PROCEEDINGS OF THE THIRTY-FIRST ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT WASHINGTON, D.C.

C. S. Hurlbut, Jr., *Secretary*

The thirty-first annual meeting of the Society was held on November 16–18, 1950, at the Hotel Statler, Washington, D. C. Scientific sessions were held in the morning and afternoon of November 16 and the morning of November 18, at which thirty-four papers were presented. Five papers were read by title. Five additional papers were presented in the afternoon of November 18 at a Symposium on *Crystal Growth.*

The annual luncheon of the Society on November 16 was attended by 154 fellows, members and guests. Following the luncheon, Arthur F. Buddington introduced the recipient of the Roebling Medal, Norman L. Bowen. Preceding the afternoon Scientific Session on November 16, the retiring President, George Tunell, addressed the Society on *Mineral Formation in Natural Chemical Systems Under Equilibrium and Non-equilibrium Conditions.*

The Council at its meeting on November 15 appointed a committee to consider candidates for nomination to fellowship. This is to be a continuing committee of six members, two new members to be appointed each year to serve for three years. It is hoped that Fellows of the Society will suggest candidates to the committee members.

Nominating Committee for Fellows 1951

3 years—Samuel Zerfoss and William Parrish
2 years—E. F. Osborn and George Faust, Chairman
1 year—H. W. Fairbairn and C. O. Hutton

REPORT OF THE SECRETARY

To the Council of The Mineralogical Society of America:

Election of Officers and Fellows

Four hundred and eight ballots were cast in the election of officers: 135 by fellows, 273 by members of the Society. The officers elected to serve in 1951 are:

President: Adolf Pabst, University of California, Berkeley, California.
Vice-President: Michael Fleischer, U. S. Geological Survey, Washington, D. C.
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 (1951–54): George T. Faust, U. S. Geological Survey, Washington, D. C.

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

J. Dabney Burfoot, Jr., Cornell University, Ithaca, New York.
Alexander de Bretteville, Jr., Signal Corps Laboratories, Fort Monmouth, New Jersey.
Jacob E. de Villiers, Geological Survey, Pretoria, South Africa.
Gabriel Donnay, Johns Hopkins University, Baltimore, Maryland.
Howard Tasker Evans, Jr., Philips Laboratories, Inc., Irvington-on-Hudson, New York.
Robert Bury Ferguson, The University of Manitoba, Winnipeg, Canada.
Rui Ribeiro Franco, University of Sao Paulo, Sao Paulo, Brazil.

Julio Garrido, Lagasca 123, Madrid, Spain.
Julian R. Goldsmith, University of Chicago, Chicago, Illinois.
Harold Lloyd James, U. S. Geological Survey, Iron River, Michigan.
Charles D. Jeffries, Pennsylvania State College, State College, Pennsylvania.
J. Laurence Kulp, Columbia University, New York, New York.
Joseph Stevens Lukesh, General Electric Company, Schenectady, New York.
Charles Mauguin, Sorbonne, Paris, France.
W. S. Tangier Smith, Menlo Park, California.
William Hodge Taylor, Cavendish Laboratory, Cambridge, England.
Robert Mitchell Thompson, University of British Columbia, Vancouver, B. C., Canada.
Frans Erik Wickman, Swedish Museum of Natural History, Stockholm, Sweden.

CHANGES IN THE CONSTITUTION AND BY-LAWS

The Council of the Society at its meeting in 1949 approved several changes in the Constitution and By-laws of the Society. The complete constitution, incorporating these changes, was printed in the July–August 1950 issue of *The American Mineralogist.* The general membership was asked to accept or reject the constitution as there printed. The changes were accepted with 383 votes in the affirmative, and 5 votes in the negative.

MEMBERSHIP STATISTICS

November 1, 1950

	1949	*1950*	*Gain*	*Loss*
Correspondents	5	5	0	0
Fellows	290	307	19	2
Members	746	747	127	126
Subscribers	630	632	49	47
	1671	1691	195	175

The above figures show a net gain of 17 fellows, 1 member and 2 subscribers. Considering the four groups together there is a total gain of only 20. The present total of members and subscribers is 1691.

The Society lost through death two fellows: Clarence N. Fenner of Clifton, New Jersey, and Martin A. Peacock of the University of Toronto, Canada.

Respectfully submitted,
C. S. Hurlbut, Jr., *Secretary*

REPORT OF THE EDITOR FOR 1950

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 a year ago. With five issues published 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 not now available will be incorporated so that the complete printed report can be compared with those given for previous years.

From the standpoint of articles published and total pagination the year 1950 will long be remembered as one of unusual accomplishments. Aside from the normal issues, attention should be called to two so-called special numbers, authorized by the Council, and devoted to specific assignments. The first, sponsored by the Walker's Mineralogical Club continued the series of *Contributions to Canadian Mineralogy*, and appeared as the May–

June issue under the editorship of the late Professor M. A. Peacock. In this number the guest editor assembled 14 interesting papers on varied mineralogical subjects and assumed full responsibility in seeing these contributions through the press.

The issuance this year of a volume of approximately 1100 pages is due in large measure to the greatly enlarged September–October number dedicated to Professor Emeritus Esper S. Larsen, Jr. This number alone carried 32 articles and totaled 344 pages. To the numerous former students and friends of Professor Larsen, who in one way or another made this number posssible, we are extremely grateful.

The editor wishes to take this occasion to express his deep appreciation and thanks to Professor Hurlbut for looking after the numerous details connected with the assembling of the manuscripts and the printing of this special issue.

The 1100 page volume of the current year represents an increase of approximately 200 pages over last year and represents the largest volume in the history of the Society with the single exception of the volume of 1937 that included the special Palache number.

While there has been some delay this year in the appearance of certain manuscripts due to the special issues in which the articles were restricted to specific assignments, the circumstances which have caused the delay this year are not likely to occur again in the near future, so that our normal publication schedule can again be established in 1951.

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 1951, still it would seem that the volume will not reach the size of that produced this year. At present no special enlarged issues are contemplated and a normal volume of about 850 to 900 pages might reasonably be stated as a likely forecast.

In regard to the *Contributions to Canadian Mineralogy*, the late Professor Peacock wrote some time ago that he hoped that a number in 1951 could be arranged and desired to have this item brought to the attention of the Council for their consideration and approval. In addition some 25 papers of varying lengths are now on hand, so that the 1951 volume would likely assume the proportions of the volume of a year ago.

Financial support this year, aside from the income obtained from dues and interest received from the Society's investments, has come from two sources. The sponsors of the Harvard number have assisted in defraying the excessive cost of the enlarged September–October number and the Geological Society of America has continued its generous assistance in defraying a substantial portion of the ordinary printing costs. For this support 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. Reduction in the length of manuscripts through condensation would go a long ways to help ease the financial situation as printing costs are not likely to decline, but unfortunately condensation is the hardest commodity to sell to the author who naturally desires full and what he considers adequate coverage.

The current volume as indicated above will run about 1100 pages and contain 92 articles. Seventeen additional articles appearing under Notes and News give an over-all total of 109 published manuscripts for the year (last year it was 73 and 25, totaling 98). Due to the widespread source material secured for the Larsen number, no less than 32 contributions from 10 countries were received from contributors residing outside of the States; 17 of which came from Canada.

These contributions were received from 122 contributors associated with 61 different Universities, research bureaus, and technical laboratories. Two new minerals were described in detail for the first time: hühnerkobelite and wherryite. The accompanying Table 1 summarizes in detail the distribution of subject matter in Volume 35.

Respectfully submitted

WALTER F. HUNT, *Editor*

TABLE 1. DISTRIBUTION OF SUBJECT MATTER IN VOLUME 35

Subjects	Articles	Pages	Per Cent of Total
Leading articles*			
Descriptive mineralogy	22		
Chemical mineralogy	23		
Structural crystallography	16		
Petrography	12		
Geometrical crystallography	5		
Optical crystallography	4		
Mineralography	1		
Memorials	2		
Miscellaneous	7		
	92	950	86.8
Shorter articles	17	36	
Notes and News	13	7	
Proceedings of Societies	6	73	13.2
Book reviews	18	18	
New mineral names	30	10	
Total entries	176	1094	100.0
Illustrations	312		
Index, Title page, Table of contents		20	
Grand total		1114	

* Leading articles average 10.3 printed pages each.

REPORT OF THE TREASURER FOR 1950

To the Council of the Mineralogical Society of America:

Your treasurer submits herewith his annual report for the year beginning November 1, 1949 and ending October 31, 1950.

RECEIPTS

Dues and subscriptions	$ 7,658.48
Sale of back numbers	1,305.41
Authors' charges on reprints	1,217.90
Interest and dividends from endowment	3,725.20
Geological Society of America aid for printing the Journal	5,299.34
Advertising	599.16
Sale of Index, volumes 21–30	93.90
Sale of Index, volumes 1–20	7.70
	$19,907.09
Cash on hand, November 1, 1949	3,601.54
	$23,508.63

DISBURSEMENTS

Printing and distribution of the Journal (6 issues)	$11,346.15
Printing and distribution of separates	1,377.15
To the Editor, Secretary, and Treasurer	1,250.00
Clerical help	550.50
Postage and express	185.10
Printing and stationery	77.06
Office equipment and supplies	117.37
Roebling Medal	139.59
New securities purchased	696.00
1949 Program and abstracts	293.63
Expenses of officers to 1949 annual meeting	204.22
Committee expenses	2.83
Safety deposit box	7.80
Back numbers purchased	14.00
Telephone and telegraph	3.32
Checks returned	47.90
Refunds	22.80
Exchange charges on checks	1.15
	$16,336.57
Cash balance, October 31, 1950	7,172.06
	$23,508.63

The endowment funds of the Society as of October 31, 1950, 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	
4M Cleveland Union Terminal, 5	4,055.00	
4C Great Northern, $5\frac{1}{2}$	400.00	
		$19,756.25

PREFERRED STOCKS

200 shares, Southern California Edison, 4.88	$5,250.00	
100 shares, Union Pacific, 4	4,570.25	
60 shares, Jones and 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	
60 shares, United Fruit Co.	3,067.50	
50 shares, Chesapeake and Ohio Railway	2,368.75	
50 shares, Pennsylvania Railroad	1,468.75	
41 shares, American Telephone and Telegraph	5,599.32	
40 shares, Kroger Co.	1,990.00	
28 shares, Standard Oil of New Jersey	1,444.84	
1 share, New York, Chicago & St. Louis Railroad	37.00	
		$19,847.16
		$69,094.90

Respectfully submitted,
EARL INGERSON, *Treasurer*

DANA FUND

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

RECEIPTS

Available balance, November 1, 1949	$340.84
Interest	1.31
	$342.15

DISBURSEMENTS

Disbursed	$129.40
Available balance, November 1, 1950	212.75
	$342.15

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, 1950. 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,
WILLIAM D. JOHNSTON, JR.
WALDEMAR T. SCHALLER
FELIX CHAYES, *Chairman*

ABSTRACTS OF PAPERS PRESENTED AT THE THIRTY-FIRST ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT WASHINGTON, D.C. NOVEMBER 16–18, 1950

PETROGRAPHY OF THE WILCOX FORMATION OF ARKANSAS

VICTOR T. ALLEN
Saint Louis University, St. Louis, Missouri

The mineral composition of representative clays and sandstones of the Wilcox formation of Arkansas was determined petrographically in cooperation with the Division of Geology, Arkansas Resources and Development Commission. Samples representing the exposed thickness near Texarkana, Hope, Malvern and Little Rock were studied and show little variation in mineral composition with stratigraphic position or along the strike of the outcrops for the 140 miles from Pulaski County to Miller County. Representative samples of the clays used in ceramics were analyzed chemically and their mineral composition was checked by *x*-ray and differential thermal methods. The principal minerals are kaolinite, quartz and montmorillonite. Small amounts of muscovite, microcline, zircon, tourmaline, rutile, epidote, ilmenite and leucoxene are present in most samples. A few grains of kyanite similar to that which occurs in the schists of North Carolina are present in some samples and suggest that part of the sediment was contributed from Appalachia. The mineral assemblage indicates thorough weathering of the source rock prior to deposition of the sediments. The kaolin minerals were formed by long continued leaching by neutral or slightly acid groundwaters under favorable climatic and physiographic conditions. The montmorillonite was formed from suitable source rocks by alkaline solutions under conditions of poor drainage. The clay minerals were eroded, mixed with quartz and other minerals and deposited in the sea which occupied this area during Eocene time.

THE SHONKIN SAG LACCOLITH REVISITED

JULIAN D. BARKSDALE
University of Washington, Seattle, Washington

Re-study of the earlier collected data and re-examination in the field has convinced the author that the gross layering in the Shonkin Sag laccolith is due to differentiation in place from one and possibly two closely connected intrusions of shonkinitic magma. The layer exhibiting exotic crystallization of biotite-augite-sanidine is a syenite-pegmatite formed during the early pneumatolytic stage of crystallization. The wider of the hornblende-aegirine syenite dikelets, which cut the pegmatite, represents the consolidation of the magmatic residium; the narrower ones are the result of solution replacement along cracks. The many sharp contacts between the various rock types in the laccolith are thought to be due to auto-injection caused by tectonic movements which involved the laccolithic disc while it was solidifying and which continued after it had cooled.

THE MORPHOLOGY AND STRUCTURE OF THE SERPENTINE MINERALS ANTIGORITE AND CHRYSOTILE

THOMAS F. BATES AND JOHN F. MINK
Pennsylvania State College, State College, Pennsylvania

Studies with the electron microscope supported by *x*-ray and DTA data show that natural and synthetic chrysotile are composed of tube-like fibers, whereas antigorite consists of plates and laths. In both instances the morphological characteristics of the artificial materials are better defined than those of the natural minerals. The units of chrysotile always show curvature of the (001) plane parallel to the *a* or *b* axis. In antigorite this curvature is less marked or absent entirely.

Interpretation of the data suggests that antigorite and chrysotile differ morphologically only in the degree of lateral curvature affecting their component units. Evidence indicates that this curvature is most pronounced where the ideal serpentine composition is obtained, such as in synthetic chrysotile, and decreases with the amount of trivalent ions replacing magnesium in the structure. It is believed that the degree of curvature depends upon (1) the discrepancy in dimensions of the "sheets" which make up the unit of structure, and (2) the strength of the bonds between the units. This is in accord with the theory previously proposed to account for tubular crystals of endellite.

PHOTOGRAPHS OF THE ATOMS IN THE STRUCTURES OF MINERALS

M. J. BUERGER
Massachusetts Institute of Technology, Cambridge, Massachusetts

A generalized microscope has been constructed which permits such magnification that the atoms in crystal structures can be seen and photographed. In this microscope light of short wavelength is used as far as the first diffraction image, and then light of a longer wavelength is used from this diffraction image to the final image. For such a microscope the magnification contains not only the usual factor of the image to object ratio, but also a second factor consisting of the ratio of the wavelengths of the second to the first kind of radiation. When visible light and *x*-rays are used for these radiations, this second factor is about 10,000 and the whole magnification is about 300,000 diameters. This is sufficient to enable one to just see the individual atoms of a crystal structure. Unfortunately, a loss of phase occurs when the wavelength is changed. This is made up by the use of phase shifters composed of mica of uniform thickness. The apparatus actually used for this generalized kind of microscopy is described, and photographs are shown of the crystal structures of pyrite, marcasite, and KH_2PO_4.

CORUNDUM DEPOSITS OF MONTANA*

STEPHEN E. CLABAUGH
University of Texas, Austin, Texas

No other part of North America presents such a rich variety of corundum deposits as central and southwestern Montana. Multi-colored sapphires have been recovered from placers near Helena, Philipsburg, and Deer Lodge, chiefly for use as watch jewels. The Yogo sapphire mine in Fergus County was one of the few important sources of precious stones in the United States and the only deposit in the world where sapphires were recovered directly from igneous rock. Deposits of ordinary corundum in metamorphic rocks in Gallatin and Madison Counties have been investigated as possible sources of natural abrasive, but they were found to be small and low in corundum content.

The placer sapphires are chiefly abraded short prismatic crystals of pale color, which probably were derived from andesitic (?) dikes similar to the dike exposed at French Bar on the Missouri River. At Yogo Gulch the sapphires are platy to equidimensional pyramidal crystals of excellent blue color in an altered analcine-bearing lamprophyre. Reaction of the lamprophyric magma with kyanite-bearing inclusions may have caused precipitation of

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corundum at an early stage in the cooling of the rock. Later the sapphires were partly dissolved and coated with spinel.

The abrasive corundum deposits are concordant tabular to lenticular bodies enclosed in metamorphosed pre-Cambrian sedimentary rocks. Feldspar, mica, sillimanite, and rutile accompany the corundum, and the texture of the rock ranges from fine-grained and schistose to pegmatitic. These deposits have recently been described as corundum pegmatites, but their form, distribution, and composition suggest an origin by metamorphism of alumina-rich sedimentary lenses.

LUMINESCENCE ACTIVATION OF ZEOLITE MINERALS BY BASE EXCHANGE

ESTHER W. CLAFFY AND JAMES H. SCHULMAN
Naval Research Laboratory, Washington, D. C.

Natural zeolite minerals do not luminesce, but luminescence may be artificially induced by substituting an activator such as Mn^{++}, Pb^{++}, Ag^{+}, or Cu^{++} for part of the minerals' cations (usually Na^{+} and/or Ca^{++}) through base exchange. The powdered mineral is merely soaked in dilute aqueous solution of the activator metal (such as 1×10^{-3} M Cu^{++} solution) at room temperature for as little as 15 minutes. Only $2\times10^{-4}\%$ (wt.) Cu in stilbite produces luminescence. Luminescence activation is a more sensitive test for base exchange than optical or *x*-ray diffraction properties, which are altered only after extensive base exchange.

Base-exchanged Cu-zeolites and Ag-zeolites show green and blue cathodeluminescence (under spark coil discharge or cathode ray excitation), respectively after heating at 300° C. (dehydrating, to an undetermined extent), some Cu- and Ag-zeolites also develop photoluminescence under ultraviolet excitation (2537A, 3650A). Mn-, Pb-, and (Mn+Pb)-zeolites, which in their normal hydrated state are unresponsive to any excitation source, also develop cathodeluminescence and/or photoluminescence after being dehydrated. When these dehydrated, base-exchanged zeolites are rehydrated, they lose their luminescence.

Luminescence of the zeolites is not a surface adsorption phenomenon, but is related to the entry of the activator ion into the crystal lattice. Removal of the activator ion from the crystal lattice by a reversed base exchange process eliminates the luminescence. Development of luminescence in base-exchanged zeolites is also a reversible process dependent on the state of hydration or dehydration. The openness of the zeolite crystal lattice and its structural water are significant. All three structure-types of zeolites have been investigated: the fibrous (natrolite), lamellar (stilbite, heulandite), and rugged tri-dimensional (chabazite).

ISOMORPHISM OF SYNTHETIC FLUORINE-AMPHIBOLES

J. E. COMEFORO, R. A. HATCH, AND WILHELM EITEL
U. S. Bureau of Mines, Electrotechnical Laboratory, Norris, Tennessee

In the course of research on the synthesis of asbestos, experimentation was conducted on the crystallization of amphiboles from melts containing fluorine. Major emphasis was given to the study of fluor-tremolite ($Ca_2Mg_5Si_8O_{22}F_2$) and fluo-richterite ($Na_2CaMg_5Si_8O_{22}F_2$). *X*-ray, chemical, and microscopic analyses indicated a number of isomorphous replacements in the structure by elements that are not observed in natural amphiboles.

The general formula for the complex amphibole group is represented by $(WX)_{2-3}Y_5(Z_4O_{11})_2$. The positions of the W ions in (WO_{12}) coordination were filled completely by Na^{+}, Li^{+}, and Ca^{++}. Attempts to substitute K^{+} resulted in the crystallization of mica to the exclusion of amphibole. The positions of X ions in (XO_8) coordination were filled completely by Ca^{++}, Cd^{++}, and partly by Sr^{++}, Ba^{++}, and Na^{+}. Magnesium ions could not be substituted in 8-fold coordination. The Y, or (YO_6) positions were satisfied completely by Mg^{++} and partly by Fe^{++}, Zn^{++}, Co^{++}, Ni^{++}, Li^{+}, and Al^{+++}. In the tetrahedral group (ZO_4)B^{+++} is capable of occupying at least 25 per cent of the 4-fold positions, Be^{++} 12 per cent, and Cr, V, and Al^{+++} undetermined amounts. It was not possible to replace Si^{+4} by Ge^{+4}. This substitution results in the crystallization of Ge-diopside. Attempts to replace F^- by Cl^- in the fluoramphibole structure by crystallization from melts were unsuccessful.

It was concluded that the extent of isomorphism of fluoramphiboles is more restricted than in fluor-micas.

The field of stability of fluor-amphiboles is small; consequently, the compositional changes brought about by attempted isomorphous substitutions frequently results in the crystallization of olivine, pyroxene, feldspar, and mica. This conforms with natural magmatic differentiation of phases by crystallization.

VARIATIONS IN CHEMICAL COMPOSITION ACROSS IGNEOUS CONTACTS

WILLIAM H. DENNEN
Massachusetts Institute of Technology, Cambridge, Massachusetts

The contact effects resulting from the intrusion of igneous material into various wall rocks are linear compositional changes only in special instances. Large variations in chemical composition from point to point may be present in both intrusive and wall rocks.

A study of these variations by the analysis of closely spaced samples with quantitative spectrographic methods indicates that all of the major rock constituents studied (Si, Al, Fe, Mg, Mn, Ca, Na, and K) are mobile when moderate temperatures and concentration gradients are present. Migration of material is believed to take place late in the cooling history by diffusion along mineral boundaries. The compositional variations resulting from this transfusive migration of hydrated ions are often sufficiently large to mask any compositional changes due to earlier reactions.

The chemical variations found can be related to the original compositions of the wall rock and intrusive material, and to the cooling history of the system. No variations in chemical composition are found across contacts between chemically identical rocks. Generally smooth and continuous variations occur across contacts between rocks of different original composition which have been held at high temperatures. Highly irregular variations are found when the intrusion and wall rock were compositionally different and steep thermal gradients existed. These latter variations may show geochemical culminations and depressions, are wave-like in form, and die out in both directions from the contact zone.

STRATIGRAPHY AND METAMORPHIC RECONSTITUTION OF PARTS OF THE GRENVILLE SERIES IN THE NORTHWEST ADIRONDACKS: A REPORT OF PROGRESS

A. E. J. ENGEL AND CELESTE ENGEL
California Institute of Technology, Pasadena, California

Although most of the metasedimentary rocks of the Grenville series in the northwest Adirondacks have been profoundly reconstituted, stratigraphic relicts exist which enable a coherent, predictable succession to be reconstructed. The pre-metamorphic metasedimentary sequence in the Balmat-Edwards region was perhaps 9,300 feet thick; 15 relict units are identifiable at points along the lithologic trend for 10 or more miles and many smaller subdivisions are recognizable locally. Stable-shelf facies consisting of thin quartzose beds in thicker dolomite zones and a siliceous, sodic shale (tuff?) predominate.

Reconstitution of some dolomite units involved large-scale dedolomitization. The magnesium was widely redistributed and was fixed in assemblages of quartz-diopside-serpentine, tremolite-anthophyllite-serpentine-talc, and granitized hornblende-andesine amphibolites. Variations of the above assemblages may include scapolite, phlogopite, chlorite, calcite, feldspar, hexagonite-tourmaline, anhydrite, hydrogen-sulfide, and graphite. Important constituents added to and irregularly distributed through the marble include alkalies, manganese, fluorine, chlorine, titanium, phosphorus, silicon, water, and locally zinc, lead, and iron sulfides. Calcium and carbon dioxide, especially, were removed.

The thick shale (tuff?) unit was commonly altered to a quartz-biotite-sodic andesine-almandite-microcline migmatite that locally contains sillimanite-bearing facies. Other, granitized portions were progressively enriched in alkalies and depleted in iron, magnesium, and calcium; these granitic rocks include gneissoid-augen, equigranular-alaskitic, granulitic, and quartz-syenitic types.

Many bodies of the reconstituted rocks tend to follow the original bedding, but other bodies are irregular and blur or obliterate the bedding.

Although of regional scope, the reconstitution was an intricate composite of "contact" and "regional" metamorphism.

CHALCANTHITE BY THE *X*-RAY PRECESSION TECHNIQUE

D. JEROME FISHER
University of Chicago, Chicago, Illinois

This paper outlines the *x*-ray precession technique as applied to determining the geometry of the lattice of a triclinic crystal. While the orientation of a triclinic subhedron is less simple for the precession technique than for the Weissenberg, once it is secured the angular constants are much more easily obtained and are far more accurate. The necessary three angular and three linear constants are given from photographs made from a single setting; the results are compared with previous goniometric and *x*-ray studies. The 1-level precession photograph is similar to the Goldschmidt gnomonogram except for scale; this will be illustrated by 0- and 1-level pictures taken on a single film.

SEDIMENTARY AMPHIBOLITES IN THE VAN HORN MOUNTAINS, TEXAS

PETER T. FLAWN
University of Texas, Austin, Texas

Amphibolite, biotite amphibolite, epidote-biotite amphibolite, biotite-anthophyllite amphibolite, anthophyllite amphibolite, almandine amphibolite, epidote amphibolite, and epidosite are found in the Mica Mine area of the Van Horn Mountains, Texas. The amphibolites occur with biotite schists in thin beds and lenses in a thick pre-Cambrian feldspathic quartzite-muscovite schist sequence. Distribution, varied composition, layered character, associated rocks, and transition rocks demonstrate a sedimentary origin. These rocks were originally ferruginous dolomitic marls and ferruginous shales in a sandstone and shale sequence.

Analyses of representative rocks are plotted on ACF diagrams. With low Na_2O, high Fe_2O_3, and excess CaO, epidote takes the place of anorthite. Almandine forms in rocks with excess Al_2O_3 if MgO and FeO act as separate components. With a deficiency of Al_2O_3, ferro-anthophyllite forms instead of almandine. With available K_2O and Al_2O_3, MgO and FeO may act as two components to form biotite and almandine or as one component to form biotite and (when K_2O and Al_2O_3 are exhausted) ferro-anthophyllite.

On Vogt's ACF diagram the rocks fall in the "sedimentary series," corroborating field evidence of sedimentary origin.

SURFACE FEATURES OF CHERT AS STUDIED BY THE ELECTRON MICROSCOPE

ROBERT L. FOLK AND CHARLES EDWARD WEAVER
Pennsylvania State College, State College, Pennsylvania

Electron microscope study of fracture surfaces of chert, using the replica technique, has shown that at least two and possibly three types of surfaces are present. Specimens which under the light microscope consist of microcrystalline quartz (minute, equant grains), show sharply defined polyhedral blocks with smooth, slightly curved faces—exactly like the shapes occupied by the air cells in soap froth. Arkansas novaculite, a very homogeneous type of chert, possesses this type of surface to a marked degree. Specimens which under the light microscope are composed of chalcedonic quartz (radiating fibers), have a more or less spongy surface, with no evidence of fibrous character when examined with the electron microscope. The sponginess is caused by the presence of abundant spherical water-filled bubbles, all very nearly 0.1 micron in diameter. These bubbles impart a brownish color to the chalcedonic quartz as seen in the light microscope, and decrease the density and refractive index (due to the Christiansen effect), in proportion to their abundance. Chalcedonic quartz without bubbles has the same refractive index as normal quartz. The properties of chert and chalcedony are adequately explained by the hypothesis that it consists of fine-grained quartz plus a variable quantity of free water in the form of distinct bubbles; there is no evidence of admixed opal.

THE IMPORTANCE OF EXCHANGEABLE MAGNESIUM IN THE STUDY OF MONTMORILLONITIC CLAYS*

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

In calculating the formulas of members of the montmorillonite group all the magnesium is generally assigned to the Al layer. However, determination of exchangeable cations in 16 montmorillonitic clays, 12 of them the identical specimens for which analyses were quoted by Ross and Hendricks (U.S.G.S. Prof. Paper 205-B), showed that in all of them some of the magnesium was exchangeable, the amount ranging from 0.11 to 1.62 per cent. In two samples exchangeable magnesium amounted to about $\frac{1}{3}$ of the total magnesium. These results indicate that the presence of exchangeable magnesium in the montmorillonitic clays is more common than is generally recognized.

Ross and Hendricks, assigning all magnesium to the Al layer in calculating the formula of montmorillonites, found that the number of ions in octahedral coordination ranged from 2.02 to 2.24. However, a recalculation of the formulae of some of these samples on which exchangeable cations were determined showed that, when total magnesium is corrected for exchangeable magnesium and only nonexchangeable magnesium is assigned to the Al layer and when the determined rather than an average base exchange capacity is used, the number of cations in octahedral coordination does not exceed 2.02, even in those samples in which the number of cations is as much as 2.13 when all the magnesium is assigned to the Al layer. Apparently, in montmorillonite then, substitution of Mg for Al in the Al layer is ion for ion, with no extra ions added in an effort toward internal compensation of charge.

HIGH-TEMPERATURE *X*-RAY STUDY OF THE POLYMORPHISM OF $MgSiO_3$

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An investigation of the polymorphic inversions of magnesium metasilicate ($MgSiO_3$) has been made with the aid of a high-temperature *x*-ray spectrometer furnace. This study

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which involved the use of both natural and synthetic material, has yielded results which differ considerably from those of previous investigators. On the basis of these results, a new scheme of relations between the three crystalline forms of $MgSiO_3$—enstatite, protoenstatite, and clinoenstatite—is proposed.

SYNTHESIS OF STAR SAPPHIRES AND RUBIES

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The properties of synthetic star sapphires and rubies manufactured by the Linde Air Products Company are described. The asterism is produced by the exsolution in oriented position of rutile needles from an initially homogeneous solid solution of titanium in corundum single-crystals grown by the Verneuil process. The initial solid solution contains about 0.06 to 0.2 atomic per cent of Ti^3 in substitution for Al, together with about 1.4 per cent Cr^3 and about 0.3 per cent Fe^3 as pigmenting material in ruby and sapphire, respectively. The clear, homogeneous boules are annealed at about 1900° C. to remove strain and are then heated for 2 to 72 hours in an oxidizing atmosphere between 1500° and 1100° to induce precipitation of TiO_2. The length of the precipitation treatment increases with decreasing temperature. Precipitation does not occur over about 1500°, and exsolved rutile can be dissolved by heating to somewhat over 1500°. The crystal chemistry of the precipitation is discussed, and criteria for the recognition of synthetic asteriated corundum are indicated.

THE CRYSTAL STRUCTURE OF CLAUDETITE (MONOCLINIC As_2O_3)

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The unit cell of claudetite has been determined by M. J. Buerger to be $a=5.25$ Å; $b=12.87$ Å; $c=4.54$ Å; $\beta=93°49'$ and the space group determined to be $P2_1/n$. The cell contains $4As_2O_3$. Due to the darkening of the general radiation streak on the c-axis zero level Weissenberg in the vicinity of the (030) reflection, doubt was cast on the existence of the two-fold screw axis (2_1). The presence of the 2_1 was confirmed by the comparison of the Harker-Patterson syntheses (Pxoz) and $P(x\frac{1}{2}z)$. From these syntheses and from Patterson projections on (001) and (100) the eight arsenic atoms were found to lie in two general four-fold positions. One set at $x=.27$, $y=.10$, $z=.03$ and its symmetry equivalents and the other set at $x=.35$, $y=.35$, $z=0.00$ and its symmetry equivalents. Electron density projections were constructed from those reflections whose phases were unequivocally determined by the location of the arsenic atoms. From these projections the locations of the oxygen atoms could be roughly determined. These are being refined by further electron density projections and intensity checks.

FORMATION TEMPERATURES OF SOUTHERN ILLINOIS BEDDED FLUORITE AS DETERMINED FROM FLUID INCLUSIONS

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Fluid inclusions in fluorite crystals were studied principally to determine the range of temperature of formation of individual crystals. Measurements were made by heating

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specimens and recording temperatures at which vapor bubbles within the inclusions disappeared. Overall accuracy, excluding pressure corrections, was of the order of 2.5° C.

Some of the fluid inclusions are arranged in geometrically regular planes parallel to cube faces. These are apparently of primary origin. Others form bands along former fractures which approximately parallel the cleavage directions and which cut across each other and the primary planes alike. Historically such inclusions have been called "secondary" although "subsequent" is considered a more meaningful designation. Most of the primary inclusions are smoothly rounded and contain petroleum, whereas "subsequent" inclusions range from jagged to smooth in outline and contain principally a clear fluid.

From measurements on primary inclusions, temperatures at which the crystals grew generally ranged from 85° to 120° C., with a mean around 100° C. Commonly the indicated growth temperature increased slightly for some distance outward from the crystal center and then dropped off toward the exterior. Measurements on "subsequent" inclusions gave results as high as 185° C., generally higher than those shown by primary inclusions.

Incomplete bulk analyses of the fluid from inclusions, probably mostly of the "subsequent" variety, show a preponderance of Ca, Na, and Cl ions, and a total concentration of dissolved material amounting to 45,000 parts per million.

SYNTHESIS OF FLUORINE-MICAS AND RELATED LAYER STRUCTURE COMPOUNDS

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The synthesis of F-micas and related layer structure compounds has progressed far enough to furnish much information on the stability field of these important rock-forming minerals. However, much remains to be done.

Techniques of synthesis used in these investigations involve (1) fusion and crystallization, or (2) solid state reaction. Many compounds such as F-muscovite can be formed only by the latter method. Special techniques often are needed to produce the desired reaction, especially at temperatures below 700° C. Examples of special techniques include the preparation and use of highly reactive batch materials, and the use of special atmospheres. Additionally, the proper choice of batch materials often is vital in obtaining the desired reaction product because in many cases, if not most, equilibrium conditions are not attained during the experiment.

Compounds synthesized include more than 100 different varieties of F-micas. Most of those related to the F-phlogopite subfamily can be crystallized from a melt; however, a few may be formed only by solid state reaction. A few of the F-phlogopites melt congruently but most of them dissociate below the melting temperature. All members of the F-muscovite and related lithium micas melt incongruently and can be formed only by solid state reaction. The synthesis of F-talc and F-pyrophyllite has not yet been achieved although an interesting F-pyrophyllite has been made. A compound which seems to be closely related to the natural clay mineral, hectorite, has been prepared from dry melts.

ORIGIN OF GRANOPHYRE IN DIABASE IN SOUTHEASTERN PENNSYLVANIA*

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

Small bodies of granophyre occur in the upper part of Triassic diabase intrusions in southeastern Pennsylvania. Near Harrisburg granophyre in the upper part of a diabase

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sheet was penetrated in a diamond drill hole. Drill core specimens show a gradational sequence from diabase to granophyre.

New data include 10 new chemical analyses and the results of petrographic study of a series of specimens from the drill core. The sequence, from diabase to granophyre, shows progressive increase in alkalies and silica; iron increases into transitional granophyric diabase, then decreases in the granophyre. The chemical variations are accompanied by changes in mineralogy.

It is concluded that crystal differentiation in a large sheetlike intrusion most satisfactorily explains the genesis of granophyre in this region. Prior to complete solidification, a residual liquid rich in iron, alkalies, silica, and volatiles accumulated locally in the upper part of the diabase sheet. In some places volatile-rich iron-bearing solutions that carried magnetite escaped into the overlying sedimentary rocks; the remaining liquid crystallized to fine-grained granophyre.

A MONOCHROMETER UTILIZING THE ROTARY POWER OF QUARTZ

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The Emmons method of double variation for the determination of refractive index would be used more extensively if a more adequate light source were available. It is believed that this instrument meets the need.

The instrument utilizes the dispersion produced by the rotary power of quartz to obtain essentially monochromatic light. Four basal sections of quartz are used. Number 1 is of left-hand quartz 60 millimeters thick. Numbers 2, 3, and 4 are of right-hand quartz 30, 15, and 7.5 millimeters thick respectively. The sections are arranged so that a columnated and polarized light beam will pass through section 1 into section 2, 2 into 3, and 3 into 4. The light on emerging from section 1 passes through a polaroid plate, which eliminates nine bands equally spaced through the visible spectrum but permits nine others to pass into section 2. As the light emerges successively from each of the sections, it passes through polaroid discs which eliminate half of the number of bands that entered. When it has passed through section 4 and its polaroid, all but one band with an average width of 150 Å has been effectively eliminated.

By rotating simultaneously all four of the quartz sections with their attached polaroids, it is possible to change continuously the position of the single pass band so that it will move completely through the visible spectrum.

Because of the large aperture of the instrument, adequate light of all wave lengths can be obtained by using a tungsten filament lamp as a light source.

GROWTH OF CRYSTALS OF MICA AND RELATED FLUOSILICATES

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It is well known that fluorine may be substituted, in whole or in part, for hydroxyl in many crystalline silicates and chemically related compounds without essential structural changes. The structural and compositional limitations to such substitutions are considered with particular respect to bonding and to geometrical configuration. Possibilities of synthesis of such fluorine substituted minerals as mica amphibole, chrysotile, topaz, apatite, and clay minerals are reviewed. Some principles are stated regarding the control of orientation in synthesis of platy and fibrous fluorine minerals by temperature gradients and other methods.

GEOLOGICAL SIGNIFICANCE OF VARIATIONS IN THE HIGH-LOW INVERSION OF QUARTZ

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Investigation of variations of the high-low inversion of quartz, has been refined and extended to include almost 300 samples of synthetic and natural quartz from various sources.

The inversion temperature of samples of quartz grown in the laboratory under controlled conditions of pressure and chemical environment is in general an inverse function of the temperature of growth. That simple relationship is complicated however, by the presence of an element such as germanium, which can substitute for silicon in the comparatively "tight" quartz structure, with profound effect on the inversion.

On the basis of temperature of inversion, natural quartz samples fall into fairly well-defined groups which are clearly related to the conditions of origin. Quartz from rhyolites and related intrusive porphyries and welded tuffs, inverts at temperatures clustered around 572.7.° Quartz from granites, with a few exceptions among those studied, inverts at higher temperatures clustered around 573.2°. "Granite" quartz and "rhyolite" quartz are completely separated on a plot of heating inversion versus cooling inversion. Most samples of vein quartz give high inversions, while samples of quartz from pegmatites show wide variations, even within one pegmatite mass. Details are presented regarding the inversion of quartz from zoned pegmatites and zoned crystals. Some suggestions are made as to the possible significance of the inversion characteristics of quartz from different types of granite.

ORIGIN OF HORNBLENDE RIMS ON ADIRONDACK GARNET

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Rims (shells) of coarse hornblende surround large garnet crystals in coarse metagabbro at the Barton garnet deposit and other occurrences of this type in the southeastern Adirondacks. It is concluded that the hornblende rims formed contemporaneously with the growth of the large garnets by a process of metamorphic redistribution of hornblende already present in the rock matrix. Each large garnet, as it grew by recrystallization from originally fine-grained, disseminated garnet, displaced matrix plagioclase and hornblende. Of these the plagioclase displayed considerable mobility and was redistributed in the matrix, but the displaced hornblende was less mobile and accumulated as a rim around the large garnet. This conclusion is based upon the nearly constant volumetric ratio of rim to garnet, the essential identity of rim and matrix hornblende, the volumetric equivalence of rim hornblende to calculated displaced hornblende, and the evidence of plagioclase mobility. Conversely, consideration of chemical composition and textural features argue against rim formation either by reaction or by retrograde destruction of the garnet.

PETROGRAPHY AS AN AID IN DATING TERTIARY VOLCANIC ROCKS*

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In connection with stratigraphic studies and mapping of Tertiary rocks in Wyoming during the last 15 years, about 500 rock samples have been collected, either personally or with the cooperation of various colleagues, both from fossil-bearing beds and from beds whose age and stratigraphic relations could be determined by other means. Thin sections were cut from all specimens and heavy mineral separations were made from some.

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From a study of these specimens it is believed that there is a general correlation between ages and types of volcanic rocks throughout all parts of Wyoming where adequate data have been obtained. Although many exceptions can be found for each generalization, the pattern of rock types, when used with caution and with a sufficient number of representative samples, is useful in dating unfossiliferous pyroclastic rocks, and determining the structural history of various areas. It is not known whether this pattern holds true in adjacent regions, but perhaps by calling it to the attention of others, they may broaden or delimit the following "petrographic calendar":

1. Lower Eocene rocks: contain little volcanic material, but where present, it is commonly hornblende andesite with plagioclase, hornblende, and biotite, deeply weathered.
2. Middle Eocene rocks: contain hornblende andesitic and rhyolitic material, fresher and more abundant than in lower Eocene.
3. Upper Eocene rocks: contain pyroxene andesitic material, characteristically green or olive drab.
4. Oligocene rocks: contain hornblende andesitic material, with plagioclase, hornblende, and biotite fresher and with characteristics different from those in middle Eocene; rocks commonly white.
5. Miocene rocks: contain pyroxene andesitic material, less weathered and distinct from upper Eocene; rocks characteristically have variety of bright-colored grains.
6. Pliocene rocks; contain rhyolitic material; data less adequate than for older Tertiary rocks.

BYSTROMITE, MAGNESIUM ANTIMONATE, A NEW MINERAL

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Antimony ores from Antimonio, Sonora, Mexico contain a new mineral corresponding in chemical composition and structure with magnesium antimonate, $MgSb_2O_6$, although in the mineral some of the oxygen is replaced by hydroxyl groups and the lattice is deficient in antimony. The mineral is massive, color light blue-gray, streak white, density 5.4 ± 0.1; the only associated mineral is quartz. Tetragonal, (ditetragonal dipyramidal), $a = 4.68$Å, $c = 9.21$Å, $c/a = 1.968$, space group P4/mnm; the structure is of the trirutile type, and the mineral is isomorphous with tapiolite ($FeTa_2O_6$) and with many artificial antimonates and tantalates. The name bystromite is proposed for the mineral after Anders Bystrom, Swedish crystal chemist, who worked out the structure of synthetic magnesium antimonate in 1941.

FURTHER ACCOUNT OF THE NATURALLY OCCURRING ANTIMONY OXIDES

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A survey of the literature shows that the alteration products of the ores of antimony are in general classified under one of the following names:

Cervantite—Sb_2O_4 or $Sb_2O_3 \cdot Sb_2O_5$—1854.
Stibiconite—$H_2Sb_2O_5$ or $Sb_2O_4 \cdot H_2O$—1832.
Hydroromeite—$(Sb^{+++}, Ca^{++})_2O(O_2,(OH)_2) \cdot 2Sb_2O_3$—1932.

The study of over fifty specimens from widely scattered localities indicates that not all of these names are valid. *X*-ray data show the existence of only one phase, which is sometimes admixed with valentinite, Sb_2O_3. By spectrographic analysis, this phase has a range in CaO up to 22%. The phase is isometric, the dimension of the unit cell being 10.27 Å. The index of refraction ranges from 1.66 to 1.9+, the density ranges from 3.2 to 5.4 and the H_2O content varies from 2% to 13%. When the CaO content is low, admixed valentinite is present, suggesting that calcium is an essential constituent of the phase.

The present work on the homogeneous phase indicates a formula corresponding to $(Ca, Sb^{III})O-2(Sb^{V}2-X)\ O, OH, H_2O)_{6-7}$ where X varies from 0.–0.5.

THE CRYSTAL CHEMISTRY OF MONTMORILLONITE. II—CALCULATION OF THE STRUCTURAL FORMULA

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As a sequel to an earlier paper describing a new hypothetical structure for montmorillonite, a scheme for calculating the contents of the elementary cell is presented. The method of calculation assumes an integral number of large anions, $(O+OH)=24$, and relegates the analytically determined cations (including hydrogen) to the basis of 48 charges in order to obtain the unit-cell contents. The assumptions involved in this method of calculation are discussed. The calculations are applied to a new analysis of highly purified montmorillonite for which water determinations are available between 305° and 760° C. and above 760° C. The results are consistent with the hypothesis postulating the occurrence of hydroxyl ions in the tetrahedral layer of this clay mineral.

IMMERSION LIQUIDS OF HIGH REFRACTIVE INDEX

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A study of inorganic, organic, and metal-organic compounds that might be employed in the preparation of high refractive index liquids has been undertaken.

Mixtures of arsenic tribromide and precipitated sulfur yielded a series of clear yellow liquids (mixture A), stable at room temperature. An index of 1.829 was obtained. After a period of 12 weeks, the maximum change in index was 0.003. The mixing curve of mixture A with methylene iodide ($n=1.74$ to 1.81) deviated considerably from a straight line.

At room temperature, mixture A and arsenic disulfide formed a series of clear green-yellow to green-amber liquids (B) whose indices range from 1.876 to 1.952. The maximum change in index after a period of 12 weeks was 0.004 for those liquids below 1.92 and 0.007 for those above 1.92. When the temperature was raised during preparation, liquid B was obtained with $n=2.006$. The mixing curve of A and B is a straight line ($n=1.81$ to 2.01).

Red mercuric sulfide added to mixture B gave a clear yellow and very viscous liquid whose index was 2.035

Black selenium added to mixture B gave a clear, light-red semiviscous liquid whose index was 2.017.

Arsenic tribromide, arsenic disulfide, and black selenium formed a very dark red, viscous liquid whose index was 2.008.

All of the liquids described give an acid reaction and decompose some minerals.

GEOLOGY OF THE BRANFORD-KILLINGWORTH AREA, CONNECTICUT†

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In the southwestern corner of Connecticut's Eastern Highland section the dominant structural and petrologic features are two stock-like massifs of granite and quartz monzonite and an older and larger pluton of biotite tonalite. The tonalite pluton contains

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gradational concentric changes in fabric from hypidiomorphic-granular to allotriomorphic-gneissic and compositional changes of the plagioclase and hornblende content. The three bodies contain flowage features which describe domal structures. These structures parallel the peripheral contacts, although a zone of mixed rocks is present in the outer part of each instrusive.

The pre-Triassic Middletown and Bolton formations, into which the plutons intruded, are principally matasedimentary rocks. The former is marked by the presence of hornblende and comprises various gneisses formed from interlayered basaltic tuff and pelitic-psammitic sediments. The Bolton formation lies stratigraphically above the Middletown gneiss and consists of schists and quartzites. Contact between the two formations is conformable. Foliation and layering in both are parallel. Both formations contain much pegmatite in bodies ranging from tiny stringers to hundred-foot lenses.

The northwest corner of the area investigated is underlain by sediments and two lava flows of the Triassic Newark group. The eastern border fault, which separates this group from the crystalline rocks, is exposed at one place where a westward dip of approximately 55 degrees was measured. Oblique faults within the Triassic Lowland area and dip abnormalities, including "reverse drag" and half-basin folds in the Newark beds, are discussed.

THE SOLUBILITY OF QUARTZ AND SOME OTHER SUBSTANCES IN SUPERHEATED STEAM AT HIGH PRESSURES

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This paper is a summary of several studies in each of which the solubility of a solid in superheated steam was determined. The results are at 400° and 500° C., and at pressures ranging from 1000 to 30,000 psi. One series of gases are those in equilibrium with liquids at the saturation surfaces in the system H_2O-Na_2O-SiO_2. Other results are in two-phase systems gas plus solid, in which the solids include quartz, NaCl, Li_2SO_4, Na_2SO_4, K_2SO_4, $CaSO_4$, Fe_2O_3 and some sulfides.

SYNTHETIC SODIUM-, AMMONIUM-, AND HYDROGEN-URANOSPINITE

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Compounds isostructural with meta-torbernite-I and having the formula $A_2(UO_2)_2(AsO_4)_2 \cdot 8H_2O$ where A = Na or NH_4, have been synthesized by base exchange with hydrogen-uranospinite, $H_2(UO_2)_2(AsO_4)_2 \cdot 8H_2O$. Hydrogen-uranospinite is ditetragonal-dipyramidal; crystals are flat tablets on {001} with {010} and {110}. *X*-ray study by the Weissenberg method gave the space group P4/nmm and cell dimensions a_0 7.16 Å, c_0 8.80 ($a_0:c_0 = 1:1.230$). Specific gravity 3.55 (meas.), 3.55 (calc.). Color lemon-yellow. Perfect cleavage {001}. Optically uniaxial negative with nO = 1.612 (pale lemon-yellow), nE = 1.584 (nearly colorless). Sodium-uranospinite has cell dimensions $a_0 = 7.12$ Å, $c_0 = 8.70$ ($a_0:c_0 = 1:1.222$), obtained by powder method. Specific gravity 3.71 (calc.). Optically uniaxial negative with nO = 1.617 (pale yellow), nE = 1.586 (colorless). Ammonium-uranospinite has cell dimensions $a_0 = 7.21$ Å, $c_0 = 8.85$ ($a_0:c_0 = 1:1.227$), by powder method. Specific gravity 3.60 (calc.). Optically uniaxial negative with nO = 1.611 (pale yellow), nE = 1.601 (colorless). All fluoresce bright lemon-yellow in long-wave ultraviolet radiation and less brightly in short-wave ultraviolet radiation. The relation of these substances to natural troegerite and uranospinite is discussed.

HYDRATION AND BASE EXCHANGE PROPERTIES OF CARNOTITE, TYUYAMUNITE AND RELATED COMPOUNDS*

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Hydrated uranyl vanadates of potassium, ammonium, thallium, calcium, strontium, barium, sodium, copper, and zinc were synthesized as part of a mineralogic study of carnotite and tyuyamunite. Microscopic and electron-microscopic examination show the crystals to be diamond-shaped plates with micaceous cleavage.

On the basis of *x*-ray powder patterns, these compounds may be classified into two structural types:

Type I. Compounds of K, NH_4, and Tl.

Type II. Compounds of Ca, Sr, Ba, Na, Cu, and Zn.

The two types of compounds also differ greatly in the degree of hydration. Type I compounds contain about 1 molecule of water in the air-dried state; type II compounds, 5 to 9 molecules. The higher hydration of type II compounds may be correlated with the presence of low-angle, basal reflections in their *x*-ray powder patterns.

The water molecules and the characteristic cations (K, NH_4, Ca, etc.) occur between uranyl vanadate layers, a condition analogous to that found in the clay mineral montmorillonite. There is a progressive decrease in the interlayer spacing of type II compounds as water is removed by heating.

Type II compounds, when treated with solution of potassium salts, rapidly exchange their cations for potassium and are converted to carnotite. This entails a contraction of the interlayer spacing as the lower hydration characteristic of type I is assumed. The reverse process, the conversion of carnotite to compounds of type II, involves the expansion of interlayer spacing, and takes place much less readily.

A SECOND SOUTH AMERICAN OCCURRENCE OF BRAZILIANITE

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In the pegmatite of the *alto* Patrimonio, at Piedras Lavradas, Paraíba, Brazil, massive amblygonite was found to be cut by veins and patches of brazilianite accompanied by wardite, apatite, and other phosphates. The brazilianite occurs in small (1–2 mm.) grains and crystals, some fairly well developed. Measurable crystals show the following forms: {110}, {010}, {320}, {130}, {670}?, {101}, {301}, {021}? {111}, {321}, {121}. The mineral was identified by indices, crystal form, and *x*-ray pattern. The associated wardite is somewhat coarser grained, shows a good cleavage, and is sometimes in crude crystals. In the veins, wardite is earliest, followed by brazilianite (usually idiomorphic) and purplish apatite. In the patches, a very finely fibrous greenish mineral, resembling hydroxy-apatite; wardite, brazilianite and apatite follow in that order, with some overlapping, and all are covered by a very fine grained compact white mineral which may be meta-variscite.

X-RAY EXAMINATION OF URANOTHORITE

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Earlier *x*-ray studies of thorite have indicated that it is metamict (Vegard, *Phil. Mag.*, **32**: 65, 1916) or have led to cell dimensions (Boldyrev et al., Leningrad, *Inst. Mines, Ann.*, **11**: 1, 1938) that seem very much out of line with those of related materials.

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Single crystal *x*-ray diffraction patterns have been obtained from unaltered uranothorite from Gillespie's Beach, South Westland, New Zealand. Rotation patterns on the *a* and *c* axes are very similar to zircon patterns but show a certain amount of streaking of the spots along "powder arcs." A cell of dimensions $a_0=7.12$ Å, $c_0=6.32$ Å contains $4ThSiO_4$. Th is substituted by U in the ratio of about 1/7. Observed and calculated densities agree at 6.7 ± 0.05. The space group is $D_{4h}^{19}-I4/amd$. The similarity of the rotation patterns to those of zircon leaves no doubt that the structure of this uranothorite is of the H3 (zircon) type.

ANION EXCHANGE IN CLAY MINERALS

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The amount and nature of the anion exchange in various clay minerals were determined using electrodialyzed materials. The effect of the chloride, sulphate, and phosphate ions was determined and compared with the base exchange capacity of these clay minerals. A tentative explanation regarding the ion exchange phenomena was developed as a result of this study. It is suggested that in kaolinite and illite the ion exchange, both anionic and cationic, takes place on "active spots" primarily due to broken valence bonds. In the case of montmorillonite, where cation exchange may result also from excess negative lattice charge, it is suggested that a similar exchange may take place with anions due to excess positive charge. As a consequence of this, clays probably are not amphoteric in the usual chemical sense.

As further evidence, additional data were obtained on the effect of particle size on the cation and anion exchange capacity of these clay minerals. The anion exchange capacity in kaolinite was shown to depend on the lateral surface area of the clay mineral. The relationship existing between anion exchange capacity and lateral surface area was also demonstrated for other clay minerals.

FURNACE ATMOSPHERE CONTROL IN DIFFERENTIAL THERMAL ANALYSIS*

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The usefulness of differential thermal analysis can be extended considerably by controlling the composition of the furnace atmosphere. The method described for securing atmosphere control is applicable to most existing differential thermal analysis furnaces. Examples are given which show the effect of a furnace atmosphere of nitrogen on differential thermal curves of clays containing organic matter and pyrite. Other curves show the effect of CO_2 on differential thermal curves of siderite, magnesite, dolomite and calcite. One curve follows the alternate dissociation-reconstitution of the $CaCO_3$ part of dolomite in an atmosphere of CO_2. The effect, on the differential thermal analysis curve, of filling the furnace with a gas which is a participant in the reaction is explained by the relation of the partial pressure to the equilibrium constant and the heat of reaction.

ORIGIN OF A LAYERED ULTRAMYLONITE FROM SOUTHEASTERN CONNECTICUT

CHARLES B. SCLAR
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At the southernmost contact of the Preston gabbro is a zone of imbricate structure which the hydrothermally altered gabbro and four tabular bodies of chlorite-actinolite,

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schist derived from it have been brought into juxtaposition with a block of medium-rank gneiss and its progressively mylonitized equivalents by reverse faulting. The lower five feet of the block of non-layered biotite-cummingtonite-hornblende gneiss was converted to a layered slate-like ultramylonite composed of alternating quartz-plagioclase laminae and biotite-amphibole laminae which range in thickness from a thin film to five millimeters. The ultra mylonite has a well-developed cleavage parallel to the lamination. The temperature which prevailed during mylonitization was apparently high enough to prevent significant diaphthoresis and low enough to prevent recrystallization. The block is at least twenty feet thick and it exhibits all stages of cataclastic reduction and increasing metamorphic differentiation from top to bottom. No transposition of s-planes was involved and the dip of the foliation in all the cataclastic rocks is parallel to the uniformly dipping reverse faults. The ultramylonite was subjected to post-layering microfaulting.

The origin of the layering is discussed in the light of the solution principle of Eskola, the mechanical hypothesis of Schmidt and Wenk, and the complex hypothesis of Sander and Turner. It is concluded that the process of metamorphic differentiation was dominantly mechanical and a consequence of the difference in mechanical behavior of the light and dark minerals under shearing stress. The degree of perfection of the lamination is believed to be a function of the kinematics of the mass during mylonitization.

RELATION OF TYPE OF COUNTRY ROCK TO THE SHAPE OF GRANITIC PEGMATITE INTRUSIONS*

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Examination of more than 1800 pegmatite intrusions in the Quartz Creek district, Gunnison County, Colorado, has shown that the shape of a granite pegmatite intrusion is controlled by: (1) the type and competency of country rock; (2) the composition of the pegmatite magma; and (3) the amount of intruded material. Of these, the first is commonly the most important.

Intrusions of pegmatite in competent rocks, such as granite, monzonite, quartzite, and hornblende gneiss, commonly cut across the older layered structures such as bedding, banding, or foliation, and follow joints or other fractures, forming thin, tabular to sinuous, branching, and irregular bodies.

The pegmatites in incompetent rocks, such as mica schist, are in general concordant with foliation and were intrudded by shouldering apart the country rock along foliation planes. Pegmatites of this type are commonly lenticular, troughlike, arcuate, or tear-drop-shaped; branching and irregular shapes are rare.

The pegmatites in the competent rocks tend to be thinner than those in the incompetent rocks; thickly lenticular pegmatites are practically unknown.

All bodies of pegmatite with the same composition do not have the same shape, although in some districts lithium-bearing pegmatites tend to be bulbous. With the intrusion of large amounts of pegmatitic material, the effect of the country rock on the shape of the pegmatite is usually obscured and the body assumes an irregular stock-like shape. The type of country rock thus appears to have the greatest control over the final shape of the smaller pegmatite bodies.

Similar relations between the shape of pegmatites and the type of country rock have been found in other districts.

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OBSERVATIONS ON TWIN LAWS COMMONLY EXHIBITED BY PLAGIOCLASE OF METAMORPHIC ROCKS

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Observations on the twin laws commonly exhibited by metamorphic (especially by deformed) rocks are placed on record. Attention is drawn to the marked contrast between the complex association of twins typical of plagioclase in igneous rocks, and the much less complex twinning of metamorphic plagioclase, as a possible basis for distinguishing (1) metasomatic from magmatic plagioclase in granitic rocks; (2) relict from metamorphic plagioclase in amphibolites.

GROWTH OF WATER SOLUBLE AND OTHER CRYSTALS AT LOW TEMPERATURES

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Crystals have been synthesized at low temperatures from (1) water solutions, (2) melts with or without temperature gradient conditions, and (3) hydrothermal processes. Extensive investigations have been made in crystal synthesis directly from aqueous solutions. Outstanding success has been attained with Rochelle Salts, ammonium dihydrogen phosphate and ethylene diamine tartrate, by various investigators in the United States and elsewhere. Numerous other inorganic and organic crystals have been grown readily. Although few of these crystals occur in nature, the principles involved in their synthesis are of interest to the mineralogist and geologist because the mechanics of growth may be similar to those of natural water soluble crystals. It is of more than passing interest however, that NaCl crystals of large size are crystallized commercially from melt at high temperatures. Certain organic crystals have been synthesized by crystallization from a low temperature melt using a temperature gradient method similar to that employed successfully for commercial synthesis of NaCl and CaF_2 at higher temperatuers. The Signal Corps Engineering Laboratories at Fort Monmouth, New Jersey, have been engaged actively in synthesis of berlinite ($AlPO_4$) since 1946. More recently this organization has synthesized $AlAsO_4$. Both of these crystalline materials are synthesized hydrothermally at or below 250° C.; both are unusual in that they have retrograde solubility characteristics. Tourmaline has been synthesized on a small scale from natural source materials at low temperatures for the Signal Corps by Baird Associates, Cambridge, Massachusetts. Considerable data have been accumulated showing that quartz crystal can be synthesized at low temperatures (250° C.). Although synthesis of the last two minerals at low temperatures has no practical value at this time, geologic implications are evident.

HUMMERITE AND MONTROSEITE, TWO VANADIUM MINERALS FROM MONTROSE COUNTY, COLORADO*

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Two new minerals, collected in the summer of 1949, are described and compared with previously known vanadium minerals from Colorado.

Hummerite was first identified in bright-orange veins in gray clay at the Hummer mine of the Jo Dandy Group on the southwest side of Paradox Valley, Montrose County, Colorado, and later as a yellow efflorescence on sandstone at the North Star mine on the

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opposite side of Paradox Valley. It is translucent, water soluble, and similar in appearance to pascoite but has the composition hydrous magnesium vanadate. The *x*-ray powder pattern of crystals formed by evaporation of a water solution is the same as that of the original vein mineral. The recrystallized material is triclinic, pinacoidal class, and forms crystals elongated parallel to the *c* axis or tabular parallel to the *b* and *c* axes. It is optically negative, has strong dispersion, and $n\mathrm{Y}=1.81$. The chemical analysis and morphologic and *x*-ray crystal data will be presented.

Montroseite, in black microscopic bladed crystals, was found in the Bitter Creek mine on the northeast side of Paradox Valley, Montrose County, Colorado. It is orthorhombic, probably rhombic-dipyramidal class, opaque, and has the composition $2FeO \cdot V_2O_3 \cdot 7V_2O_4 \cdot 4H_2O$. Morphologic and *x*-ray crystal data are presented together with spectrographic and chemical analyses.

SURFACE STRUCTURE AND CRYSTAL GROWTH

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The concept, that the cube face of a crystal having NaCl structure consists of a checkered pattern emanating positive and negative force fields, represents an idealization which is useless for explaining the surface properties of a large number of crystals. It is not understandable on this basis why sintering of calcined MgO should require the very high temperature it does and why it can be accomplished at a much lower temperature if certain "impurities" are present. An explanation for this and related phenomena is presented on the basis that crystals containing ions of widely different polarizabilities develop surfaces which contain primarily the most polarizable ion in the extreme outer layer, followed by the less polarizable ion which is slightly recessed. This deviation of the surface from the bulk structure can lead to an electrical double layer setting up repulsion forces between the single particles and thus preventing sintering.

The surface structure depends largely on the surrounding medium, a fact which can be demonstrated by the change in the hydrophilic and the catalytical properties of PbF_2 and HgI_2 on removal of the water layer.

These concepts are applied to the crystallization of substances from various solvents as affected by impurities.

PETROLOGY OF THE ALKALINE ROCKS OF THE NEMURO DISTRICT, HOKKAIDO, JAPAN

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In the Nemuro Peninsula, alkaline rocks occur in the Cretaceous formations as sheets, laccoliths, or rarely as submarine flows. Their age is probably upper Cretaceous or lower Tertiary. The rocks vary from picritic trachydolerite, trachydolerite, and trachybasalt, to monzonitic and syenitic rocks. Minerals present, which often show zonal structures, include plagioclase, anorthoclase, orthoclase, analcite, natrolite, thomsonite, augite, aegirine-augite, olivine, biotite, and iron ores. The preponderance of K_2O over Na_2O is remarkable, and the Peacock alkali-lime index is 52.1.

The margins of thick sheets or laccoliths are chilled porphyritic trachybasalt. Dark picritic trachydolerite rich in olivine and augite lies immediately above the lower chilled margin and grades upward into less dark trachydolerite and monzonitic rocks near the upper chilled margin. The materials only whin the chilled margins are occasionally cut by syenitic veins varying in thickness from a few inches to a foot. Thus gravitational differentiation *in situ* is inferred to have occurred in these intrusive bodies.

Various parts of the pillow structure, which is sometimes well developed in the thinner sheets, show noticeable differences in texture as well as in chemical composition. It is argued that crystallization in an extremely water-rich magma rather than under a water cover is responsible for the formation of the pillows.

The original magma of these alkaline rocks was probably shonkinitic in composition, with abundant volatile components, which played an important role in crystallization, especially in the late magmatic and hydrothermal stages.

COMPLETE SUBSTITUTION OF ALUMINUM FOR SILICON: THE SYSTEM $3MnO \cdot Al_2O_3 \cdot 3SiO_2$—$3Y_2O_3 \cdot 5Al_2O_3$

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Thermal, optical, and *x*-ray data indicate that there is a complete series of solid solutions between spessartite, $Mn_3Al_2(SiO_4)_3$ and yttrogarnet, $Y_3Al_2(AlO_4)_3$. The substitution $Y^{+3}Al^{+3} \rightarrow Mn^{+2}Si^{+4}$ may be represented by the formula:

$$(Mn_{3-x}Y_x)Al_2(Si_{3-x}Al_x)O_{12}.$$

Yttrogarnet has a cube edge of 12.01±0.02 A and the space group O_h^{10}. Using the coordinates of grossularite as determined by Menzer, good agreement was obtained between calculated and observed intensities. The atomic positions are:

Al in 16(a)	0	0	0
Y in 24(c)	$\frac{1}{4}$	$\frac{1}{8}$	0
Al in 24(d)	$\frac{1}{4}$	$\frac{3}{8}$	0
O in 96(h)	x	y	z

where x, y, and z are 0.04, 0.055, and 0.64 respectively. The yttrium is in eight-fold coordination; the aluminum is in both four- and six-fold coordination. Yttrogarnet inverts to a high form at approximately 1970±50° C.

This is the first case on record of the complete substitution of aluminum for silicon in an orthosilicate. It contradicts the prevalent idea that the substitution of aluminum for silicon always decreases as the Si/O ratio decreases.

THE MECHANISM OF VEIL FORMATION IN CRYSTALS*

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Numerous observers have reported that there is a maximum practical rate of crystal growth. Crystals grown at faster rates invariably develop flaws—veils. These veils are lines, planes or bodies of liquid and gaseous inclusions commonly oriented with respect to some growing face. One expects, that when a seed is planted in a saturated solution, there will be considerable veiling to make the adjustment of the seed to the equilibrium endform of the crystal. Thereafter when the endform is in equilibrium with the solution, growth at a slow rate should proceed with a high degree of perfection. Experience with laboratory growth of numerous crystals together with pilot plant growth of ADP is drawn upon to elaborate a mechanism of veil formation and of crystal growth from water solution. Examples of natural crystals can be used to support the general picture.

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* The material in this talk will be published under the authorship of P. H. Egli, S. Zerfoss and S. Slawson.

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