

PRESENTATION OF PAPERS
A HISTORY OF THE STUDY OF ORE MINERALS

(Presidential Address)

ELLIS THOMSON

A history of progress made in the study of ore minerals from the start of the last century up to the present day. The developments along the main avenues of approach were passed in review. These include studies of general methods, abrasives and polishing methods, chemical methods, mill-products, quantitative macroscopic and microscopic analysis, technique, and x -ray methods. (Complete address is printed in this issue.)

SILICIFIED WOOD IN DOLOMITE*

JULIAN D. BARKSDALE†

Small logs and broken pieces of jet black silicified wood occur in dolomite beds of Karnic age outcropping in the Sonoma Range, Nevada. In thin sections some of the specimens of wood, tentatively identified as *Araucarioxylon*, show perfect preservation of their cellular structure by the infiltration of siliceous solutions now crystallized as quartz. Single anhedrons of quartz sometimes include several cells filling even the smallest openings in the cell walls. The crystallization of the quartz in other specimens has disrupted the cell walls and produced a coarse pseudo-cellular structure controlled by the crystallographic directions in the growing quartz grains as they attempted to clear themselves of the carbonaceous material. The difference in type of preservation is thought to be due to the difference in condition of the woods at time of silicification. The black color of the wood is due entirely to its carbonaceous content. Chips fired in a ceramic furnace have the appearance of unglazed white tile.

* Presented through the Geological Society of America.

† Introduced by G. E. Goodspeed.

EUROPEAN COLLOFORM ORES OF MISSISSIPPI VALLEY TYPE*

CHARLES H. BEHRE, JR.

Lead-zinc ores of "Mississippi Valley type" in certain districts of western Europe, like those of the Upper Mississippi Valley district in the United States, show distinctive mineralogic features. In calcareous country rock the ore and gangue minerals, as usual and as already noted in the literature, are typically blende (often light-colored), galena, pyrite (and marcasite), barite, fluorite, calcite, dolomite, ankerite, and quartz. Especially characteristic are the colloform masses of wurtzitic blende banded alternately with the other sulphides, galena being largely in the interior of the masses. In districts where the country rock is non-calcareous, these types are not known; the minerals of the gangue change and the colloidal appearance of the ore minerals is conspicuously absent, as especially well shown at Aachen and in the Rhine Valley.

These facts suggest that (1) the calcium ions in the gangue minerals and (2) the colloform structures of most of the ores are due to the influence of the calcareous country rock.

* Presented through the Geological Society of America.

THE MORPHOLOGY OF MECHANICAL TWINNING IN CRYSTALS

JAMES FORBES BELL

Since the discovery of mechanical twinning in calcite by Brewster in 1816, mineralogists and crystallographers have used the morphologic relationship between the faces of a crystal before and after deformation to determine the twinning elements which can be mechanically produced in crystals. These relationships have been used in connection with

the constants of a strain ellipsoid developed by a process of simple shear which was proposed as a geometrical means of describing mechanical twinning by Liebis in 1889. Analytical expressions for the indices of a crystal face in the untwinned crystal in respect to the indices of the same face after reorientation and referred to the axes of the twinned crystal in terms of the constants of a strain ellipsoid were derived by O. Muegge in 1889. These formulae have been used as an indirect solution of the twinning elements by most crystallographers since that time. A new and direct graphic solution of the twinning elements from the relative positions in respect to the original crystal axes of two or more faces before and after deformation was presented.

The differences between the morphology of a mechanically twinned crystal and a growth twin involving the same twinning elements were explained.

A compilation of all of the work which has been done on mechanical twinning and new investigations attempting to correlate the twinning elements and the crystal structure are now being carried on.

A MICRO-BALANCE FOR SPECIFIC GRAVITY DETERMINATION

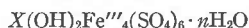
HARRY BERMAN

A micro-balance of the torsion type has been applied, after slight modification, to the measurement of specific gravities of fragments from 3 to 50 milligrams. The attainable accuracy is well within one per cent, and the time required for the necessary measurement is only a few minutes.

COMPOSITION AND OPTICS OF COPIAPITE

L. G. BERRY

From x-ray and density measurements on analyzed copiapite from Chuquicamata, Chile, Peacock has obtained triclinic structural elements and the cell formula:



in which X represents several bases amounting to one oxygen equivalent.

Reduction of many analyses of copiapite to 6 atoms of sulphur, instead of the usually accepted 5, confirms this formula and shows that the component X may be $\frac{3}{2}\text{R}'''(\text{Fe}''', \text{Al})$, $1\text{R}''(\text{Fe}'', \text{Mn}, \text{Cu}, \text{Zn}, \text{Ca}, \text{Mg})$, or $2\text{R}'(\text{Na}, \text{K})$, and the full value of n is 20. For the varieties in which X is mainly Fe''' , Fe'' , or Mg (each represented by several good analyses), the names *ferricopiapite* (natural and artificial), *ferrocopiapite* and *magnesiocopiapite*, respectively, are proposed. For the variety in which X is mainly copper, the name *cuprocopiapite* was recently proposed by Bandy. Ferricopiapite and cuprocopiapite are also optically distinguishable from ferrocopiapite or magnesiocopiapite, which are optically similar.

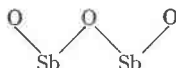
THE MECHANISM OF THE GENESIS OF POLYMORPHOUS FORMS

MORTIMER C. BLOOM

Polymorphous forms are found throughout the mineral kingdom under conditions of apparent thermodynamic instability. The mechanism of the genesis of such forms was the subject of this paper.

In the Sb_2O_3 system, precipitation from pure aqueous solutions gives the stable senarmonite structure. Sufficiently acid solutions generate the unstable valentinite structure which contains some of the acidic constituents in solid solution, thus increasing its thermodynamic stability. Acid concentration is not the sole factor. The anion of the acid has a marked effect.

These results are determined by (a) the nature of the groups in solution, (b) the nature of the available crystal structures. The low temperature structure of Sb_2O_3 consists of discrete Sb_4O_6 molecules, the high temperature structure of chains composed of units of the following type:



Acid antimonious solutions contain antimony predominantly in the form of SbO^+ ions and organization into the valentinite chains is easily effected by elimination of H_2O between two SbO-OH groups. Recent crystal structure work has shown analogous groups in $\alpha\text{-FeOOH}$, $\beta\text{-FeOOH}$, AlOOH , and MnOOH . That such groups are formed in acid antimonious solutions is indicated by the fact that precipitates from such solutions are very hydrous.

The valentinite structure has large channels capable of housing HCl readily, HClO_4 with some distortion. HCl gives rise to the valentinite structure at acid concentrations where HClO_4 gives rise to a mixture predominantly of the senarmontite structure.

Analogous studies will probably indicate analogous mechanisms for the genesis of polymorphs in other systems.

ILMENITE-HEMATITE-MAGNETITE RELATIONS IN SOME EMERY ORES

JOSEPH M. BRAY

The major mode of occurrence of hematite and ilmenite in emery ores from a number of localities is in the form of unique exsolution intergrowths, suggesting unusual crystallization-temperature-solution conditions. Magnetite, not a component of these exsolution intergrowths, is the most abundant opaque constituent in some polished sections, but is rare or totally absent in others. Ilmenite exsolves from hematite to sharp magnetite-hematite boundaries, showing that much of the hematite now present crystallized originally as hematite, and is thus not a later replacement product of magnetite. Some replacement of magnetite by hematite is noted, but only a minor percentage of the total hematite present has formed in this manner.

Ilmenite of a single age often exsolves parallel to two crystallographic directions within hematite. In addition, two readily distinguishable ages of exsolution ilmenite in hematite are often observed. The ilmenite bodies of each age have a characteristic orientation in the hematite. The original solid solution varied from dominant hematite to dominant ilmenite.

Undoubted exsolution of hematite from corundum is very well shown in some sections. A further study of these intergrowths is in progress.

THE CRYSTAL STRUCTURE OF GUDMUNDITE

M. J. BUERGER

The crystal structure of gudmundite, FeSbS , has been completely determined. The ordinary gudmundite "crystal," in common with other members of the arsenopyrite group, is actually a twinned composite simulating a single orthorhombic individual. The composite gives orthorhombic x -ray diffraction effects, but a properly separated fragment gives monoclinic diffraction effects. The space group is C_{2h}^5 . New, revised, cell data are:

	referred to primitive cell $P2_1/c$	referred to side-centered cell $B2_1/d$
	$a=6.02 \text{ \AA}$	$A=10.00 \text{ \AA}$
	$b=5.93$	$B=5.93$
	$c=6.02$	$C=6.73$
	$\beta=67^\circ 52'$	$\beta=90^\circ 00'$
	(axes comparable with marcasite axes)	
Formula	4 FeSbS	8 FeSbS
weights per cell		
calculated density 6.93	

All atoms are in the general position. A very intensive parameter study leads to the following positions of the atoms:

atom	$P2_1/c$			$B2_1/d$		
	x_a	y_b	z_c	X_A	Y_B	Z_C
Fe	— .300	.015	.300	0	.015	.300
Sb	.149	.131	.132	.140	.131	— .008
S	— .356	.145	.667	.156	.145	.511

The interatomic distances found in gudmundite confirm the author's earlier work regarding the abnormal interatomic distances in the members of the marcasite, loellingite, and arsenopyrite groups.

THE ROSEBUD METEORITE, MILAM COUNTY, TEXAS*

FRED M. BULLARD

The Burlington meteorite, received by the University of Texas in 1915, is listed as the Rosebud meteorite in several catalogues but has not been described up to the present time. The specimen, which weighs 54.9 kilograms, is an almost perfect conoid-shaped mass with well developed radial pittings on the front surface. The apex is smooth. In composition the meteorite is of the stony type with slightly more than 13% metallic content. It contains well developed chondrules consisting, for the most part, of olivine and enstatite. A chemical analysis, spectrographic analysis, and a petrographic description were given.

* Presented through the Geological Society of America.

CRYSTAL SPACE-GROUPS DETERMINED WITHOUT X-RAYS

J. D. H. DONNAY

The concepts of *multiple indices*¹ and of the two types of zonal distribution (*simple zones* and *double zones*)² are necessary prerequisites for the understanding of the present communication. Orthorhombic crystals only are considered here; similar results are obtained for other systems.

I. Zones of faces that are not perpendicular to possible glide-planes determine the *unit cell* and the *lattice centering*.

II. Zones of faces perpendicular to possible glide-planes indicate the presence or absence of a glide. The character of the axial zones, imposed by the lattice, is modified by *glide-planes*: (1) The dominant face of a simple zone may be shifted towards a pinacoid, as when (012) predominates over (011). The shift indicates the glide direction; e.g., a shift towards the *c* face indicates a *c* glide-plane. This occurs in primitive and one-face centered lattices. (2) A simple zone going into a double zone means an *n* glide-plane (in *P* lattice) or a *d* glide-plane (in *F* lattice). (3) A double zone going into a simple zone means a glide-plane to be lettered by either pinacoid of the zone (in *I* lattice).

In case there is no glide-plane, a pinacoid whose indices are not already doubled by the lattice, may have them doubled by a *screw-axis* (in primitive and one-face centered lattices).

Such simple rules enable one to read directly, from the gnomonic projection, the Mauguin symbol of the space-group (or possible space-groups). Examples: chalcocite, epsomite, enargite, cerussite, danburite, andalusite, brookite, $\text{NH}_2\text{SO}_3\text{H}$, carnallite, hemimorphite, natrolite, sulfur.

¹ *Amer. Min.*, 22 (Palache volume), 446-467, (1937).

² *Ann. Soc. géol. Belgique*, 61, B, 260-287 (1938).

DEHYDRATION AND X-RAY STUDY OF POLLUCITE

MICHAEL FLEISCHER AND C. J. KSANDA

Previous x-ray studies of pollucite have led to a suggested crystal structure which is at variance with the chemical composition found by analysis, and with the behavior of the water present in the mineral. Dehydration curves have been obtained for pollucite specimens from Hebron, Maine, and from the island of Elba, and the material has been studied optically and röntgenographically before and after dehydration. The crystal structure, the chemical composition and the role of the water in the mineral were discussed in the light of the new evidence obtained.

PETROLOGY OF THE SHALLOWATER METEORITE

W. F. FOSHAG

The meteorite was found in 1936, near Shallowater, Lubbock County, Texas. It is an extraordinarily coarse diogenite, made up of enstatite 83½%, forsterite 5%, oligoclase ($\text{Ab}_{88}\text{An}_{17}$) 1½%, nickel-iron and troilite 10%. The silicates are iron free (enstatite 4% FeO). The association of iron free silicates with metallic iron were considered.

CRYSTAL HABIT VARIATION IN SODIUM FLUORIDE

CLIFFORD FRONDEL

An experimental study was made of the effect of foreign materials on the habit of organic crystals of NaF and other NaCl-type alkali halides. Approximately 250 inorganic and organic cosolutes, including 120 dyes, were investigated. The inorganic cosolutes which effect variation from the ordinary (100) habit of NaF fall into two groups:

(1) Cosolutes which afford OH^- ion directly or by hydrolysis, and certain organic cosolutes which contain OH groups cause an octahedral habit. The variation results from the substitutional adsorption (surface isomorphism) of OH^- for F^- , such as shown by Buckley for the adsorption of RO_4 ions by K_2SO_4 , KClO_3 , etc. The variation to octahedra finds explanation in Kossel's and Stranski's analysis of the growth of ionic NaCl-type crystals.

(2) Cosolutes which react chemically to form compounds with NaF cause variation in habit, as found by Retgers and Orloff for other alkali halides. Experimental evidence indicates that the adsorption is not by substitution, but involves the formation of a new, essentially two-dimensional, crystal phase held in ordered apposition to the surface NaF ions. The direction of variation is related to structural coincidences between NaF and crystals of the adsorbed compound. This mechanism illustrates the view of habit variation taken by Bunn.

Extremely few dyes are effective with the alkali halides, in contrast to K_2SO_4 , etc., and their action is specific for different halides. The arrangement of polar hydroxyl or sulphionate groups in the dye influences the adsorption. Dye adsorption by neutral, (100), planes is common, contrary to France's theory of adsorption by charged planes.

PERTHITE FROM TORY HILL, ONTARIO

SAMUEL S. GOLDICH AND JAMES H. KINSER

An unusually well-developed perthitic intergrowth of microcline and albite was discovered in pegmatite masses occurring in syenite near Tory Hill, Haliburton County, Ontario. Film and vein perthite are both recognized. In the latter type, the albite is in braid-like veins trending parallel to the trace of the front pinacoid (100). These veins are composed of intertwining blebs of albite which are parallel to the prism faces, (110)

and (110), arranged in two superimposed *en echelon* groups forming the braid. Striking features of the intergrowth are the uniformity in orientation and in size of the blebs and the high percentage of albite. Gradations from this regular intergrowth into less regular patterns are believed to be significant in considering some of the theories which have been advanced for the origin of perthites. Petrographic data indicate that the potassic and sodic members of the intergrowth are relatively pure. The composition from a chemical analysis is Ca-f, 0.1; Na-f, 57.7; K-f, 42.2.

METASOMATISM OF A SHALE TO AN IGNEOUS APPEARING ROCK*

G. E. GOODSPEED, RICHARD E. FULLER, AND HOWARD A. COOMBS

During the summer of 1938, a cut in the western extension of the Mount Rainier highway from the southern entrance of the Park at Ohanapechosh disclosed a transition in the metasomatism of a shale. The rock belongs to a series of coal bearing sediments which are exposed along the road for over three miles, and which presumably represent the Puget series of the Eocene. The shale is a dark reddish brown homogeneous rock with fine jointing, and occurs here both in normal beds, and as rounded, angular or irregular blocks ranging from a fraction of an inch to ten feet or more in diameter, enclosed in a light gray rock containing megascopic plagioclase and quartz. Although the contact is locally sharp, it more commonly shows in less than an inch a gradation from the unaltered shale to a rock which by itself would be called a porphyritic dacite and be classed with the Kechelus volcanic series. This transitional facies is marked by the development of feldspathic porphyroblasts in the shale, and by the change of the rock to a pale greenish shade owing to disseminated chlorite. The igneous appearing rock at the contact shows no sign of chilling, while the groundmass locally appears to be indistinguishable from the shale. Some blocks of the shale exhibit fine vein-like extensions of the igneous appearing rock with a coarseness of grain which denotes a crystalloblastic origin. The size and shape of the blocks of the fragile shale preclude a pyroclastic origin and give additional evidence of a metasomatic replacement, in which relics of the shale survive in various stages of transformation.

* Presented through the Geological Society of America.

THE BEHAVIOR OF SERPENTINES BETWEEN 500° AND 650°C.

JOHN W. GRUNER

In connection with the study of the structure of serpentines, it was shown by Selfridge and the writer that there are two distinct structures which were named antigorites and chrysotiles by them. Contemporaneously Caillière¹ in an extensive study had shown that two types of serpentine (called α and β antigorites by her) exist. Caillière's distinction is based on the different behavior when heated and the appearance of their thermal curves. The writer finds that there is no agreement between the two classifications. A chrysotile may be either an α or β antigorite, or one of the α or β antigorites of Miss Caillière may be an antigorite or chrysotile of the writer.

It was found that all chrysotiles change to olivine (and probably colloidal silica) if held in air at a temperature of 560°C. for 4 to 19 days. The antigorites on the other hand, are not changed so rapidly and some of them seemed to remain serpentine after 34 days as seen by x-rays. In an atmosphere of CO₂ all of them change to olivine at 560°C. within 2 to 22 days. At 650°C. in air even the antigorites change to olivine relatively rapidly. No indication of the formation of enstatite was found at either temperature which is not in agreement with results reported by Caillière.

¹ Caillière, S., *Bull. Soc. Franc. Min.*, 59, 163 (1936).

ADSORPTIVE CLAYS OF THE TEXAS GULF COAST

ARTHUR F. HAGNER

Numerous clay pits containing an abundance of material suitable for the clarification and purification of petroleum products are found along the Texas Gulf Coastal Plain. Microscopic, chemical, and x-ray examinations indicate that the principal mineral constituent is montmorillonite. Microscopic textures and structures, when well preserved, are significant of origin. Many beds represent the result of alteration in situ of volcanic ash. Substantial amounts of kaolinite, halloysite, and allophane occur in some deposits, indicating variations in origin. The amount of alteration is variable. Some of the original material has altered sufficiently to clay to form fuller's earths of usable quality. In certain deposits alteration has been so complete as to obliterate any definite evidence of origin of the clay.

The waxy character of many moist clay layers has proved of interest. Waxy clays contain more nearly pure montmorillonite than the other types which are soft, granular and kaolinitic. The waxiness may be attributed to the unusual hydration characteristics of montmorillonite. Kaolinitic mixtures occur in the northeastern part of the clay belt, whereas the more nearly pure montmorillonite occurs in the southwestern part. The prevalence of kaolinitic material in the fuller's earths of eastern Texas may account for efficiency ratings below those of the Georgia-Florida fuller's earths.

A review of the literature, correlated with field observations, indicates that the clays of eastern Texas have formed during the Eocene, and Oligocene or Miocene epochs. Correlation of physical, chemical, and optical properties with adsorptive efficiency has been attempted.

CHEMICAL STUDIES OF HEXAHEDRITE METEORITES FROM CHILE

E. P. HENDERSON

A great many of the siderites from Chile belong to the hexahedrite class of meteorites. This suggests that either there has been a shower of this type of material or if these are unrelated falls, then perhaps a chemical study would detect some differences between them. Five new analyses of recently acquired Chilean meteorites (Puripica, Sierra Gorda, Rio Loa, Negrillos, and Coya Norte) are given and compared with each other, as well as with other analyses of this type of meteorite. Between all these Chilean hexahedrites a remarkable agreement was found and if this group alone is considered, it would suggest that all five are from the same fall. However, when these analyses are compared with others of this same classification of meteorites and from widely scattered areas over the world, there still is found the same close agreement, which suggests that this is the fundamental type of material in iron meteorites. Comparing these analyses with those of kamacite, a component in octahedrites, there is also a striking agreement. Henceforth, it certainly seems more logical to consider hexahedrites as meteorites composed entirely of kamacite. Metallographic studies between kamacite and hexahedrites support this conclusion and more detailed studies are being made.

COMPARISON OF THE FABRICS OF XENOLITHS AND THE ADJACENT INTRUSIVE ROCK

EARL INGERSON

Fabric studies of two intrusions and their included xenoliths have been made: (1) The Port Deposit granodiorite in Maryland and (2) the Uncle Sam quartz monzonite porphyry near Tombstone, Arizona. The Port Deposit granodiorite has undergone metamorphism after its intrusion was completed, but the Uncle Sam porphyry is unmetamorphosed. Mica and quartz fabrics of the Port Deposit granodiorite and the xenoliths studied are identical. There is little mica in the Uncle Sam porphyry and none in its xenoliths, which are mostly

quartzite. The quartz fabric of the inclusions is unlike that of the porphyry, indicating that the fabric of the inclusions was not produced during intrusion. Presumably, then, the identity of fabric in the Port Deposit granodiorite was produced by metamorphism of the intrusive and its xenoliths after intrusion rather than by working over of the inclusions during intrusion.

MARSHITE FROM CHUQUICAMATA, CHILE

O. W. JARRELL

A few specimens of marshite were recently found in the oxide ore body of the disseminated copper deposit at Chuquicamata, Chile. Its properties agree essentially with the previously described material from Broken Hill, N.S.W. A description of the new occurrence, complete index of refraction determinations, and a new analysis were presented.

AN EXPLANATION OF DIAMOND CUTTING IN TERMS OF ATOMIC STRUCTURE

EDWARD H. KRAUS AND CHESTER B. SLAWSON

Long experience of diamond cutters shows that the hardness of the diamond varies materially with the crystal surface on which the cutting or polishing is done. The hardness is least on planes parallel to faces of the cube. It is greatest on planes parallel to faces of the octahedron, and such planes can be worked only with great difficulty, if at all. The characteristics of diamond dust which make it suitable for sawing and polishing of the diamond were described. The directions in which these processes may be effectively done were indicated in terms of atomic structure. An explanation of the perfect octahedral cleavage was also given.

MINERALS OF EIGHT MILE PARK, COLORADO

KENNETH K. LANDES

Eight Mile Park is the partially wooded upland lying immediately north of Royal Gorge in Fremont County, Colorado. It is floored with crystalline rock of pre-Cambrian age. Granite pegmatites are abundant, and at least three of these have been exploited for feldspar. One deposit, the Mica Hill, has produced more feldspar than any other mine in the state.

The dominant minerals in the Park pegmatites are microcline and quartz. Muscovite is abundant, in some instances occurring in large radiating masses. Beryl crystals with a maximum diameter of two feet are common in the lower part of the Mica Hill open cut. Albite is subordinate. Garnet crystals occur near the margins of some of the pegmatites. An unexploited pegmatite east of Mica Hill contains abundant pink tourmaline and lepidolite. Black tourmaline is found with milky quartz in a hill to the southwest.

In most of these pegmatites the hydrothermal phase was relatively subordinate.

OVERITE, A NEW MINERAL FROM FAIRFIELD, UTAH

ESPER S. LARSEN, 3RD

Overite, $\text{Ca}_3\text{Al}_6(\text{PO}_4)_8 \cdot 20\text{H}_2\text{O}$, according to a preliminary analysis, is a new mineral from the variscite nodules of Fairfield, Utah. It is orthorhombic and occurs as pale green to colorless prismatic crystals, flattened on (010), in cavities in altered variscite. Cleavage: (010) perfect, (100) poor. $H=4$; $G=2.53$. Biaxial negative, $2V=75^\circ \pm 10^\circ$; $r > v$ weak; $X=c$, $Z=b$. $\alpha=1.568$, $\beta=1.574$, $\gamma=1.580$, all $\pm .002$. Elements (morphological): $a:b:c = 0.7839:1:0.3794$. Structural lattice: $a_0=14.62 \text{ \AA}$, $b_0=18.68 \text{ \AA}$, $c_0=7.08 \text{ \AA}$; $a_0:b_0:c_0 = 0.7827:1:0.3788$; $V_0=1936 \text{ cubic \AA}$. Cell contains $2[\text{Ca}_3\text{Al}_6(\text{PO}_4)_8 \cdot 20\text{H}_2\text{O}]$.

The mineral is named after Mr. Edwin Over of Colorado Springs, Colorado, who, with Mr. Arthur Montgomery, recognized the mineral as new and collected a sufficient amount for a chemical analysis.

THE SYMMETRY OF PHOSPHOSIDERITE

DUNCAN MC CONNELL

An investigation involving the use of Laue, powder and oscillation methods, as well as etching experiments, demonstrates that phosphosiderite is monoclinic with: $a_0=5.30$, $b_0=9.79$, $c_0=8.67 \text{ \AA}$ (all $\pm 0.02 \text{ \AA}$) and $a:b:c=0.541:1:0.886$, $\beta=89-90^\circ$. This mineral displays pronounced pseudosymmetry which impedes certain measurements. The space group is probably $C_{2h}^2=2 C_i-2$. If the unit cell is assumed to contain four molecules of $\text{FePO}_4 \cdot 2\text{H}_2\text{O}$ the theoretical density becomes 2.74, as compared with a recorded value 2.76.

Phosphosiderite is isomorphous with metavariscite only if the latter is pseudosymmetric and, in reality, monoclinic also. Strengite is probably dimorphous with phosphosiderite.

VESUVIANITE FROM GREAT SLAVE LAKE REGION, CANADA

V. BEN MEEN

The crystallographic, optical and chemical properties of well-formed crystals of vesuvianite from this new locality were discussed.

AN ASSOCIATION OF HARMOTOME, CORUNDUM AND HYALOPHANE
AT GLEN RIDDLE, PA.

ADOLPH E. MEIER AND W. HAROLD TOMLINSON

In a recent paper an occurrence of harmotome in a basic dike at Glen Riddle, Delaware Co., Pa., was described.* Corundum and potash-barium feldspar were so associated in the rock matrix that a paragenetic relation between all three minerals was indicated. Further study indicates that they were formed at various stages of the same dynamic hydrothermal sequence.

There are two types of hyalophane present, with an orthoclase-celsian content of $\text{Or}_{85}\text{Cn}_{15}$ and $\text{Or}_{90}\text{Cn}_{10}$. Both types occur as antiperthites with andesine or oligoclase, or as separate grains in close association with the latter. An occasional perthite occurs in the more alkaline association. Four types of plagioclase are present. The range in anorthite content is from An_{50} to An_{15} . Intermediate types are An_{20} and An_{40} . Spatial relationships of the feldspars are such as to impart to the dike an anorthositic core and a gabbroic rim. Intermediate feldspars, hyalophane and corundum occur mainly along variously spaced crush zones parallel to the foliation in the dike.

The contemporaneous deposition of the hyalophane and corundum and the later deposition of harmotome is considered to be the result of

- (1) deformation of a thin dike of anorthositic gabbro, emplaced in pyroxenite, by forces accompanying the intrusion of a hornblende granite close by,
- (2) infiltration during or after stress along favorable channels of hydrothermal potash barium solutions emanating from the granite and setting up a series of reactions which resulted in the deposition of mineral suite described.

* Given at the Eighteenth Annual Meeting of the Min. Soc. of Amer.

LIQUID-VAPOR EQUILIBRIA IN THE SYSTEM $\text{K}_2\text{O}-\text{SiO}_2-\text{CO}_2-\text{H}_2\text{O}$ *

G. W. MOREY AND MICHAEL FLEISCHER

Although there is general agreement that hydrothermal and pneumatolytic processes play important roles in the formation of ore deposits, there is so little physico-chemical data available on the properties of complex solutions at high pressures and temperatures that it is not possible at present to pass upon the validity or competency of the various mechanisms which have been suggested to account for the mode and order of ore deposition. As the first step towards obtaining such data, we have designed an apparatus with

which to study the equilibrium distribution of two volatiles between the liquid and vapor phases at high temperatures and pressures. The present paper reports the results obtained in the system $K_2O-SiO_2-CO_2-H_2O$ at $500^\circ C$. The effect of changing potash-silica ratios on the distribution of the volatiles is discussed. The change in composition of the vapor phase with diminishing pressure at constant temperature is shown graphically for various initial compositions.

* Presented through the Geological Society of America, as a Geological Society Project.

THE CRYSTALLOGRAPHY OF VEATCHITE

JOSEPH MURDOCH

Some terminated crystals of veatchite, the newly discovered calcium borate from Lang, California, have been measured on the goniometer, and the elements calculated. Using the published values for the unit cell dimensions, the elements are as follows:

$$\begin{array}{ll} a:b:c = 0.163:1:0.998 & \beta = 121^\circ 2' \\ p_0:q_0:r_0 = 6.1227:0.8551:1 & \mu = 58^\circ 58' \\ r_2:p_2:q_2 = 1.1694:7.1599:1 & \\ p_0' = 7.1455 & q_0' = 0.998 & x_0' = 0.6017 \end{array}$$

The following forms are tentatively recorded: (010) (100) (001) (017) (014) (013) (025) (023) (056) (011) (054) (043) (021) (230) (120) (140) (150) (160) (I66) (I.7.12). Of these forms, (010) is always present, well developed, but the clinodome and prism zones are characterized by many narrow and often indeterminate faces, of which the more definite have been selected. Pyramids are rare, only three faces having been found on eight crystals.

INTRODUCTION OF FELDSPAR INTO INCLUSIONS, ELLSWORTH, NEW HAMPSHIRE

LINCOLN R. PAGE

Inclusions of quartz-biotite schist in a porphyritic facies of the Kinsman quartz monzonite, one-half mile east of the north end of Stinson Lake, town of Ellsworth, New Hampshire, show porphyroblasts of soda-feldspar which appear to have been introduced from magmatic sources. These porphyroblasts, up to 6 cm. in length, are similar in appearance to the phenocrysts in the quartz monzonite, but the latter, dominantly microcline feldspar with small amounts of myrmekite, contain few inclusions of the groundmass. The porphyroblasts are present as separate carlsbad twinned crystals and as groups of grains of different optical orientation. Abundant inclusions of the groundmass minerals are present in both occurrences. In some cases these inclusions are scattered throughout individual crystals and in others they are grouped together and surrounded by rims of feldspar up to 5 mm. thick. Replacement textures, inclusions of original minerals within feldspar rims, and mineralogic and field relations strongly suggest that the soda has been added to the quartz-biotite schist from igneous sources.

THE MEASUREMENT OF REFLECTIVITY AND COLOR OF MINERALS

WILLIAM PARRISH

Recently, an attempt has been made to identify opaque minerals by determining their reflectivity by means of auxiliary microscope apparatus such as the Berek slit microphotometer or Orzel photoelectric ocular. In general, measurements obtained with these instruments do not lead to a unique determination of the mineral.

This paper describes a technique for the measurement of the diffuse reflectivity and other data by use of the Hardy recording photoelectric spectrophotometer, which is also

known as the color analyzer (*J.O.S.A.*, **28**, 360, 1938). It has the advantages of accuracy to three significant figures, speed, completeness of data, and simplicity of operation; it is applicable to opaque and non-opaque minerals. The chief disadvantage of the instrument is its high cost. It operates automatically and plots a continuous spectrophotometric curve (reflectivity as a function of wavelength) for the entire visible spectrum in about one minute. The specimens may be natural crystal faces or prepared as metallic mirrors, polished surfaces, or powders. The reflectivity curves of about 100 minerals were determined on this instrument and each of these curves is unique.

The Handbook of Colorimetry (M.I.T., 1936) uses three terms to describe color on an absolute color scale: brightness, dominant wavelength, and purity. From the reflectivity curve one can easily calculate these terms and thus describe the precise color of the mineral.

Further experiments are in progress on the determination of the specular reflectivity, with the intention of using this constant to calculate refractive index, absorption, density, and conductivity.

CRYSTALLOGRAPHY OF COPIAPITE

M. A. PEACOCK

On copiapite from Chuquicamata, Chile, Palache obtained the hitherto unpublished triclinic elements:

$$a:b:c=0.4058:1:0.4039; \alpha=93^{\circ}50', \beta=102^{\circ}10', \gamma=99^{\circ}21\frac{1}{2}'$$

X-ray photographs, kindly made by Buerger, on a crystal from the same locality, gave the following structural elements in the normal setting:

$$a_0=7.33, b_0=18.15, c_0=7.27 \text{ \AA}; \alpha=93^{\circ}51', \beta=101^{\circ}30', \gamma=99^{\circ}23\frac{1}{2}'$$

$$a_0:b_0:c_0=0.404:1:0.401$$

On copiapite from Sierra Gorda, Chile, Ungemach (1935) noted 144 forms and obtained elements which, transformed to the normal setting, give:

$$a:b:c=0.4005:1:0.3971; \alpha=93^{\circ}58\frac{1}{2}', \beta=102^{\circ}08', \gamma=98^{\circ}50'$$

These variations in the crystallographic elements of copiapite may be explained by the variations in the composition and optics discussed by Berry at this meeting.

In addition to affording a fine example of form development according to the Law of Bravais, a projection of the forms of copiapite presents a striking case of the problem of multiple morphological periods.

NEPHELINE-SYENITE PEGMATITES IN THE BEARPAW MOUNTAINS OF MONTANA

WILLIAM T. PECORA

In the western Bearpaw Mountains of Montana is situated a composite stock of Tertiary age, made up chiefly of pyroxenite, shonkinite, syenite and nepheline syenite. The pegmatites described are intimately associated with the nepheline syenite bodies as late segregations, or with the adjacent older rocks as dike injections. The deposits are numerous, varying in width up to six feet and in length of outcrop up to a few hundred feet.

The primary minerals present are feldspar, nepheline, biotite, and garnet (melanite). Replacement minerals include sphene, ilmenite, fibrous and prismatic aegirine, eudyalite, lamprophyllite, and occasional metallic sulfides. Tabulations and discussions of chemical analyses and optical properties are also included. The mineral associations of these hitherto undescribed pegmatites are similar to those of other better-known localities, such as the Kola Peninsula.

A MINERALOGICAL TRIP TO EUROPE

AUSTIN F. ROGERS

An account of collecting trips to Mill Close, Castleton, Llandudno, Saltbura, Fallowfield, Cornwall, Moresnet, Ytterby, Langban, Oslo, Snarum, Kongsberg, Langesund, Kragerø, Erje, Iveland, and Saalfeld.

An account of visits to establishments at Antwerp and Idar-Oberstein and to the museums and mineralogical institutes of London, Oxford, Cambridge, Edinburgh, Cambridge, Brussels, Ghent, Louvain, Liège, Amsterdam, Leiden, Groningen, Copenhagen, Oslo, Stockholm, Upsala, Berlin, Zurich and Paris.

MONTICELLITE ROCK FROM CRESTMORE, CALIFORNIA

AUSTIN F. ROGERS

For many years the rare mineral monticellite (a double salt with the formula: CaMgSiO_4) was known from only one locality in this country (Magnet Cove, Arkansas).

In 1917 Eakle described it from the contact-metamorphic zone of Crestmore, where he found it with xanthophyllite in blue calcite. More recently Mochlman and Gonyer describe it as a minor constituent of a metamorphic silicate complex from Crestmore.

Crestmore probably ranks as the most prominent locality for monticellite, for the writer about a decade ago found it here in huge blocks in the "Wet Weather" quarry.

The monticellite rock is a pale brown medium-grained granulose massive rock with green spots of idocrase. The idocrase apparently replaces the monticellite and it seems likely that at least some of the massive idocrase at this locality is a replacement of the monticellite rock.

PRELIMINARY REPORT ON THE SYSTEM, $\text{FeO-Al}_2\text{O}_3\text{-SiO}_2$

J. F. SCHAIRER

In order to obtain more information on the compositions and stability relations of the FeO-bearing pyroxenes, it will be necessary to obtain silicate equilibrium data for quaternary systems involving $\text{CaO-FeO-Al}_2\text{O}_3\text{-SiO}_2$ and $\text{MgO-FeO-Al}_2\text{O}_3\text{-SiO}_2$. Before beginning determinations on these quaternary systems it is necessary to know the relations in the system, $\text{FeO-Al}_2\text{O}_3\text{-SiO}_2$.

The system, $\text{FeO-Al}_2\text{O}_3\text{-SiO}_2$, is under investigation and substantial progress has been made in determining the liquidus surfaces of the several solid phases. Tridymite, cristobalite, spinel (hercynite), fayalite, mullite, and corundum liquidus surfaces have been determined in whole or in part. One eutectic and two reaction points have been located. So far no ternary compounds have been encountered at the liquidus temperatures.

RHYODACITE FROM THE TRANQUILLE PLATEAU, BRITISH COLUMBIA

LOUISE STEVENS STEVENSON

Siliceous lavas are very uncommon in the Tertiary volcanics of the British Columbia interior plateaus, and the present paper records what is believed to be the first such occurrence to be studied in petrographic detail. A plug-like outcrop of white, fine-grained, porphyritic rock was found in the upper Tranquille valley in a group of middle-Tertiary lavas. It has been identified microscopically as a rhyodacite, corresponding to 237E of Johannsen's classification. Phenocrysts of oligoclase, quartz, sanidine, and biotite are embedded in a microcrystalline groundmass. Results of optical study of the minerals, and of Rosiwal determinations, were given.

**TWINNED OCTAHEDRA OF FLUORITE AND ASSOCIATED MINERALS
FROM MT. ANTERO**

GEORGE SWITZER

During the summer of 1938 a study was made of the pegmatites of the Mt. Antero region, in company with Mr. Arthur Montgomery and Mr. Edwin Over.

Fluorite crystals were found twinned by the usual law but showing only, or dominantly, the octahedron form, a new habit for this mineral.

The fluorite-bearing pegmatites may be grouped in five different types. The paragenesis of each type was described and the habit-association relationships of some of the minerals pointed out. The minerals occurring in the pegmatites are feldspar, quartz, muscovite, beryl, phenakite, topaz, bertrandite, fluorite, limonite, and sulphur.

THE CORUNDUM IN THE GLEN RIDDLE DIKE

W. HAROLD TOMLINSON

Discussion of corundum pegmatites and their connection with gabbro differentiates. Connection shown between corundum pegmatites and granite volatiles. Description given of corundum dike and associated rocks at Glen Riddle. Two reactions illustrated by which corundum is formed from excess alumina liberated from anorthite when attacked by volatile elements. A theory contending that all alumina available for corundum was carried in magma as anorthite and that corundum was formed by reaction between anorthite and volatile elements. This reaction at near magma temperatures. Application of this theory to some corundum localities.

**POTASSIUM TETRATHIONATE AS AN EXAMPLE OF MONOCLINIC
HEMIHEDRAL SYMMETRY**

G. TUNELL, H. E. MERWIN, AND C. J. KSANDA

Crystals of potassium tetrathionate and potassium pentathionate were synthesized and analyzed by Dr. E. T. Allen in connection with an investigation of the volcanic activity and hot springs of Lassen Peak, where pentathionate was proved to be present in some of the fumarolic products; tetrathionate was not proved to be present and could not have exceeded a few tenths of one per cent in the samples examined from Lassen Peak, if it occurred in them at all. The crystallographic properties of the potassium tetrathionate were determined in the present study, also its space-group. Potassium tetrathionate is notable for its pronounced monoclinic hemihedrism, and was found by Messrs. Hendricks and Jefferson to have an unusually strong pyroelectric effect.

AN OCCURRENCE OF CHRYSOBERYL NEAR GOLDEN, COLORADO

W. A. WALDSCHMIDT AND R. V. GAINES

Chrysoberyl, found near Drew Hill, about ten miles from Golden, Colorado, occurs in a small granite pegmatite dike. The crystals and crystalline masses of chrysoberyl from this locality are exceptionally large. One tabular mass weighs slightly over two pounds. The largest single crystal found measures 11/16 inch in thickness, 1-9/16 inches in width, and 3-3/4 inches in length. All of the specimens of chrysoberyl thus far found in place are near the center of the dike in close association with massive quartz or quartz-muscovite segregations.

**LARGE SPHENE CRYSTALS FROM SAN JACINTO MOUNTAINS,
CALIFORNIA**

ROBERT W. WEBB

Large sphene crystals disseminated in plutonic rocks are not commonly found. Recently an area in the batholith of the San Jacinto Mountains, Riverside County, California,

has been found in which a microcline quartz-diorite contains crystals of sphene which are abundant in sizes up to $1'' \times \frac{1}{2}'' \times \frac{1}{2}''$. The crystals are perfectly formed euhedrons, occurring separately and in groups. Thousands of crystals of good size are obtainable without difficulty from the decomposed rock. Microscopic examination shows the crystals to include subhedral grains of andesine and anhedral grains of quartz. These relations and other features of the sphene indicate a late or secondary introduction of the sphene crystals.

MINERAL COMPOSITION OF HAWAIIAN CERAMIC CLAY

CHESTER K. WENTWORTH, ROGER C. WELLS, AND VICTOR T. ALLEN

Since 1935 small amounts of medium or light gray residual clay of ceramic quality have been found in restricted upland areas on Oahu, Maui, Molokai, and Kauai. The deposits take the form of thin underclays, always overlain by a well marked humus or peat layer at the modern surface, and usually underlain by thin but more or less continuous masses of iron pan followed by weathered, buff or brown residuum.

In every instance the clay occurs in sloping areas of little relief, remnants of original constructional surfaces of volcanic domes, which receive rainfall of 150 to 400 inches annually but have long remained free from significant disturbance by erosion or deposition. In elevations ranging from 2500 to 5500 feet, patches of more or less distinctive bog vegetation have developed and are apparently the basis of the reducing conditions under which a clay fairly low in iron has been produced.

Three complete chemical analyses show a rather variable composition, silica 34 to 57 per cent, alumina 22 to 26 per cent, iron oxides 3 to 9 per cent. Most surprising is over 14 per cent of titanium oxide in two of the samples. Preliminary petrographic studies indicate the derivation of the clay from basaltic lavas, the feldspar phenocrysts changing to kaolinite and the matrix, originally feldspars and ferromagnesian minerals, to illite. Elutriation concentrates from the clay contain plagioclase, ilmenite, and leucoxene. The latter minerals probably account for the high titanium which was derived from original ilmenite and titaniferous augite.

OPTIC PROPERTIES OF ORGANIC AND INORGANIC COMPOUNDS COMPARED

A. N. WINCHELL

A diagram has been prepared showing the optic properties of about 1000 organic compounds (including all those that have been measured). Such a diagram can be used for the rapid identification of any unknown compound which has been placed on it. By comparison with a similar diagram of optic properties of inorganic compounds it appears that organic compounds show considerably greater variation than the inorganic, both in refraction and in birefringence.

SYMMETRY AND UNIT CELL OF HOPEITE

C. W. WOLFE

X-ray examination of hopeite gave the following cell lengths: $a_0 = 10.64 \text{ \AA}$, $b_0 = 18.32 \text{ \AA}$, $c_0 = 5.03 \text{ \AA}$; $a_0:b_0:c_0 = 0.5808:1:0.2745$; $M_0 = 1833.0 = 4[\text{Zn}_2(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}]$. In Spencer's work on this mineral where it was considered to be holohedral, the above axial relations may be expressed as $b:3a:c$. Ungemach later recognized the proper lengths, but thinking that hopeite represented a 33rd crystal class, that is, orthorhombic with but one plane of symmetry, he changed the setting to make this plane basal. The transformations from the Spencer setting and from Ungemach's setting to the structural one are respectively: 010/300/001 and 010/001/100.

A study of the spectral omissions plus consideration of symmetry limitations noted by Spencer, Ungemach, and the author (on new crystals) definitely fixes the symmetry of hopeite to be bisphenoidal with the space group $D_2^4 - P 2_1 2_1 2_1$. The one, two, or three planes of symmetry commonly observed on hopeite are due to twinning, two of these twin laws having been demonstrated by earlier workers and the third, postulated by the author.

It is estimated that more than 250 attended the various sessions of the Society. Among those who registered were:

Alling, Harold L.	Dickey, Parke A.	Holmes, Ralph J.
Alling, Merle	Doll, Charles	Honess, A. P.
Andersen, Olaf	Donaldson, Frank	Hooker, Marjorie
	Donnay, J. D. H.	Horowitz, I. L.
Bain, George W.		Hunt, Walter F.
Baker, J. M.	Ehrmann, Martin L.	Hurlbut, Cornelius S., Jr.
Balk, Robert	Evans, E. L.	
Barksdale, J. D.		Ingerson, Earl
Barrett, Richard L.	Fisher, D. Jerome	Irwin, William H.
Bascom, Florence	Fisher, Lloyd W.	
Bateman, Alan M.	Fleischer, Michael	Jacobs, R.
Bell, James F.	Foote, Freeman	Jarrell, O. W.
Bennett, M. G.	Foreman, Fred	Johnston, W. D. Jr.
Berman, Harry	Foshag, William F.	
Berry, L. G.	Fraser, Donald M.	Kaikow, Julius
Billings, Marland	Freedman, J.	Kaiser, Edward
Bloom, Mortimer, C.	Freeze, A. C.	Keller, W. D.
Bowen, Norman L.	Frondel, Clifford	Kennedy, G. C.
Brauneck, Dorothy		Keppel, David
Bray, J. M.	Gallagher, David	Kerr, Paul F.
Broughton, J. G.	Garretson, Mary W.	Klepper, M. R.
Bruce, E. L.	Gault, H. R.	Knopf, Adolph
Bryson, Robert P.	Gilluly, James	Knopf, E. B.
Buckingham, Russell J.	Glass, Jewell J.	Koons, E. D.
Buddington, Arthur F.	Goddard, E. N.	Kraus, Edward H.
Buerger, M. J.	Goldich, S. S.	Krieger, Philip
Buller, A. E.	Grawe, O. R.	
Bunton, Paul B.	Griggs, David	de Laguna, Wallace
Bush, James	Grim, Ralph E.	Landes, Kenneth K.
	Grout, Frank F.	Lane, Alfred C.
	Guild, Philip W.	Larsen, Esper S.
Cameron, Eugene		Larsen, Esper S., 3rd
Carhart, Grace M.	Hagner, Arthur F.	Levin, S. Benedict
Chapman, C. A.	Hagner, Feodor	Lovering, T. S.
Chayes, Felix	Hartnagel, C. A.	Lowenstein, Kurt
Church, H. Victor, Jr.	Henderson, E. P.	
Chute, Newton E.	Hershey, H. G.	Macksoud, Adrienne
Cooley, Mary	Hess, Frank L.	MacLean, A. J.
Cooper, John R.	Hess, Harry	Mather, L. Bryant, Jr.
Currier, Louis W.	Hewett, D. F.	Maurice, C. S.
	Heyl, Allen V.	Maynard, James E.
Day, Arthur L.	Hobbs, S. Warren	McCaughy, W. J.
Denis, B. T.		

- McLellan, Roy D.
Meen, V. Ben
Merritt, Philip
Montgomery, Arthur
Morey, G. W.
Morton, James F.
Moyd, Louis
- Page, Lincoln R.
Palache, Charles
Parrish, William
Parsons, Arthur F.
Patmore, W. H.
Pecora, W. T.
Peltier, Louis
Pigman, A.
Pollak, Miriam
Pough, F. H.
- Quinn, Alonzo
- Ridland, G. C.
Ries, H.
Roberts, Ralph J.
Roedder, Edwin
Rogers, Austin F.
Rogers, B. R.
Rosalsky, Maurice
Ross, Clarence S.
Rothrock, H. E.
- Rozanski, George
Ruthruff, R.
- Sampson, Edward
Schairer, Frank
Schaller, Waldemar T.
Shand, S. James
Shaub, Benjamin
Sherman, Helen
Short, Max N.
Slawson, Chester B.
Smith, H. T. U.
Snelgrove, A. K.
Steierman, B. F.
Stevenson, John S.
Stevenson, Louise S.
Stow, Marcellus
Strock, Lester W.
Stuckey, Jasper
Switzer, George
- Tatge, Eleanor
Taylor, E. D.
Taylor, Hall
Thatcher, Russell N.
Thomson, Ellis
Tleitanen, Anna
Todd, Ruth
Tolman, Carl
- Tomlinson, H. W.
Tooney, F. J.
Toothaker, Charles R.
Tunell, George
Tuttle, O. F.
- Van Alstine, R. E.
Vance, R. C.
Varni, Stephen
Vhay, John S.
Vitaliano, Charles
- Waldschmidt, W. A.
Wallace, Harriet
Watanabe, Takeo
Watson, K. deP.
Wellnitz, Anna
Wells, Dana
Wells, Frances
Wells, R. C.
Wenden, Henry E., Jr.
Wheeler, E. R., 2nd
White, D. E.
Winchell, A. N.
Wolfe, C. W.
Woods, A. E.
- Yang, I. Y.
Zerfoss, S.