

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* Approved by Director of U. S. Geological Survey.

ROBINSONITE, A NEW LEAD ANTIMONY SULFIDE

L. G. BERRY, JOSEPH J. FAHEY, AND EDGAR H. BAILEY
Queen's University, Kingston, Ontario; U. S. Geological Survey,
Washington, D. C., and U. S. Geological Survey, Los Gatos, California

Triclinic; $a=16.51$, $b=17.62$, $c=3.97A$, $\alpha=96°04'$, $\beta=96°22'$, $\gamma=91°12'$. Slender prismatic [001], striated [001]; also massive, fibrous to compact. Cleavage, not observed; fracture irregular; brittle, H $2\frac{1}{2}-3$. Measured specific gravity, 5.27 (artificial crystals), 5.20 (natural fragments), 5.34 (artificial fused material). Composition and cell content, $7PbS \cdot 6Sb_2S_3$, with calculated specific gravity 5.40. Strongest x-ray powder lines in Angstroms: 4.08A(6), 3.97(6), 3.41(10), 3.19(6), 3.04(6), 2.74(5), 2.68(5).

Occurs as a primary mineral with pyrite, sphalerite, stibnite and boulangerite as small pieces in oxidized ore bodies at the Red Bird mercury mine, Pershing Co., Nevada.

PETROLOGY OF THE GUFFEY-MICANITE REGION, COLORADO

JAMES E. BEVER
University of Michigan, Ann Arbor, Michigan

The Guffey-Micanite region, which is in the southeast part of Park County and in the north-central part of Fremont County, Colorado, is underlain chiefly by pre-Cambrian rocks, bounded, except on the south, by extrusive igneous rocks of Tertiary age. The pre-Cambrian rocks include: (1) The Idaho Springs formation, which consists of mica schists and gneisses, sillimanite schists and gneisses, and lime-silicate rocks, all of meta-sedimentary origin. (2) Lenses and layers of hornblende gneiss and amphibolite that may represent metamorphosed gabbros or basalts. (3) Several bodies of granite, which may belong to more than one intrusive period. (4) Granitic pegmatites, related to the granite, containing the accessory assemblage: beryl (including golden beryl), garnet, apatite, columbite, schorl, Fe-Mn phosphates, magnetite, bismutite, beyerite, cordierite-pinite, sillimanite, monazite, and uranothorite (?). (5) Migmatite formed locally by intense injection of granitic material into rocks of the Idaho Springs formation. In addition to the pegmatite minerals, feldspar, sheet and scrap mica, beryl, and columbite, other minerals of economic significance include galena, sphalerite, scheelite, chalcopyrite (with anthophyllite), and sillimanite.

STRUCTURES IN ICE WEDGES OF NORTHERN ALASKA

ROBERT F. BLACK
U. S. Geological Survey, Washington, D. C.

Minute structures, generally considerably smaller and more complex than structures in glacial ice, were found in ground ice during petrofabric study of ground-ice wedges near Barrow, Alaska. Not all can be explained easily. However, results supplement concurrent research on ground contraction, temperatures, and composition and provide corroborative evidence for Leffingwell's contraction hypothesis of origin of ice wedges.

All wedges have myriad bands of air bubbles and inclusions of organic material and silt, sand, and gravel, which in most wedges produce marked foliation subparallel to the sides. Other bands crisscross within the wedges. Most air bubbles and inclusions are elongated vertically regardless of orientation of the band they are in.

All wedges show marked development of one or more microscopic growth fabrics in which c-axes are oriented about normal to cooling surfaces. The best-developed fabric, presumably resulting from recrystallization under pronounced temperature gradients and considerable lateral compression, is fan-shaped and conforms roughly to the shape of the

wedge. Other fabrics are produced by growth of hoar and ice crystals in contraction cracks and tension fractures.

Most wedges also show one or more deformation fabrics superimposed on growth fabrics or vice versa. Individual grains respond to stress by strain, reorientation (apparently in part to permit slipping on the basal pinacoid or rolling around the c-axis), fracture, granulation, and recrystallization. Movement within wedges is indicated by granulated and recrystallized grains, tension fractures, shear planes, offset bands of air bubbles and inclusions, dragged sediments on sides of wedges, and surface ridges.

SYNTHETIC GRANITES AND THEIR MELTING BEHAVIOR UNDER HIGH H_2O PRESSURES

N. L. BOWEN AND O. F. TUTTLE
Geophysical Laboratory, Washington, D. C.

Mixtures of $NaAlSi_3O_8$, $KAlSi_3O_8$ and SiO_2 have now been examined as to their melting behavior at 4 isobars, 500, 1000, 2000 and 3000 kg/cm² pressure of water vapor. At each pressure it is found that the addition of SiO_2 to the feldspar solid solution series induces the expected further lowering of melting temperatures. The minimum melting temperature of the binary feldspar series is reflected in the ternary compositions as a minimum temperature on the boundary curve between the field of quartz and that of feldspar solid solutions. These minimum-melting mixtures are synthetic alkali granites.

The temperature of the minimum decreases with increasing pressure of water vapor, owing to the increased solubility of water in the liquid phase, but, whereas the first effects of increasing pressure are very marked, these diminish rapidly and the difference between the value for 2000 kg/cm² and that for 3000 kg/cm² is only about 5°, the actual temperatures being 675° and 670° respectively. Moreover, the composition of the minimum moves with increasing pressure towards a somewhat lower quartz content.

Some of the consequences of these observations on theories of the origin of granite will be discussed.

STUDIES OF RADIOACTIVE COMPOUNDS: IV—PITCHBLENDE FROM LAKE ATHABASKA

E. J. BROOKER AND E. W. NUFFIELD
Geological Survey of Canada, Ottawa; University of Toronto, Canada

Chemical analyses of six specimens of pitchblende from Lake Athabaska gave a range in U^6/total U from 17.4 to 85.0 per cent. With increasing U^6/U the specific gravity decreases from 8.20 to 4.10, the lustre becomes dull, and the mineral loses its hard, compact and brittle aggregation and assumes a soft, earthy form. Thus in a general way the physical properties are indicative of the degree of oxidation.

Specimens relatively low in U^6 gave sharp x-ray powder photographs. With increasing U^6/U, back reflections became weak and diffuse, then low angle reflections became diffuse and finally with U^6/U $= 85.0$ per cent no pattern was obtained. The corresponding cell edges decreased from 5.45 kX for U^6/U $= 17.4$ per cent as compared to 5.46 for synthetic UO_2, to 5.39 for U^6/U $= 78.5$ per cent. Therefore in the six specimens the quality of the x-ray pattern and the cell sizes are related to the degree of oxidation.

After heating for $\frac{1}{2}$ hour in vacuum the patterns were sharper and the cell edges decreased to 5.43 for synthetic UO_2, and to a minimum of 5.38 for the more highly oxidized specimens. In specimens with U^6/U about 50 per cent another oxide, possibly U_2O_5 also formed; this was replaced by U_3O_8 when U^6 dominates over U^4.

Heating for 5 minutes in air oxidized those specimens with U^6/U about 50 per cent to

U_2O_5, while those with a higher or lower U^6/U ratio were oxidized to U_3O_8. The cell edges of U_3O_8 increased with increasing availability of U^6 in the untreated material.

ISOTOPIC COMPOSITION OF LEAD AND THE AGES OF MINERALS IN A PRECAMBRIAN GRANITE

HARRISON BROWN, MARK C. INGHRAM, ESPER S. LARSEN, JR., CLAIRE PATTERSON AND GEORGE TILTON

University of Chicago, Chicago, Illinois; U. S. Geological Survey, Washington, D. C.

Techniques have been devised for the analysis of microquantities of lead and uranium in granitic materials using isotopic tracers. The general method consists of equilibrating known microamounts of lead or uranium highly enriched in a single isotope with known amounts of the sample, chemically isolating the element, and measuring the change in the isotopic composition of the tracer. Chemical procedures, which progressed from a macro- to a microscale, and surface ionization techniques in a mass spectrometer of a very high sensitivity were used. The concentration and isotopic composition of lead and uranium in mineral separates of a Canadian granite have been studied. These data have given the lead-uranium and lead-lead ages of the minerals. The data have also given the isotopic composition of a nonore lead of known Precambrian age, and the isotopic composition of nonore uranium.

ASSOCIATION OF PERTHITIC MICROCLINE WITH HIGHLY UNDULANT OR GRANULAR QUARTZ IN SOME CALCALKALINE GRANITES

FELIX CHAYES

Geophysical Laboratory, Washington, D. C.

Perthite is on the whole uncommon in the micaceous calcalkaline granites of New England, Texas, and the southeastern states. It is usually rare or lacking if quartz is ungranulated and shows only moderate undulance, may or may not be common if quartz extinction is highly undulant, and is never rare if quartz is extensively granulated. The shearing stresses which render quartz extinction undulant and finally granulate the quartz evidently induce or accelerate the unmixing of albite-poor microcline which might otherwise remain indefinitely metastable.

DISTINCTION BETWEEN THE DIFFERENT MEMBERS OF THE POTASH-FELDSPAR GROUP USING ONLY A MICROSCOPE

L. DOLAR-MANTUANI

University of British Columbia, Vancouver, British Columbia

As the different members of the potash-feldspar group have the same values of refractive indices and birefringence, overlapping values of the optic angles and finally an often only apparent triclinic orientation determined with a microscope, the following data should be used for their distinction:

1. the presence or absence of microscopically visible lamellar twinning;
2. the optic angle; 3. the extinction angles or coordinates of crystallographic elements; 4. the interfacial angles; 5. the habit; 6. the paragenesis indicating the conditions of crystallization.

The general properties and some limitations of their values as they may be determined with a microscope are listed for the various members. The terms perthite and potash-feldspar are briefly discussed. Detailed determination and publication of data especially of anomalous members are recommended.

AIDS FOR SINGLE-CRYSTAL TECHNIQUES

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Two nomographs have been devised which permit rapid interpretation of rotation and Weissenberg photographs. One of them gives, from a rotation photograph, the direct lattice translation of the rotation axis. The other gives, from a zero-layer Weissenberg photograph, the reciprocal lattice translations. The use of the charts, when they are carefully constructed, entails no loss of accuracy.

Many crystals can have one of their lattice rows adjusted only approximately by optical means. A simple procedure has been worked out in which the corrections to be applied to the arcs of the goniometer head are obtained from a single film, on which a 10° oscillation with unfiltered radiation and a rotation with filtered radiation are superimposed. Measurement of the position of the continuous streak, due to the oscillation, with respect to the rotations record, leads to the desired corrections.

CRYOLITE TWINNING

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The cubic pseudo-symmetry of a multiple cell leads to the prediction of many twin laws, most of which have been reported by Brögger. The submultiple cell used by Dorothy Wrinch has the same shape as the multiple cell and therefore leads to exactly the same twin laws, but it has a structural significance which the multiple cell does not possess. Her interpretation of twinning can be generalized in that the submultiple cell need not be pseudo-cubic, but can be pseudo-orthogonal. Its validity as a law of observation can only be established by further experimental evidence.

ORIGIN AND EVOLUTION OF HORNBLENDE-ANDESINE AMPHIBOLITES AND KINDRED FACIES*

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Nearly identical hornblendic amphibolites, in which andesine is commonly a major constituent, may evolve from: (1) skarnlike metasomatism of carbonate sediments and (2) reconstitution without appreciable chemical changes of tuffs and marls, gabbro masses, diorite sills, and basalt flows.

Commonly no obvious physico-chemical feature of these amphibolites offers an unequivocal clue to their origin or evolution. The amphibolites occur in most older pre-Cambrian terranes and in many younger orogens where each of the above-stated parent rocks and processes of formation are either apparent or readily inferred.

Clues to the derivation of these amphibolites seem to exist, however, in their differential inheritance of accessory elements. Amphibolites derived from mafic igneous rocks, for example, are, like their parents, commonly higher in Co, Ni, Cr, Sc, and Cu and lower in Pb, Au, and Ba than amphibolites derived from carbonate sediments.

Quantitative analyses of these elements in 82 parent rocks and amphibolites of known origin are discussed in conjunction with other features of the rocks. Apparently dynamothermal metamorphism of the gabbros does not remove the initial concentrations of Sc,

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* Publication authorized by the Director, U. S. Geological Survey.

Cr, Co, Ni, and Cu as rapidly as it obliterates other diagnostic properties. Conversely, amphibolites derived by replacement of marbles tend to maintain higher concentrations of Ba, Pb, and Au than many known ortho-amphibolites.

Moreover, the incipient granitization of amphibolites does not always obliterate the critical accessory-element differences at stages in which, by less subtle physio-chemical standards, various amphibolites are indistinguishable.

The accessory-element values in these amphibolites, and in some of their component minerals, are also compared with examples of enigmatic amphibolites from the Canadian shield, the Alps, and elsewhere.

NEW UNIVERSAL MICROSCOPE GONIOMETER

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The instrument consists of a standard synchronous-nicol microscope supported on a triangular base plate so that its optical axis is horizontal with what was its "north-south" vibration direction inclined downward to the left (as viewed from the ocular) at 45°. The crystal is mounted on a standard x-ray camera goniometer head in the usual fashion. This head attaches to a vertical axis with the crystal extending downwards from it. The vertical axis, which is supported from the base plate independently of the microscope, is provided with two translation movements, one vertical, the other horizontal and normal to the microscope axis. The vertical axis has a graduated circle with vernier and tangent screw.

The crystal may be immersed in a suitable oil; this is held in a multiple cell of any convenient thickness. This cell which has thermocouple wires for temperature measurement fits in a frame supported on a vertical arm extending up from the base plate. The cell frame support is provided with two rack-and-pinion translations, one vertical, the other horizontal and normal to the microscope axis. The regular converger from the microscope substage is mounted "above" the stage so that it can be thrown in or out of the optical path; it is centerable and has a translation movement parallel to the axis of the microscope.

There is a detachable lamp housing with collimator and Websky slit, so that the instrument may function as a one-circle goniometer by using the Bertrand lens.

The instrument may be employed for optical orientation of an anhedron. Or conversely it may be used to locate the optical indicatrix of an anhedron whose orientation has been obtained by any x-ray method. It is superior to the Universal stage technique for these purposes, since it is more general; thus, no cleavage is needed for orientation purposes, and a single crystal with a single mounting is used for determining both the indicatrix and the lattice. Preliminary tests indicate it is superior to the U-stage in accuracy, also. The tremendous advantage gained by the use of synchronously rotating nicols should be obvious.

GEOLOGY OF THE CARRIZO MOUNTAIN SCHIST*

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The name Carrizo Mountain schist has been applied to pre-Cambrian metasedimetary and meta-igneous rocks of the Van Horn area, Texas. The unit includes feldspathic meta-quartzite and meta-arkose, mica schist, chlorite schist, phyllite, slate, limestone, metarhyolite (in part mylonitized), and amphibolite. Regional metamorphic grade increases from

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northwest to southeast. In the northwestern area a retrogressive metamorphism has followed the regional metamorphism.

To the southeast the Carrizo Mountain schist is composed mainly of thoroughly recrystallized quartzofeldspathic rocks. Relict sedimentary structures are not evident. Associated almandine-bearing schists and amphibolites indicate a medium metamorphic grade. Crystalloblastic fabrics and equilibrium mineral assemblages characterize these rocks. To the northwest slate, phyllite, chlorite schist, and limestone occur with meta-quartzite and meta-arkose. Cross-bedding is preserved in the quartzofeldspathic rocks. Cataclastic fabrics, fine grain size, retrogressive disequilibrium relations, smearing, comminution, microfolding, and microfaulting are characteristic here. The retrogressive metamorphism occurred during the period of dislocation in which the Carrizo Mountain schist was thrust northwestward over the pre-Cambrian Allamoore limestone. Intrusive rhyolite diorite (now metarhyolite and amphibolite) were affected only by this later cataclastic metamorphism.

STUDY OF HOEGBOMITE

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An investigation of the emery deposits of the Appalachian belt led to the discovery of a new hoegbomite locality in North Carolina, a reinvestigation of the Virginia hoegbomite and an examination of a New York locality from which hoegbomite has not been previously described.

Of the eight known hoegbomite occurrences seven have been reported in emery, the emery being as a rule associated with basic rocks. Hoegbomite is a secondary mineral that formed by the replacement of spinel.

The hoegbomite of the New York emery deposits was formed later than the emery but earlier than the high-temperature quartz veins which represent the last stages of the intrusion that gave rise to the emery.

ROLE OF THE HYDROGEN BOND IN THE FORMATION OF SOME METASTABLE PHASES

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It has been well established that in the genesis of certain polymorphous mineral forms the pH of the crystallizing solution is a determining factor. However, the role of hydrogen has always been considered to be of a minor or secondary nature, such as causing the formation of new groups or complexes that add to or remove from the solution inhibiting impurities. Recent chemical research and a close inspection of structural relationships indicate that the formation of metastable phases in the case of some polymorphic pairs, such as senarmontite-valentinite, can be explained by the hydrogen bond. The closer oxygen-oxygen distances that exist in the high temperature form valentinite, can be maintained during the growth of this form, well below its stable temperature range, through the formation of O-H-O bonds. Because of the small energies involved in the formation and rupture of the hydrogen bond, it is not believed necessary to achieve or retain measurable proportions of hydrogen in the crystals produced by this mechanism. The involvement of chemically bonded hydrogen in one phase and its total absence in another restricts us from regarding the pair of phases in this instance as truly polymorphic; and consequently the generation of a phase containing hydrogen should not be considered a priori metastable.

MINERALOGY AND STRUCTURE OF THE LUZONITE-FAMATINITE SERIES

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New chemical analyses confirm that the formula of luzonite is Cu_3AsS_4 and that of famatinite is Cu_3SbS_4. They form an isomorphous series with the nearly pure end-members occurring, respectively, at the type localities for the two minerals. Intermediate members of the series are also found, at other localities. Crystals of luzonite from Mankayan, Luzon, Philippines, and of luzonite-famatinite from Goldfield, Nevada, were examined by goniometry and x-ray diffraction, and especially good x-ray results were obtained with fragments of famatinite from Sierra de Famatina, Argentina.

Luzonite-famatinite crystallizes in the tetragonal system, and luzonite is a polymorph of enargite. There are two cleavages, {100} and {101}. Twinning is on {111}, and the twin axis is normal to {110}.

The space group is $I\bar{4}2m$, and the cell is pseudo-cubic, with $a_0 = 5.27$ Å and $c_0 = 10.39$ Å for luzonite, and $a_0 = 5.38$ Å and $c_0 = 10.76$ Å for famatinite. Powder photographs show a sphalerite type of structure. The structure has been tentatively worked out, and can best be compared for illustration with that of stannite, with which it is isostructural. To do this, arsenic atoms take the place of the iron atoms in stannite, and copper replaces the copper and tin atoms. This gives a body-centered tetragonal cell containing $Cu_6(AsSb)_2S_8$. Preliminary intensity calculations show this structure to be at least a very close approximation to the true structure.

SYENITES AND NEPHELINE SYENITES OF STETTIN, MARATHON COUNTY, WISCONSIN

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A southern extension of the complex crystalline rocks of the pre-Cambrian Canadian Shield crops out in the Driftless Area of north-central Wisconsin, Stettin township, 8 miles west of Wausau, central Marathon County. A preliminary field survey was made of 6 square miles. A road-metal quarry in syenite (section 22, township of Stettin) offered excellent, fresh rock surfaces, in an area of otherwise scant and poor outcrops, where formerly only reconnaissance work had been done. Detailed study of the syenite quarry and adjacent ¾ square mile established (1) gray argillite, the original country rock; (2) "granite hybrid" with rounded included quartz grains; (3) nepheline syenite, bearing eucolite; (4) pink, fine-grained syenite apparently the main intrusive; (5) hornblende syenite in the pink syenite, possibly a darker phase of the syenite; (6) granite pegmatite containing zircon crystals. Nepheline was determined by treating slides with phosphoric acid and staining with methylene blue. A new occurrence of a mineral of the eudyalite-eucolite series was found and determination was made by thin section, fragment, and x-ray studies.

Nepheline syenites are often associated with limestones or carbonate rocks. There is no indication, up to the present time, of limestone in the Wausau area, although the argillite is rich in microscopic carbonate. These nepheline rocks and associated minerals resemble those of Magnet Cove, Arkansas; Haliburton-Bancroft, Ontario; Alnö, Sweden; and Oslo, Norway.

Further field and laboratory work is needed to determine whether these rocks are igneous, meta-igneous or meta-sedimentary in origin.

ORIGINAL CRUST IN THE CANADIAN SHIELD AREA

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Archaean rock series in the Canadian Precambrian Shield include sediments, but none of the coarse clastics characteristically derived from granite. This is taken as direct evidence that the original crust was basic—probably basaltic, and that granite was scarce, if not entirely absent. The granitic rocks so abundant in the Shield developed and became exposed through repeated cycles of sedimentation, mountain building, and erosion.

NEW BASIC COPPER PHOSPHATE MINERAL FROM SANTA RITA, NEW MEXICO

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Crystallographic studies of small, emerald-green crystals from the Santa Rita pit, Chino Mines Division, Kennecott Copper Corporation, Santa Rita, New Mexico, lead to the description of a new mineral dimorphous with pseudomalachite, $Cu_5(PO_4)_2(OH)_4$.

X-ray studies by the Weissenberg method on the new mineral showed it to be orthorhombic and gave a space group $Pnn—C_{2v}^{10}$ with cell dimensions $a_0 = 7.47$ Å, $b_0 = 8.31$ Å, $c_0 = 5.83$ Å and axial ratios $a:b:c = 0.8989:1:0.7016$. The unit cell contents are $Cu_{10}(PO_4)_4(OH)_8 = 2[Cu_5(PO_4)_2(OH)_4]$.

The optical data are: $\alpha = 1.698$, $\beta = 1.745$, $\gamma = 1.783$; $2V = 90° \pm$; optically $(+)$; $X = c$.

Crystal forms present are $b\{010\}$, $m\{110\}$, $n\{011\}$. Cleavage is $\{110\}$, perfect.

The calculated specific gravity is 5.24 and the measured specific gravity is 5.22.

AUROSTIBITE—A NEW MINERAL IN THE PYRITE GROUP*

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A new mineral identical with the intermetallic compound $AuSb_2$ has been found in gold ores from the Giant Yellowknife Mine, North-West Territories, and from the Chesterville Mine, Larder Lake Area, Ontario. In the former locality it occurs in dolomitic carbonate and quartz with gold, freibergite, stibnite, jamesonite, chalcostibite, bournonite, arsenopyrite, pyrite, chalcopyrite, and sphalerite; in the latter in quartz with gold, galena, tennantite, chalcopyrite, sphalerite, arsenopyrite, gersdorffite and pyrite. In polished section the mineral is galena-like with a slight pinkish tinge; in hand specimen minute anhedral grains show a bornite-like tarnish. The standard etch reactions in the order of reactivity are: HNO_3, $FeCl_3$, HCl, KOH positive; $HgCl_2$ and KCN negative. The hardness is C−. The composition of the mineral was determined by comparing its x-ray powder pattern with that of the synthetic compound, and was checked by microchemical tests. The crystal structure is pyrite type; the unit cell containing Au_4Sb_8 has $a = 6.646 \pm 0.003$ kX. (synthetic 6.644 ± 0.003 kX); the single Sb parameter is 0.386 ± 0.007. The calculated gravity is 9.91 compared with 9.98 measured on synthetic material.

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PETROLOGY OF THE PALEOZOIC SHALES OF ILLINOIS*

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A series of Paleozoic shales ranging from the Ordovician through the Pennsylvanian from widely separated geographic localities in Illinois were investigated by x-ray diffraction, differential thermal, chemical, and microscopic methods, in order to determine their clay mineral composition and textural characteristics.

Illite is the dominant clay mineral in most of the shales investigated, a chloritic clay mineral is present in many of them in varying abundance, kaolinite is a component of many of them in varying abundance, and montmorillonite was found in only a few of them in minor quantities.

An analysis of the data shows that certain clay mineral compositions are characteristic of certain parts of the Paleozoic section in Illinois. A discussion is presented of the relation of clay mineral composition to the texture of shales and of the implication of the relation of composition to the genesis of the shales.

VARIATIONS IN GRANITIC ROCKS OF THE HUNTINGTON LAKE AREA OF THE SIERRA NEVADA

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The rocks of the Huntington Lake area, 160 square miles of the western slope of the central Sierra Nevada, of California, are dominantly granitic. Two square miles of the area are underlain by metamorphic rocks, chiefly quartzites and marbles.

The granitic rocks vary from calcic diorite to alkali alaskite and form twelve separate plutons. Each of these plutons varies within itself, and a series of maps has been prepared illustrating the following variables: rock type, abundance and relative proportions of ferromagnesian minerals, abundance of dark inclusions, grain size, and quality of primary flow structures. Gradational variations within plutons are of considerable magnitude in some cases; in two plutons, for example, rock type varies from quartz diorite through granodiorite to quartz monzonite. In another pluton, content of ferromagnesian minerals varies from two to nineteen per cent. The "typical" granitic rock would be a hornblende biotite quartz monzonite.

Total dark minerals, soda lime feldspar, and the proportion of hornblende to biotite in general increase together; precise statements regarding their interrelation are not warranted.

The abundances of ferromagnesian minerals and of dark inclusions are closely parallel. The inclusions probably have a xenolithic origin.

PETROLOGY OF THE FRANKLIN-SYLVA PEGMATITE DISTRICT, NORTH CAROLINA

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The Franklin-Sylva pegmatite district, which includes parts of Clay, Macon, Jackson, Transylvania and Haywood counties in North Carolina, is underlain in its western two-thirds chiefly by high-grade metamorphic rocks and in its eastern one-third mainly by the Whiteside batholith, which varies in composition from quartz dioritic to granodioritic and by whose crystallization the mica-bearing pegmatites were derived. The metamorphic

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* Presented with the permission of the Chief of the Illinois State Geological Survey.

rocks, which were studied by Keith, were divided by him into two formations: the Carolina gneiss, which included mainly biotitic gneisses and schists, and the Roan gneiss, which he described as dominantly hornblende gneiss and schist. More detailed work has revealed a much wider variation in rock types. Rocks previously classed together under Carolina gneiss include: biotite gneiss, biotite-garnet gneiss, biotite-muscovite gneiss ± garnet, quartz-biotite gneiss ± garnet, feldspathic biotite gneiss, garnetiferous quartzite, kyanite gneiss ± garnet or staurolite, kyanite-sillimanite gneiss and schist, sillimanite-biotite gneiss ± garnet, a series of rocks containing variable amounts of garnet (rhodolite), anthophyllite, biotite, hypersthene, sillimanite and quartz, a group of rocks containing corundum in various combinations with garnet, biotite, kyanite, hypersthene, hornblende or chlorite, and locally, minor marble. The Roan gneiss is now known to contain hornblende gneiss and schist ± garnet, amphibolite, garnet amphibolite and actinolite schist. This complex of probable pre-Cambrian age, was intruded first by bodies of dunite, troctolite and peridotite, which display various degrees of serpentinization and complex hydrothermal alteration. Later, possibly in Carboniferous time, the Whiteside batholith with its satellitic pegmatites and aplites was emplaced, and migmatites were developed locally in the schists and gneisses through intense, small-scale injection.

NOTES ON THE GEOCHEMISTRY OF BERYLLIUM*

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Extensive sampling of nonpegmatitic rocks by the U. S. Geological Survey has provided many new data that suggest modification of prevailing concepts of beryllium geochemistry.

Common silicates, particularly those characterized by tetrahedrally coordinated aluminum, contain as much as 0.0X per cent BeO. Substitution of $Be^{2+}Si^{4+}$ for $Al^{3+}Al^{3+}$ is probable. Idocrase is exceptional in that it can contain a maximum of nearly 4 per cent BeO. When shown on a triangular diagram with coordination-number coordinates, nonberyllian idocrase analyses are grouped near Machatschki's formula $(Ca_{19}(Al, Mg)_{13}Si_{18}(O, OH, F)_{76})$. Idocrase with more than 0.1 per cent BeO lies far outside the normal field, but if beryllium is not included in the calculation the plots are normal. Probably a third of the beryllium replaces silicon; the rest enters normally unoccupied tetrahedral positions. Beryllian idocrase is known only at localities where beryllium minerals such as helvite are found. Garnet is similar to idocrase in structure, but it contains less than a tenth as much beryllium.

Igneous rocks vary widely in beryllium content. New tentative averages are: 0.0025 per cent BeO in feldspathoidal rocks, 0.002 in granitic rocks, and 0.0007 in intermediate rocks. Feldspathoidal intrusive rocks in the United States, including the rare pegmatitic phases, do not contain beryllium minerals. Beryllium is apparently accommodated in the lattices of aegerite and nephelite.

About 15 per cent of the pyrometasomatic deposits in the United States contain tactites with more than 0.005 per cent BeO, but none approach in size and grade the Iron Mountain, N. Mex., deposit. The association of idocrase, usually fluorine-rich, with fluorite is indicative of beryllium.

ON THE SUPERSTRUCTURE IN ANORTHITE

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Taylor and his coworkers (1934, 1951) have shown that in anorthite the true periodicity in the c-direction is approximately twice that of albite. Additional observations here reported may be helpful in the final determination of the anorthite structure, considerable differences are observed with variation of heat treatment. Anorthites from several localities as well as synthetic anorthite show three types of reflections:

(a) (hkl) with $l=$even and $(h+k)=$even
(b) (hkl) with $l=$odd and $(h+k)=$odd
(c) (hkl) with $(h+k+l)=$odd
  (1) $(h+k)=$even, $l=$odd
  (2) $(h+k)=$odd, $l=$even

Type (a) spots correspond to those of the albite structure, are always sharp, and unaffected by heat treatment. Types (b) and (c) are affected by history and heat treatment. (b) and (c) can be diffuse, although (c) reflections are elongated in the direction normal to (010), when diffuse.

If all of the spots are or have been made sharp (6 days at 1150° C. for synthetic anorthite) the average ratio of the intensities of (a)/(c, 1)/(b), (c, 2) is approximately equal to 20/5/1. In 15 minutes at 1500° C. the (c) spots virtually disappear so that the average intensity (a)/(c)/(b) is 20/0/1). (The apparent disappearance of the (c) spots may be due to greatly increased diffusion, and must be checked photometrically.)

It is believed that these observations are best explained by assuming the (a) spots to be due to a fundamental plagioclase structure. The subsidiary spots (b) and (c) are a consequence of order-disorder relations with Al-Si ions controlling the (b) reflections, Ca ions the (c) reflections.

Additional data obtained from synthetic anorthites in which partial replacements were made of Al by Ga, of Si by Ge, and of both Al and Si by Ga and Ge confirm this hypothesis.

PROBLEM OF THE CARBONATE APATITES. IV—STRUCTURAL SUBSTITUTIONS INVOLVING CO$_3$ AND OH

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That the formula for francolite cannot be written correctly as $3Ca_3(PO_4)_2 \cdot CaCO_3$ is conclusively demonstrated by the fact that the atomic ratios Ca:P:C are not constant and do not closely approximate 10:6:1. Although certain authors have presumed that francolite consists of two phases, namely fluorapatite and $CaCO_3$, this presumption is inconsistent with most of the experimental data.

Optical and x-ray diffraction data completely fail to indicate the presence of a second $CaCO_3$ phase. If it is assumed that the $CaCO_3$ particles are so small as to produce no diffraction lines, one would expect the francolite lines to be broad and diffuse because the dimensions of the $CaCO_3$ particles could not be less than one-tenth the dimensions of the francolite particles. The diffraction lines of francolite are quite as sharp and narrow as those of apatite, however.

Although the diffraction patterns of apatite and francolite are similar, important differences exist. The optical properties are different also. Thus the basic structure of francolite must be similar to that of apatite, but certain statistical substitutions are necessary. Crystal chemical calculations indicate the following isomorphic substitutions: (i) C for P, i.e. $3PO_4 \rightarrow 4CO_3$, (ii) $(OH)_4$ for PO_4, and probably (iii) H_2O for Ca. This hypothesis is con-

sistent with the average composition for five recent analyses of francolite, a fact which can hardly be fortuitous.

These concepts have important implications concerning the crystal chemistry of teeth and bones, because of the necessity for explaining the carbonate content of the substances in view of their apatite-like diffraction patterns.

HURLBUTITE, $CaBe_2(PO_4)_2$, A NEW MINERAL

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A new calcium beryllium phosphate closely associated with triphylite has been found on the dump at the Smith Mine, Chandler's Mill, Newport, New Hampshire. The original find of three crystals (summer of 1949) has recently been increased to twenty-two.

Hurlbutite is orthorhombic-dipyramidal; crystals are colorless to greenish white, 4 mm. to 25 mm. along [110], stout prismatic [001] with observed forms {001}, {010}, {110}, {201}, and {311} doubtful. The faces often are delicately etched and show striations on {110}. Cleavage, not observed. Fracture conchoidal. Brittle. Hardness 6. Specific gravity 2.877 (meas.); 2.88 (calc.). Luster vitreous to greasy. Transparent to translucent. Optically biaxial negative ($-$) with $nX=1.595$, $nY=1.601$, $nZ=1.604$; $2V=70°$; $r>v$, weak; $X=b$ $Y=c$. Chemical analysis gave: CaO 21.84, BeO 21.30, P_2O_5 56.19, Insol. 0.76, Total 100.09.

X-ray study by the Weissenberg method about all three axes was made on a single fragment of known orientation, drilled out from the original crystal found, following the location of the axes by the oscillating technique. Space group $Pmmm$. Unit cell dimensions a_0 8.29 Å, b_0 8.80, c_0 7.81 ($a_0:b_0:c_0=0.9420:1:0.8875$). The strongest x-ray powder lines are 3.67 Å (10), 3.03 (9), 2.78 (9), 2.21 (9).

Hurlbutite occurs in a pegmatite of the complex acid type with lithium, beryllium, and phosphate phases. The mineral assemblage includes muscovite, albite, triphylite, and massive light-smoky quartz, with indications that hurlbutite is later than triphylite but earlier than quartz. Perfect crystals are usually embedded in the smoky quartz. Secondary minerals include beryllonite, albite, brazilianite, twinned amblygonite crystals, colorless and purple apatite, siderite, and siderite pseudomorphs after hurlbutite.

THE UNIT CELL OF HYDROMAGNESITE

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X-ray study of crystals of hydromagnesite from Crestmore, California, by powder, rotation and Weissenberg equi-inclination photographs, shows the following values for the crystallographic constants:

Monoclinic, pseudo-orthorhombic

$$a_0=18.69\text{Å} \quad b_0=9.02\text{Å} \quad c_0=8.33\text{Å}$$
$$a:b:c=2.0720:1:0.9235 \quad \beta=90°$$

These values represent a doubling of the original a axis. Rotation and Weissenberg pictures were taken about [001] and [010]. The layer line (equator, first and second layers) photographs show that the original a axis must be doubled, and also show systematic extinctions which apparently place the symmetry in class C_{2v}^{14} (orthorhombic). This apparent symmetry is produced by polysynthetic twinning on {100} which fails to appear in the layer line pictures because of the orthorhombic aspect of the elementary lattice.

The powder photographs can be satisfactorily indexed using the new cell dimensions.

Values for $\frac{1}{2}a_0:b_0:c_0$, and spacings and intensities of the powder photographs correspond closely with those determined by Fenoglio in 1936 on hydromagnesite from Pennsylvania and from Val d'Aosta.

OBSERVATIONS ON THE STRUCTURE OF SOME KAOLINITES AND DEHYDRATED HALLOYSITE

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The structures of several kaolinites and dehydrated halloysite, as indicated by x-ray powder diffraction technique and differential thermal analyses, have some significant variations. These variations are found within the unit structural layer and also in the manner in which the layers are stacked one upon the other. The term "degree of crystallinity" is used to compare the structural variations and is defined to include the disorder within the crystallographic unit layer and also the stacking variations of these unit layers.

The kaolinites and dehydrated halloysite were listed according to their degree of crystallinity first using criteria based on x-ray powder diffraction data and then using criteria based on differential thermal analyses. These two lists were compared and are in general agreement with the major exception of dehydrated halloysite.

Based on x-ray criteria, dehydrated halloysite has a poor "degree of crystallinity"; but based on differential thermal criteria, it has a good "degree of crystallinity." This indicates that the unit layer has very little disorder but that these layers are stacked with complete randomness.

AGE OF MINERALIZATION: THERMOLUMINESCENCE AND RADIOACTIVITY OF FLUORITE

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The intensity of thermoluminescence of fluorite per unit radioactivity appears to be a function of the age of mineralization of the fluorite deposit. The intensity of thermoluminescence is proportional to the total radiation (alpha particle bombardment) received by the crystal lattice from radioactive impurities in the fluorite. The total radiation received by a given sample is a function of the present radioactivity of the specimen and its age, or the length of time since its formation.

About twenty fresh (not exposed to sunlight) samples of fluorite were obtained from the principal fluorite-producing areas in the United States, and from other mineralized areas where fluorite was available and the approximate geologic age of the mineralization was known. The procedures and apparatus for measuring the thermoluminescence and the radioactivity of the fluorite samples will be discussed briefly.

The fluorite samples used in this study range in geologic age from Precambrian to Tertiary. In most cases, the geologic evidence can only indicate an age as "post-this" and "pre-that," with perhaps a gap of a geologic period or more between the limits. With this new method involving the thermoluminescence and radioactivity of fluorite, the time of mineralization can generally be placed within a geologic period or a part thereof, according to the generally accepted absolute time scale of the National Research Council.

The possible sources of error, corrections involved, and the accuracy of this method will be discussed briefly. This general method is probably applicable to all thermoluminescent minerals, including calcite, dolomite, feldspar and quartz.

MAGNETIC SUSCEPTIBILITY OF CHROMITE FROM MONTANA AND ITS RELATION TO OTHER PHYSICAL AND CHEMICAL PROPERTIES

JOE WEBB PEOPLES AND GORDON P. EATON
Wesleyan University, Middletown, Connecticut

Because qualitative tests have indicated considerable variation in the magnetic properties of chromite from the Stillwater Complex, Montana, a study was made of the magnetic susceptibility of cleaned chromite concentrates previously analyzed. The magnetic susceptibility, at a field strength of 6400 gauss, ranges from 5.16×10^6 to 121.94×10^6 Cgs units for 33 chromite samples from the Stillwater Complex, but for one sample from Red Lodge, Montana, it is 505×10^6 Cgs units. Complete analyses of 10 of the samples, and determination of Fe and Cr for the rest had previously been made by R. E. Stevens and M. K. Carron of the U. S. Geological Survey. Preliminary microscopic study shows little evidence of nonhomogeneity; the magnetic properties are, therefore, considered as a property of the chromite itself. In general no correlation between magnetic susceptibility and weight per cent of total Fe is evident. Eight of the ten samples analyzed for all major constituents show a linear relationship between magnetic susceptibility and the ratio Fe(mol)/Fe(mol) +Mg(mol).

The variations of the physical properties and geologic occurrence of the magnetic and nonmagnetic chromite samples are compared with those of chromite from other deposits.

NEW MECHANICAL TWINNING IN CALCITE

EUGENE C. ROBERTSON
Harvard University, Cambridge, Massachusetts

Cylinders of calcite were caused to deform by subjecting them to hydrostatic pressure plus additional compression parallel to the axes of the cylinders. The test specimens were right circular cylinders, one-half inch in diameter, cut from single crystals of calcite; in one orientation the cylinder axes were perpendicular to a cleavage face, $(10\bar{1}1)$, and in another orientation the axes were parallel to a crystallographic a-axis. The resulting deformations were by twin gliding on the prism: $T = \{10\bar{1}0\}$, with two directions of gliding on the twin plane, $t_1 = (0001)$, and $t_2 = (000\bar{1})$. Slipping on the twin plane for relatively large distances was observed, and may be a parting mechanism of deformation with self-healing on the slip plane. The specimens were jacketed to prevent weakening by penetration of the pressure fluid into cracks. The shearing stress on the twin plane at the initiation of copious strain was not constant because of the irregularities of stress distribution in the cylinders, especially near the ends. A low hydrostatic pressure, less than 250 atmospheres, seems to be required before the twinning can be produced.

COMPOSITION AND SIGNIFICANCE OF FLUID INCLUSIONS IN MINERALS

EDWIN ROEDDER
University of Utah, Salt Lake City, Utah

During the formation of many minerals small amounts of the fluid medium from which deposition occurred are trapped within the growing crystals as microscopic fluid inclusions. These inclusions thus represent a true sample of the original medium from which deposition has taken place, and any information, however meager, which can be obtained from them as to the chemical nature of these fluids would be of considerable value in such diverse problems as the origin of cherts, the identification and correlation of veins or epochs of deposition in faulted or complex mining areas, the origin of certain detrital sediments, and the

origin and nature of the fluids which have deposited pegmatites, quartz veins, and the ores of the metals.

A technique has been developed for the extraction and limited wet chemical and spectrographic analysis of the fluid from fluid-filled inclusions in quartz. At present it appears adequate to yield significant data on the sulfate:chloride ratio, the K:Na ratio, and certain spectrographic determinations. The technique and its limitations are discussed and results are given for quartz samples from a number of widely divergent types of occurrence, along with their significance in connection with the nature of the ore-forming fluid.

STUDIES OF MINERALS IN DUNITES AND IN OLIVINE-RICH INCLUSIONS IN BASALTIC ROCKS

C. S. ROSS AND MARGARET D. FOSTER

U. S. Geological Survey, Washington, D. C.

Dunites and olivine-rich inclusions in basaltic rocks, both of world-wide provenance and both characterized by the same four minerals—olivine, enstatite, diopside, and a spinel —provide an unusual opportunity to compare the composition of the minerals, and the distribution of the elements in them. These relationships contribute to an understanding of the genetic history of such rocks.

Materials were obtained from 14 widely distributed localities, and the various minerals were carefully separated for detailed mineralogical and chemical study. The analyses showed that the respective silicate minerals in olivine-rich inclusions and in dunites were strikingly similar in composition. This was particularly true of the olivine, in which, for all the specimens studied, there was a range of only 1 per cent in the silica content and of only 2 per cent in the magnesia. Much greater differences were found in the composition of the spinel, particularly in that in olivine-rich inclusions, which differed greatly in iron, chromium, and, especially, in alumina content. The samples of spinel from dunites were very similar to each other and were much higher in chromium than were those from olivine-rich inclusions.

Their striking mineral identity suggests that the original source both of dunites and of olivine-rich inclusions is the same and that the inclusions are derived from the peridotite zone of the earth's crust, as has been commonly believed for dunites.

DETERMINATION OF SMALL QUANTITIES OF DOLOMITE BY DIFFERENTIAL THERMAL ANALYSIS

RICHARDS A. ROWLAND AND CARL W. BECK

Shell Oil Company, Houston, Texas

In a furnace atmosphere of CO_2 the two endothermic loops of dolomite are separated and sharply defined. The first, between 700° C. and 800° C., is formed during the decarbonation of the magnesium carbonate. The second, between 900° C. and 1000° C., accompanies the decarbonation of calcium carbonate and coincides with the thermogram loop for calcite. The ratio of the areas enclosed by these loops and the extended base line is directly proportional to the dolomite content of a carbonate rock, and the area of the first loop reflects the dolomite content of other rocks when only a small amount of dolomite is present. Calibration curves are obtained by plotting these areas or area ratios from thermograms of prepared mixtures against the known dolomite content. For mixtures containing less than five per cent dolomite, the first loop is recorded at a sensitivity about thirty times as great as the sensitivity used for the second loop. The change from high to low sensitivity is made at 850° C. This method, by which the dolomite content of a carbonate rock can be quantita-

tively determined when as little as 0.3 per cent dolomite is present, is most useful in following dolomitization far beyond the limits of microscopy or x-ray diffraction and in evaluating the products of experiments in the laboratory synthesis of dolomite.

THE SYSTEM MgO-Al₂O₃-H₂O

D. M. ROY AND E. F. OSBORN

Pennsylvania State College, State College, Pennsylvania

Phase equilibria in the binary systems $MgO-H_2O$ and $MgO-Al_2O_3$ were investigated. New data in the former system indicate that the transformation $Mg(OH)_2 \leftrightarrows MgO + H_2O$ takes place from 700° to 800° C. varying within the range of water vapor pressures studied (2000–20,000 p.s.i.). In the system $MgO-Al_2O_3$ spinel solid solutions were formed containing up to 85 mole per cent Al_2O_3. Exsolution of the solid solutions was accomplished under both dry and hydrothermal conditions. The extent of solid solution was found to decrease with decreasing temperature, the limit of solid solution being 65 mole per cent Al_2O_3 at 1500° C., and exsolution being almost complete at 800° C. in the presence of water vapor.

Under hydrothermal conditions, spinel was formed at temperatures between 900 and 375° C. At temperatures lower than 375° C. it is replaced by brucite+diaspore. Hydrotalcite $(6MgO \cdot Al_2O_3 \cdot CO_2 \cdot 12H_2O)$, a mineral occurring naturally as a decomposition product of spinel was synthesized below 310° C. under varying H_2O and CO_2 pressures. A nitrate analogue of hydrotalcite was also synthesized at temperatures below 420° C. under hydrothermal conditions. This compound was found to coexist with spinel between 420° and 375° C. below which the spinel no longer forms.

PHASE EQUILIBRIA IN THE SYSTEM Al₂O₃-SiO₂-H₂O

RUSTUM ROY AND E. F. OSBORN

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The equilibrium assemblages of phases in the system alumina-silica-water have been studied under hydrothermal conditions over the range of 100° to 950° C. and 15 to 30,000 psi. Seven curves of univariant equilibrium are presented on a pressure-temperature diagram, representing the conditions at which one set of stable phase assemblages gives way to another. Two new phases are reported, one a pure aluminian end member of the montmorillonites and the other a mica-like phase formed on the decomposition of kaolinite.

The data serve to establish the stability relationship of endellite $(Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O)$ to halloysite $(Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O)$. The decomposition temperature of endellite changes from just above 100° C. at 15 psi. water pressure to nearly 200° C. at approximately 10,000 psi. The equilibrium decomposition temperature of the kaolinite group of minerals was found to be 450° C. and is very similar for the various members of the group. Pyrophyllite is a stable phase in equilibrium with a fluid in the system $Al_2O_3 - SiO_2 - H_2O$ from 420° to 575° C. At temperatures above 575° C. mullite appears as a phase in all mixtures. It was not found possible to synthesize andalusite, sillimanite, or kyanite under any of the conditions used; however, these minerals were successfully decomposed to yield equilibrium phases. This latter decomposition was achieved in an apparatus for grinding at elevated temperatures (up to 500° C.) and pressures (up to 10,000 psi.).

SYSTEM FeO-Al₂O₃-SiO₂

J. F. SCHAIRER AND KENZO YAGI

Geophysical Laboratory, Washington, D. C.

Phase equilibrium studies of this system, at and just below temperatures where a liquid phase is present, show one ternary compound, the iron analogue of cordierite $(2FeO \cdot 2Al_2O_3$

$\cdot 5SiO_2$), which decomposes at $1210 \pm 10°$ C. to mullite, tridymite, and liquid. The fields of stability of corundum, mullite, hercynite, iron cordierite, cristobalite, tridymite, fayalite, and wüstite have been delineated. The following invariant points (the first two eutectics and the remainder reaction points) were located:

Fayalite+wüstite+hercynite+liquid	$1148 \pm 5°$
Fayalite+iron cordierite+tridymite+liquid	$1083 \pm 5°$
Fayalite+iron cordierite+hercynite+liquid	$1088 \pm 5°$
Hercynite+iron cordierite+mullite+liquid	$1205 \pm 10°$
Iron cordierite+mullite+tridymite+liquid	$1210 \pm 10°$
Corundum+mullite+hercynite+liquid	$1380 \pm 5°$
Cristobalite+tridymite+mullite+liquid	$1470 \pm 10°$

Iron cordierite crystallizes with some reluctance and the metastable invariant points fayalite+tridymite+spinel+liquid at $1073 \pm 5°$ and mullite+hercynite+tridymite+liquid at $1205 \pm 10°$ can be realized. No ferrosilite or almandine garnet could be crystallized from the melts at any temperature even when melts were seeded with these crystalline phases. Natural almandine from Botallack, England (91.3 per cent almandine), when heated begins to decompose at an appreciable rate as low as 900° C. and yields a mixture of hercynite, iron cordierite, and fayalite. The bearing of these results on petrology and slags is discussed.

MARGARITE-EPHESITE SERIES; THEORY VERSUS FACT*

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U. S. Geological Survey, Washington, D. C.

The formula of margarite, the best known of the brittle micas, $Ca \cdot Al_2 \cdot Al_2Si_2 \cdot O_{10}(OH)_2$, requires 14.09 per cent CaO. Yet not a single one of nearly 5 dozen analyses shows this much CaO.

The presence of several per cent of Na_2O in many margarites has long been known—the soda margarites. Substituting one sodium for one calcium in the margarite formula leaves a deficiency of one in the cation charges. Theory calls for the addition of one atom of a univalent element whose ionic radius is close to that of aluminum in order to balance the charges. Lithium is the only element which meets these requirements and it goes into the only vacant position, in the octahedral group, of the margarite formula. The theoretical formula of the calcium-free sodium analogue of the margarite formula thus becomes $Na \cdot Al_2Li \cdot Al_2Si_2 \cdot O_{10}(OH)_2$, the mineral ephesite.

Now what are the facts? The calculated amount of Li_2O in the ephesite formula is 3.85 per cent. The two recorded analyses of ephesite from Postmasburg, South Africa, show only 0.9 and 1.5 per cent Li_2O. Either the theory is wrong or the reported analytical determinations of Li_2O are wrong. A new analysis of this ephesite was therefore made and 3.80 per cent Li_2O was found, thus confirming the theoretical approach to the correct formula of ephesite.

CHLORITE-CALCITE PSEUDOMORPHS AFTER ORTHOCLASE PHENOCRYSTS, RAY, ARIZONA

GEORGE M. SCHWARTZ
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Peculiar dark pseudomorphs after orthoclase phenocrysts occur along fracture zones near the margin of the metallized area at Ray, Arizona. The most intensely altered crystals contain no recognizable orthoclase but consist principally of chlorite and calcite plus small,

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* Publication authorized by the Director, U. S. Geological Survey.

but variable amounts of sericite and quartz. Rutile, leucoxene, kaolinite, allophane, hydromica and sulfides are present in some thin sections.

It is thought that the pseudomorphs were formed by solutions loaded with calcium, magnesium and iron that moved upward and outward from the orebody where the rocks had been intensely sericitized and the bases other than potassium removed to a considerable degree.

The occurrence emphasizes the problem of the time of alteration. The propylitic stage is often considered to be an early stage, whereas it probably is often a marginal stage that coincides in time with sericitization, or other alteration, near the center of activity. An expanding sericite-quartz stage of alteration may cause those minerals to invade the propylitic rock and thus furnish evidence of an age difference, but in fact propylitization is probably taking place farther out at the same time.

CORONITES FROM THE PRESTON GABBRO, NEW LONDON COUNTY, CONNECTICUT*

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Battelle Memorial Institute, Columbus, Ohio

Corona-bearing rocks from the olivine hyperite facies and the troctolite facies of the Preston gabbro are described. Double coronas are present between olivine and plagioclase and between iron ore and plagioclase; single coronas are found between late-magmatic iron ore and plagioclase. The inner shell of the double corona consists of a colorless fibrous mineral (orthopyroxene, anthophyllite, or cummingtonite) that was derived at least in part from magmatic reaction rims of hypersthene that surround the olivine. The outer shell is composed of fibrous actinolitic amphibole that developed partly at the expense of deuteric(?) brown hornblende but mainly by replacement of the adjoining plagioclase. Enigmatic double coronas between plagioclase and iron ore were originally formed between plagioclase and olivine that was later selectively replaced by iron ore. Partly altered magmatic reaction rims of hypersthene surrounded by fully developed outer shells of actinolitic amphibole suggest that the inner shells of many double coronas were formed after the peripheral shells. The single coronas are identical with the outer shells of the double coronas and have the same developmental history.

The coronites grade into more highly altered equivalents in which the outer shells of the double coronas remain intact and the inner shells are replaced by either talc or chlorite and actinolite.

Field evidence does not support Shand's hypothesis of thermal metamorphism as the catalytic factor in corona formation. These coronites are believed to have developed as a result of hydrothermal alteration within a critical temperature range of chemically and mineralogically favorable rocks.

It is proposed that the term "corona" be limited to shells of post-magmatic synantectic minerals. Criteria for distinguishing magmatic from post-magmatic reaction rims based on mineralogical composition and fabric relationships are discussed.

RELATION OF MICROPEGMATITE TO PEGMATITE AT SAFE HARBOR, PENNSYLVANIA

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At Safe Harbor, Pa., Antietam sediments containing pegmatite pockets and veins have been intruded by basaltic magma. The sediments vary in composition from compact mica

schist strata to more porous arenaceous strata composed of quartz and felsitic minerals. Part of the aureole has been entered by sodic vapors which penetrated readily through the arenaceous strata, less freely through the schist strata and pegmatitic material.

Alteration noted in the biotite-rich schist strata, when caught within the aureole, indicates that there was always a mafic mineral stable under the conditions imposed. Metamorphism of high thermal type follows conventional lines and presents no problem.

Alteration noted in the arenaceous strata suggests that a magmoid condition was reached. There is flow or movement. This magmoid forms fairly large masses of irregular extent with uniform composition. It solidifies to the rock that has been called "pink diabase" and "granophyre."

Result of sodic vapors acting on felsic minerals can be studied to best advantage in the pegmatite veins. Where these have been caught within the aureole, residual cores of orthoclase and quartz (strained) are surrounded by zones of fine-grained micropegmatite, albite and quartz (straight).

Author's conclusions:

Micropegmatite can form from pegmatite minerals by soda pneumatolysis.

Granophyre or pink diabase, as occurring at Safe Harbor, Pa., derived from sedimentary strata composed essentially of granitic minerals by soda pneumatolysis.

FOUR SERIES OF ALKALI FELDSPARS

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On the basis of x-ray and optical examination alkali feldspars may be divided into four series: microcline-low albite, orthoclase-low albite, sanidine-high albite, and "high" sanidine-high albite. The first three series usually occur in nature as cryptoperthite, a condition which may be revealed only by x-rays. All specimens (5) examined, which belong to the microcline-low albite series, consist of a submicroscopic intergrowth of nearly pure microcline and pure low albite. The orthoclase-low albite series is also usually unmixed to pure orthoclase and pure low albite of submicroscopic dimensions. Representatives of the sanidine-high albite series are usually completely unmixed to pure potash feldspar and pure soda feldspar; only rarely are they homogeneous. Some optically homogeneous representatives of this series consist of three phases: a potash feldspar, soda feldspar, and an intermediate phase representing the original material still unmixed. Synthetic feldspars belong to the high sanidine-high albite series. Natural alkali feldspars can be converted to homogeneous members of this series by appropriate heat treatment.

Optical properties are given for distinguishing the four series. The changes of optical properties with composition and heat treatment are discussed.

BLISTER HYPOTHESIS AND THE PETROGENIC CYCLE

C. W. WOLFE
Boston University, Boston, Massachusetts

Many writers have suggested that magmas are the direct result of radioactivity. The Blister Hypothesis would suggest that all magmas are directly or indirectly the result of this process and are derived from previously existing solid rock. Since a Blister is a relatively warmer and expanded subcrustal sector, any level within the Blister may become magma under proper conditions of pressure. It is assumed that some differentiation but almost no convection takes place in the Blister when it becomes sufficiently warmed to form a fluid phase. The particular magmatic type which develops depends principally upon
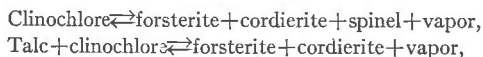
the nature of the rock which is transformed into magma and upon the extent of that transformation. Above the roof of the Blister where plateau flows are apt to form, the sequence of magmatic types is thought to result from the formation of magmas at various levels in a layered crust, although some magmatic differentiation certainly obtains. Hybrid magmas result from the transformation of unusual parent rocks or from mixing during translation and emplacement of magmas from non-homogeneous sources. Geosynclinal sectors are apt to yield rather pure femag pretectonic magmas, variable but usually silicic concordant tectonic magmas derived from the transformation of sediments, and hybrid discordant post-tectonic magmas. The late post-tectonic magmas are apt to be of deep-seated origin and femag in character. It is assumed that the presence of Blister makes such petrogenesis possible, not only through its provision of heat but also through its provision of forces sufficient for orogenesis.

STABILITY RELATIONS OF CLINOCHLORE AND CORDIERITE IN THE SYSTEM MgO-Al₂O₃-SiO₂-H₂O

HATTEN S. YODER, JR.

Geophysical Laboratory, Washington, D. C.

Equilibria in a portion of the system $MgO-Al_2O_3-SiO_2-H_2O$ have been determined at temperatures from 450° to 900° C. at pressures of water vapor up to 30,000 psi. The univariant pressure-temperature curves have been bracketed for the following reactions:

$$\text{Clinochlore} \rightleftarrows \text{forsterite} + \text{cordierite} + \text{spinel} + \text{vapor,}$$
$$\text{Talc} + \text{clinochlore} \rightleftarrows \text{forsterite} + \text{cordierite} + \text{vapor,}$$

and the reactions in the $MgO-SiO_2-H_2O$ system investigated by Bowen and Tuttle (1949) are confirmed.

Pure clinochlore has a maximum stability limit of 680° C. at 15,000 psi water vapor pressure. Below about 550° C. a new form having the clinochlore composition is obtained. It is suspected that this form, although its stability has not been fixed with certainty, may be isostructural with one form of serpentine.

Cordierite is stable at least as low as 510° C. in the presence of water vapor. Pyrope was not synthesized and it is concluded that it is not stable in the presence of an excess of water vapor in the temperature range investigated. Amesite and magnesian chamosite were not produced. The metastable formation of the phases mentioned above is common and their reaction rates are very slow.

It can be demonstrated that several common hydrothermal alterations which have been interpreted as retrograde metamorphism, in the sense of lower grade, need not mean a change in pressure or temperature conditions, but may mean access of water vapor. The presence of an "excess" or "deficiency" of water vapor greatly influences the mineralogy of a metamorphic rock.

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1949 Joseph Murdoch, H. H. Hess, Clifford Frondel, Lewis S. Ramsdell.
1950 Clifford Frondel, Lewis S. Ramsdell, E. F. Osborn.
1951 Cliford Frondel, Lewis S. Ramsdell, E. F. Osborn, George T. Faust.

Annual Meeting Places

1920 Chicago, Illinois	1936 Cincinnati, Ohio
1921 Amherst, Massachusetts	1937 Washington, D. C.
1922 Ann Arbor, Michigan	1938 New York, N. Y.
1923 Washington, D. C.	1939 Minneapolis, Minnesota
1924 Ithaca, New York	1940 Austin, Texas
1925 New Haven, Connecticut	1941 Boston, Massachusetts
1926 Madison Wisconsin	1942 No meeting held
1927 Cleveland, Ohio	1943 No meeting held
1928 New York, N. Y.	1944 No meeting held
1929 Washington, D. C.	1945 Pittsburgh, Pennsylvania
1930 Toronto, Canada	1946 Chicago, Illinois
1931 Tulsa, Oklahoma	1947 Ottawa, Canada
1932 Cambridge, Massachusetts	1948 New York, N. Y.
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Orville Frank Tuttle, November 1951.