

## PRESENTATION OF PAPERS

## THE PEGMATITES OF THE KEYSTONE AREA\*

CONSTANTIN N. APSOURI

Detailed mapping of the Hugo, Peerless, Dan Patch, Bob Ingersoll and lesser pegmatites in the Keystone area, supported by critical study of the relations between their minerals and the country rock lead the writer to conclude that:

(1) Some criteria interpreted as favoring replacement need revision, having been used to support two diametrically opposed views; examples are euhedral crystals.

(2) Even a well-established criterion should be employed in the light of spatial and structural relations.

(3) While replacement did take place, its role is over-emphasized. The spodumene "logs" at the Etta mine are not products of replacement.

(4) The common belief that muscovite and muscovite books are replacement products is not supported by the field evidence cited by advocates of replacement. Muscovite forms less than 1% in common pegmatites. The contention that mica occurs at the contact is not strictly correct: mica books are frequently far from a major contact. Not all pegmatites bear mica. The almost constant association of schist xenoliths with an aureole of muscovite books suggests a genetic relationship. The mica probably resulted from the assimilation of the schist by the pegmatitic magma.

(5) Structure and mode of emplacement of pegmatites has not been stressed lately. Pegmatites distend the country rock, or slope their way through, or both, as suggested by xenoliths and the sharp transgression of schistosity by some contacts.

(6) The sequence of mineral paragenesis described by Landes (1928) is revised.

(7) A single mapping of a pegmatite is insufficient. Repeated visits and mapping, concurrent with the progress of mining, are essential to uncover significant data, otherwise irretrievably lost.

\* Presented through the Society of Economic Geologists.

## STILPNOMELANE, NONTRONITE, AND HALLOYSITE FROM NORTHERN MICHIGAN

VINCENT L. AYRES

Stilpnomelane, nontronite, and halloysite have not heretofore been reported from the Michigan iron mining districts.

The first of these, stilpnomelane, occurs as a *contact* mineral where granite pegmatite has intruded ferruginous slate at Crystal Falls. Notable in the complete analysis is an abnormally high content of ferric iron together with appreciable manganese. The arc spectrograph proves the absence of potash. Refractive indices are:  $\alpha = 1.634$ ,  $\beta$  &  $\gamma = 1.730$ .

The nontronite superficially resembles chrysocolla. It occurs abundantly with halloysite and limonite lining cracks in a shatter zone at the New Richmond pit east of Palmer on the Marquette Range, and also in a seam in post-Huronian granite five and one-half miles to the west. Nontronite also is to be found at scattered localities on the Menominee and Gogebic Ranges.

The halloysite may not be hydrothermal, but at least it is another example of alumina transported in solution.

STRUCTURAL CONTROL IN EUROPEAN LEAD-ZINC ORES  
OF THE MISSISSIPPI VALLEY TYPE\*

CHARLES H. BEHRE, JR.

This discussion is limited to tectonic, non-mineralogic features, observed during nine months of field work, supplemented with observations by others.

The flat-lying strata of German and Polish Silesia and those of the north Moroccan deposits (Oujda, Toussit) show ore following bedding-partings near normal faults; absence

\* Presented through the Geological Society of America.

of obvious trunk channels suggests the Upper Mississippi Valley and Tri-State relationships in the United States. The ores near Alston (northern England) and Djalta (Tunisia) are similar. Somewhat similar also are those of Derbyshire (Mill Close mine), but here mineralized fissures are well exposed.

At Aachen and near-by Limburg (Holland) and Moresnet (Belgium) mineralized large faults, from which the ore spreads outward, are well-marked and bedding plane openings are still prominent. But in Wales (Halkyn) and the middle Rhine valley (e.g., Ems) fault openings play the only important role.

At the opposite extreme from the Silesian deposits are replacements and fissure fillings in Alpine limestones at Mezica (Yugoslavia), Cave di Predil (Italy), and Bleiberg (Austria). These show replacements confined to the neighborhood of complex faults, largely thrusts, yet mineralogy and paragenesis are essentially as in the cases first cited.

Summarizing, widespread studies yield transition types between (1) deposits in highly strained rocks and (2) deposits in almost undeformed sediments, in which the direction of mineralization is still actively debated, both here and abroad. The tectonic relations of the less deformed types can therefore scarcely be adduced as arguments against hydrothermal origin.

#### CLASSIFICATION OF THE NATIVE ELEMENTS, SULPHIDES, AND SULPHO-SALTS

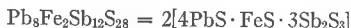
HARRY BERMAN

The classification is that to be followed in the seventh edition of Dana's "*System of Mineralogy*." Native elements are arranged beginning with the gold group. Sulphides and sulpho-salts are arranged according to a decreasing  $A:X$  ratio, where  $A$  represents the metallic and  $X$  the nonmetallic elements. Groups are based on crystallographic and chemical similarities.

#### STRUCTURAL CRYSTALLOGRAPHY AND COMPOSITION OF JAMESONITE

L. G. BERRY

Jamesonite with basal cleavage, from Cornwall (type locality), Huanuni, Bolivia, and the Itos Mine near San Felipe de Oruro, Bolivia, gives identical  $x$ -ray powder photographs. Rotation and Weissenberg photographs of a needle-like crystal from the Itos Mine show monoclinic symmetry; space group  $P2_1/a$ ;  $a_0$   $15.68 \pm 0.05$ ,  $b_0$   $19.01 \pm 0.05$ ,  $c_0$   $4.03 \pm 0.01 \text{ \AA}$ ;  $\beta = 91^\circ 48' \pm 30'$ ; twinning on (100). The available good analyses on jamesonite with basal cleavage give the cell content:



Specific gravity 5.67 (calc.), 5.63 (meas.). The structural lattice is simply related to the geometrical elements of Slavík (1914); the cell content confirms the empirical formula derived by Loczka (1908) and reached independently by Schaller (1911).

#### THE STRUCTURAL SCHEME OF ATTAPULGITE

W. F. BRADLEY

The tendency of clays to form aggregates which exhibit preferred orientation can often be made use of to provide  $x$ -ray diffraction data not apparent in powder diffraction diagrams. Flaky aggregates of attapulgite formed by sedimentation from a suspension consist of fibrous particles whose fibre axes lie in the plane of the flakes. A series of patterns made with radiation incident at various inclinations to such flakes show fairly well developed arcs for reflections of the type  $hk0$  (the fibre axis being  $c$ ). The  $c$ -axis periodicity is about  $5.2 \text{ \AA}$ . Too little data are available for a complete solution of the structure, but a projection on to 001 of an idealized structural scheme consistent with the observed  $hk0$  interferences is proposed.

Attapulgité is probably monoclinic, probable space group  $C_{2h}^3-C2/m$  with  $a_0 \sin \beta = 12.9 \text{ \AA}$ ,  $b_0 = 18 \text{ \AA}$ . The ideal formula, derived from that of the amphiboles, can be written  $(OH_2)_4(OH)_2Mg_5Si_3O_{20} \cdot 4H_2O$ , there being two molecules to the unit cell. Partial replacement of  $Mg^{++}$  by  $Al^{+++}$  on a three for two basis is extensive but such replacement can probably not be complete. The structure is made up of amphibole-like chains running parallel to  $c$  (at  $00Z$  and  $22^{11}Z$ ) with each chain linked through oxygen at its corners to four neighboring chains. Interstitial chains of water molecules also parallel the  $c$ -axis and separate the amphibole chains.

The scheme is consistent with the fibrous nature of the material its clay habit, its optical properties, and its dehydration characteristics.

#### AN X-RAY INVESTIGATION OF THE SOLID PHASES OF THE SYSTEM $Cu_2S-CuS$

NEWTON W. BUERGER

A systematic  $x$ -ray study of the solid phases of the system  $Cu_2S-CuS$  has been made. A special camera was designed to make  $x$ -ray photographs of powder samples at high temperatures. This camera allows the specimen to remain heated continuously, and the heat treatment can be controlled as in a furnace. The resulting phase diagram shows that the system contains three compounds and six phases. The compounds are:

chalcocite, ideally  $Cu_2S$   
 digenite, ideally  $4Cu_2S \cdot CuS = Cu_9S_5$   
 covellite,  $CuS$

Chalcocite undergoes three transformations, and none of the high temperature phases is cubic up to at least  $250^\circ C$ . The revised inversion scheme is:

above  $105^\circ C$ ., non-isometric completely disordered basic structure  
 $78^\circ C$ . to  $105^\circ C$ ., non-isometric partially disordered basic structure  
 $52^\circ C$ . to  $78^\circ C$ ., non-isometric ordered basic structure  
 below  $52^\circ C$ ., orthorhombic superstructure.

The superstructure phase is capable of dissolving up to 8 atomic per cent  $CuS$  while the ordered basic structure can dissolve only 2 atomic per cent  $CuS$ . The experimental evidence indicates a hitherto unrecognized compound  $Cu_9S_5$ , whose powder pattern is essentially identical with that of the discredited mineral digenite, to which the formula  $2Cu_2S \cdot CuS = Cu_9S_5$  had been assigned. Below approximately  $47^\circ C$ . digenite has the ideal composition  $Cu_9S_5$ , but above this temperature it takes increasing amounts of either  $Cu_2S$  or  $CuS$  into its composition. Evidently digenite has been regarded as the phase of chalcocite stable above  $91^\circ C$ . Certain regions of the phase diagram of this system may be applied to problems of geologic thermometry, providing that proper criteria are recognized.

#### THE BARTLETT METEORITE, BELL COUNTY, TEXAS

FRED M. BULLARD

This nickel-iron meteorite, weighing 8.59 kilograms, was ploughed up in a field about 5 miles west of the town of Bartlett in Bell County, Texas, about 4 years ago. A polished and etched section showed well developed Widmanstätten figures. The meteorite is a medium octahedrite consisting essentially of grouped kamacite plates with narrow borders of taenite and smaller amounts of plessite, schreibersite, and troilite. A chemical analysis gave 90.41% iron, 8.88% nickel, and small amounts of cobalt and phosphorus. A spectrographic analysis showed small quantities of copper, silicon, and germanium in addition to the elements reported in the chemical analysis.

## THE CONCEPT OF UNIQUE DIAMETERS IN CRYSTALLOGRAPHY

J. DABNEY BURFOOT, JR.

A unique diameter is a line, or diameter, unlike any other in the crystal. All parallel lines are the same line crystallographically. All properties, physical, chemical, and crystallographic, along a unique diameter are different from those along any other line in the crystal.

Several criteria based on physical and chemical properties, the groupings of faces and angles between faces, and the dimensions of crystals may be used to recognize unique diameters. Likewise, laws controlling their distribution in crystals and their relations to the various elements of symmetry may be formulated. Since their arrangement in each crystal system is different from that in any other, except that the tetragonal and hexagonal are alike, unique and like diameters may be used to define the six crystal systems independent of symmetry and axes of reference, and the selection and orientation of axes of reference may be based on them.

Some of the applications and relationships of this concept are: (1) the assignment of crystals to systems without the use of symmetry or hypothetical axes of reference; (2) the easy selection of axes of reference; (3) the determination of the crystal system to which a mineral belongs from its cleavage fragment; (4) a clarification of some of the relationships and conditions observed in optical mineralogy; and (5) the simplification of the teaching of crystallography, especially in short courses where it is desirable to present only the commoner forms and not to discuss classes.

This concept elevates systems to a rank of prime importance in crystallography based on independent properties and not on hypothetical axes of reference or groupings of classes.

## PETROGRAPHY OF TWO IOWA LOESS MATERIALS

F. LEICESTER CUTHBERT

Two samples of loess material, selected by the Iowa State Highway Commission as being significant in highway construction, were investigated by several methods with the purpose of determining their mineralogical constitution. Although the materials are nearly similar as far as standardized highway laboratory tests are concerned, one affords a stable highway foundation while the other gives considerable difficulty, causing the slab to buckle and dip. Field examination revealed that the materials differed in their relation to a heavy gumbotil; one being located immediately above, and the other about ten feet above the gumbotil. The samples were fractionated by sedimentation and by a supercentrifuge. Chemical, x-ray, optical, and base-exchange studies were made on each of the colloidal separates obtained. The results show that one of the samples contains as its principal clay mineral, montmorillonite, while the other contains mixtures of kaolinite and illite. Evidence points to the conclusion that highway engineers must take into consideration both the geological positions of the materials to be used in subgrades and their clay mineral content.

## ELEMENTARY DERIVATION OF THE 230 SPACE GROUPS

J. D. H. DONNAY

Elementary derivations of the 32 crystal classes and 14 lattices are known. The extinction criteria of the lattice modes can be established by simple considerations (Friedel's *Leçons*, 1926); the same method holds for deriving the extinction criteria of the various kinds of glide-planes and screw-axes. From these criteria, the different types of zonal distribution (described elsewhere)<sup>1</sup> are graphically derived (with the aid of the reciprocal

<sup>1</sup> Donnay, J. D. H., Le développement des zones cristallines: *Ann. Soc. géol. de Belgique*, 61, B 260-287 (1938).

lattice): *simple zones*, either with unit-face dominant or with dominant shifted, and *double zones*, in which the dominant is always the unit-face. A simple search of all the permissible combinations of such zone types for each lattice mode in each crystal system leads to the 97 *morphological aspects*. Which space-group (or space-groups), in the several classes, correspond to any one aspect then becomes immediately apparent. The method naturally lends itself to the use of the international (Hermann-Mauguin) notation for space-groups, and leads to the appropriate symbols for all alternate crystal settings.

The morphological expression of the space-group symmetry is shown, by means of simple conventions, on a stereographic projection. This projection assumes further value as an unequivocal graphic representation of the *aspect* in a certain setting.

### SPECTROGRAPHIC STUDY OF CINNABAR

ROBERT M. DREYER

A quantitative spectrographic study of cinnabar from twenty quicksilver deposits has indicated the elemental content of quicksilver mineralizing solutions and the extent to which various impurities exist in solid solution in cinnabar. The study indicates that certain heavy metals are invariably associated with cinnabar ores (*viz.*, iron, chromium, manganese, silver, copper, zinc, nickel, germanium, lead, and cobalt). Of these elements, certain are markedly differentially concentrated (presumably in solid solution) in the cinnabar—namely, copper, lead, cobalt, germanium, and silver. Such concentrations are found regardless of geological or geographical occurrence. The varying shades of cinnabar coloration are found to be independent of the elements differentially concentrated in the cinnabar.

### A NEW PROJECTION-PROTRACTOR

D. JEROME FISHER

This projection protractor is made for either the stereographic or gnomonic projections. It is designed for general use with these projections, rather than solely for crystallographic purposes. It should therefore appeal to the field and laboratory geologist. Besides the usual stereographic and gnomonic scales drawn to spheres of radii 5 and 2 centimeters, it embraces a meridional stereographic half-net and a centimeter scale. It may be used as an ordinary protractor, straight-edge, scale, and right-angle triangle. It is available as an 8×20 centimeter rectangle on colorless transparent cellulose acetate .025 inch thick

### THE BINARY SYSTEM: $\text{NaAlSi}_3\text{O}_8$ - $\text{CaSiO}_3$

W. R. FOSTER

A study of the equilibrium relations of the binary system carnegieite, nephelite-pseudowollastonite, wollastonite has been made as part of an investigation of the ternary system carnegieite, nephelite-pseudowollastonite, wollastonite-albite. The liquidus and sub-liquidus relations, and their petrological significance, are discussed.

### EXSOLUTION GROWTHS OF ZINCITE IN MANGANOSITE

CLIFFORD FRONDEL

Manganosite crystals from Franklin, N. J., contain thin plates of zincite intergrown along octahedral planes. The two minerals are mutually oriented, with zincite {0001} [10 $\bar{1}$ 0] parallel to manganosite {111} [110]. This position of orientation marks an exact coincidence in crystal structure of the two minerals. The zincite apparently has exsolved from the manganosite.

## REDEFINITION OF TELLUROBISMUTHITE

CLIFFORD FRONDEL

Tellurobismuthite, long considered a variety of tetradymite, is a distinct species. Composition of unit cell  $\text{Bi}_2\text{Te}_3$ ; rhombohedral, with  $a_0=4.43 \text{ \AA}$  and  $\alpha=57^\circ 11'$ ;  $G=7.66$  (calc.), 7.65 (meas.); perfect cleavage {0001}. Ten localities are cited. Vandiesitte, a supposed telluride of Bi and Ag from Colorado, is shown to be a mixture of tellurobismuthite and hessite. X-ray powder data and polished section data are summarized for tellurobismuthite, tetradymite, gruenlingite, joseite and wehrlite.

## THE RADIOACTIVITY OF SEDIMENTARY ROCKS AND ASSOCIATED PETROLEUM\*

CLARK GOODMAN, K. G. BELL, AND W. L. WHITEHEAD

Determinations of the radioactivity of 21 sedimentary rocks and 7 associated crude oils have been made by the precision method developed by R. D. Evans (1). The specimens consisted of cuttings and cores from wells in the Bartlesville, Cromwell, Frio, Woodbine and Viola-Simpson formations. Considerable variability in radioactivity was found in the sandstones ( $1.4$  to  $0.19 \times 10^{-12}$  gms Ra/gm) and limestones ( $1.3$  to  $0.18 \times 10^{-12}$  gms Ra/gm). The radium content of limestones decreases with increasing purity. The shales were quite uniform ( $1.2$  to  $1.0 \times 10^{-12}$  gms Ra/gm). Apparently, discrete mineral particles in sandstone and impurities in limestone account for their occasional high radioactivity. The radon content of the crude oils ( $0.47$  to  $0.05 \times 10^{-12}$  curies/gm of oil) was in one sample 38 times, and averaged 10 times, the amount in equilibrium with the radium present. The results corroborate the inferences of former investigators that radon tends to concentrate in crude oils. Maximum radon content and maximum ratio of radon to radium were found in petroleum produced from a permeable, Oligocene (Frio) sandstone of high radioactivity. Cracking of hydrocarbons with generation of hydrogen has been proved by S. C. Lind (2) to result from bombardment with alpha rays. The amounts of radioactivity found in these crude oils are quantitatively sufficient to cause appreciable cracking by alpha radiation during geologic time. These reactions, together with subsequent hydrogenation, may account for important changes in petroleum. This hypothesis would also explain the presence of hydrogen in some natural gases. The hydrogen content of soil gases is suggested as a possible method of geophysical prospecting for oil fields.

(1) Evans, R. D., *Rev. Sci. Inst.*, **6**, 99-112 (1935).

(2) Lind, S. C., "The Chemical Effects of Alpha Particles and Electrons," Chemical Catalog Co. (1928).

\* Presented through the Society of Economic Geologists.

## TUNGSTEN ARCS\*

PAUL F. KERR

The tungsten deposits of the Cordillera of the United States define three belts for convenience designated as *tungsten arcs*: (1) extending from southern California to eastern Washington; (2) extending from southern Arizona to eastern Idaho; and (3) extending from Silverton, Colorado, to the Black Hills. More important tungsten localities along the arcs are:

*Western arc*—California: Atolia, Posey, Pine Creek, Tungsten Hills.  
 Nevada: Silver Dyke, Nightingale, Oreana, Mill City.  
 Oregon: Baker-Wallowa Mountain.  
 Washington: Germania.

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*Central arc*—Arizona: Dragoon, Las Guijas, Boriana.

Nevada: Snake Range.

Idaho: Lemhi

*Eastern arc*—Colorado: San Juan, Boulder.

South Dakota: Black Hills.

The western arc is perhaps connected with later phases of Nevadian orogeny, the central and perhaps the eastern arcs with Laramide. In each district the mineralization shows a relationship to the trend of the respective arc and suggests influence of an underlying igneous source.

Deposits are apparently confined to areas of actual or proximate igneous activity. The immediate contact is frequently barren. Aplite and pegmatite dikes or quartz veins favor concentration evidently as conduits from magmatic sources. Conduit bodies frequently contain traces but rarely concentrations of tungsten minerals. Field examination with ultra-violet light evidences the connection between ore formation in a host rock, scheelite bearing aplitic conduits, and adjacent granitic intrusives.

Considerable deposits may consist chiefly of scheelite, wolframite, hübnerite or ferberite ores but the psilomelane or limonite type may prove to be important. Tungsten-bearing minerals occur in hot spring deposits, in quartz veins, in pegmatite dikes, in greisen zones and in contact metamorphic deposits. Ca-tungstate predominates in the western arc with the exception of Germania. Ca-, Fe-Mn-, and Mn-tungstates are important in the central arc. Fe-, Mn-, and Fe-Mn-tungstates are most abundant in the eastern arc.

#### FURTHER STUDIES ON THE VARIATION OF HARDNESS IN THE DIAMOND

EDWARD H. KRAUS AND CHESTER B. SLAWSON

Approximate hardness curves for certain crystal faces of the diamond are indicated, and the areas of optimum cutting and those which resist cutting are delimited.

#### THE GEOGRAPHIC CLASSIFICATION OF ANALYSES OF METAMORPHIC AND IGNEOUS ROCKS\*

EDWARD B. MATHEWS

The ambitious undertaking supported by grants from the Geological Society is now well advanced and it has been deemed advantageous to present to the Fellows of the Society something of the manner of procedure and the results obtained, and how the results may be serviceable before the undertaking is completed.

One of the largest published collections of chemical analyses of rocks is that in Professional Paper 99 which carried analyses published before 1913. This contains something over 9000 analyses. The present collection which is to be carried to 1940 already contains between 30,000–40,000 analyses grouped in single degree units. Since the sources are indicated this work may well serve as a series of bibliographies of small geographical units, and a geologist going into a new region may readily secure a clue to practically all the available literature sufficiently detailed to have analyses of rocks.

The method of classification, some of the difficulties encountered in securing the location of the samples analyzed and some suggested improvements which can be made by authors in the future will be discussed if time permits.

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## THE ISODIMORPHOUS SERIES, VARISCITE-METAVARISCITE

DUNCAN MCCONNELL

Through the use of x-ray methods the minerals starred have been referred definitely to an isodimorphous series.

Orthorhombic	Monoclinic ( $\beta \rightarrow 90^\circ$ )	Composition
*Variscite	Metavariscite	$\text{AlPO}_4 \cdot 2\text{H}_2\text{O}$
*Barrandite	—	$(\text{Al}, \text{Fe})\text{PO}_4 \cdot 2\text{H}_2\text{O}$
—	Vilateite	$(\text{Fe}, \text{Mn})\text{PO}_4 \cdot 2\text{H}_2\text{O}$
*Strengite	*Phosphosiderite	$\text{FePO}_4 \cdot 2\text{H}_2\text{O}$
*Scorodite	—	$\text{FeAsO}_4 \cdot 2\text{H}_2\text{O}$

The axial ratios, optical properties, etc., permit the classification of the substances for which x-ray data have not been obtained. A more complete investigation will probably reveal that several poorly known substances are to be associated with this series.

## DESCENT OF PLAGIOCLASE-RICH CORUNDUM BEARING PEGMATITES FROM DESILICATED GRANITE AT GLEN RIDDLE, PA.

ADOLPH E. MEIER

Two divergent opinions are held on the origin of albitites and plumasites (corundum-plagioclase bearing dikes). Du Toit, Gordon and Cobb favor a process of desilication of high silica pegmatites by reaction with basic wall rock. Larsen believes that they possess a hydrothermal mode of origin. Analogous types occurring as dikes or hydrothermal veins at Glen Riddle are rich in oligoclase where flanked by serpentine (meta-pyroxenite), and rich in andesine, oligoclase and corundum where associated with narrow dikes of gabbro previously emplaced in pyroxenite.

On the basis of a recent study of relations between the local hornblende granite, meta-pyroxenite and gabbro<sup>1</sup> and of more detailed work on the granite now in progress, it is believed that desilication and hydrothermal replacement have both played a significant role in the formation of the plagioclase-rich dikes and of the corundum found in the types mentioned.

Sufficient data has been collected thus far in three typical exposures to show that in comparatively large masses of granite the magnesium content increases and the quartz content of the latter decreases from the center of the mass to the bordering meta-pyroxenite. Where granite stringers or tongues narrow down to ten feet or less the quartz content is reduced to two per cent.

The conclusions to be drawn are that a process of desilication took place during an early stage of granitic intrusion as a direct result of assimilation of the invaded pyroxenite. As a result of this chemical conditioning the granitic exudates carried a high concentration of alkalis which filtered into the country rock, and produced veins analogous to plumasites by hydrothermal reaction with previously emplaced gabbro, and types analogous to albitites where pyroxenite alone was the host rock.

<sup>1</sup> Corundum in a dike at Glen Riddle, Pa: Tomlinson, W. H., *Am. Mineral.*, **24**, 339-343 (1939).

Association of harmotome and barium feldspar at Glen Riddle, Pa.: Meier, A. E., *Am. Mineral.*, **24**, 540-560 (1939).

## THE CRYSTALLOGRAPHY OF ULEXITE

JOSEPH MURDOCH

Measurable crystals of ulexite discovered at Kramer, California, show that the mineral is triclinic, with the following elements:



$a:b:c$	0.68553:1:0.51911	
$\alpha=90^{\circ}16'$	$\beta=109^{\circ}08'$	$\gamma=105^{\circ}07'$
$p_0:q_0:r_0$	0.78523:0.50804:1	
$\lambda=84^{\circ}20\frac{1}{2}'$	$\mu=70^{\circ}05\frac{1}{2}'$	$\nu=73^{\circ}53\frac{1}{2}'$
$p'_0=0.83514$	$q'_0=0.54032$	
$x'_0=0.34662$	$y'_0=0.10483$	

The crystals occur as an irregular network of prismatic forms in a matrix of borax and clay. They are sometimes as much as five mm. long, though few terminated crystals are this size. In general the shape of the crystals is lath-like, with elongation 3–4 times the short dimension. The consistently broad face in the prism zone is (100), and other common faces here are (010) (110) and (1 $\bar{1}$ 0). (130) (350) (3 $\bar{1}$ 0) and (120) were also seen. Terminal faces, in order of frequency, are ( $\bar{1}\bar{1}$ ) (0 $\bar{1}$ 1) (001) ( $\bar{1}$ 11) ( $\bar{1}$ 01), the form ( $\bar{1}\bar{1}$ 1) appearing on practically every crystal.

#### THE TERNARY SYSTEM AKERMANITE--GEHLENITE--PSEUDO-WOLLASTONITE

E. F. OSBORN AND J. F. SCHAIRER

Phase equilibrium studies on the ternary system with the melilite molecules akermanite and gehlenite and a simple pyroxene,  $\text{CaSiO}_3$ , have just been completed. Akermanite and gehlenite form a complete series of solid solutions, but no appreciable solid solution exists between  $\text{CaSiO}_3$  and either akermanite or gehlenite. There is no ternary eutectic, but a minimum at  $1302 \pm 2^{\circ}$  with two solid phases present—a melilite (solid solution of akermanite and gehlenite) and pseudo-wollastonite. For some mixtures in this system, as crystallization proceeds melilite crystals are first enriched in akermanite, then reverse and become enriched in gehlenite.

#### CUPROBISMUTITE—A MIXTURE

CHARLES PALACHE

Cuprobismutite is shown by a study of the type material to be a mixture of three minerals—empectite, bismuthite, and chalcocopyrite. Crystals of the two first-named minerals were measured.

#### MICROLITE FROM TOPSHAM, MAINE

CHARLES PALACHE AND F. A. GONYER

An analysis and physical description is given of a new occurrence of microlite which had previously been mistaken for gahnite.

#### RAMMELSBERGITE AND PARARAMMELSBERGITE, DISTINCT ORTHORHOMBIC FORMS OF $\text{NiAs}_2$

M. A. PEACOCK

Rammelsbergite from Schneeberg, Saxony (type locality) and Eisleben, Thuringia, gives identical  $x$ -ray powder photographs. The specimen from Eisleben is compact, fibrous to lathy, tin-white, with bright narrow cleavage planes. The polished section is white, homogeneous, hard, strongly anisotropic. With the fibre axis vertical Weissenberg photographs give orthorhombic symmetry; holohedral space group  $Pmmn$ ;  $a_0$  3.53,  $b_0$  4.78,  $c_0$  5.78 Å. Twin plane (110); cleavage {110}. The unit cell contains  $\text{Ni}_2\text{As}_4$ .  $G$  7.06 (calc.), 6.9–7.158 (Dana). These structural data conform to the meagre geometrical data (Dürrfeld, 1911), and show the expected similarity to those of marcasite (Buerger, 1931).

Recently described materials provisionally named rammelsbergite (Peacock and Michener, 1939), from Cobalt, Ontario, and Elk Lake, Ontario, give identical  $x$ -ray powder photographs unlike those of from Schneeberg and Eisleben. The specimens are compact,

tin-white, with small bright cleavage areas. The polished sections are white, homogeneous, hard, strongly anisotropic. Analysis: Ni 28.1, Co 0.4, As 68.5, S 2.6=99.6. Weissenberg photographs give orthorhombic (or pseudo-orthorhombic) symmetry; apparent holohedral space group *Pbma*;  $a_0$  5.74,  $b_0$  5.81,  $c_0$  11.405 Å; twinning not observed; cleavage {001}. The unit cell contains  $Ni_8As_{16}$ .  $G$  7.24 (calc.); 7.12 (meas.). The Canadian mineral is thus a distinct species for which the name *pararammelsbergite* is proposed.

The cell-edges of rammelsbergite and pararammelsbergite are not simply related to the cube-edge of smaltite-chloanthite (Oftedal, 1925), supposed to have the composition (Co, Ni) $As_2$ .

#### RECONNAISSANCE OF THE CONTACT METAMORPHISM OF THE KATAHDIN GRANITE

SHALER S. PHILBRICK

The Katahdin granite, an intrusive some 60 miles long, in Piscataquis and Penobscot counties, Maine, has been found to have metamorphosed its country rock, a series of slates and thin interbedded quartzitic sandstones of varying composition, with the development of hornfels and schist. Near the igneous contact considerable aplitic material has been injected in veinlets and pygmatic folding and brecciation have been produced in the hornfels. The reconnaissance has been confined to the southern and southwestern portions of the intrusive where a belt of metamorphics some 35 miles in length has been noted outcropping on several mountain ranges. The metamorphics are strikingly similar in general character to those found about 10 miles to the south in the three zoned aureole surrounding the Onawa pluton, a small body about 11 miles long. The greater size of the Katahdin granite, as far as can be determined at this time, seems not to have comparably influenced the degree or lateral extent of the metamorphism.

Keith has mapped a belt of Cambrian or Ordovician rocks along the boundaries of the Katahdin granite in the area under consideration and also surrounding the Onawa pluton. In the latter case the writer believes that these rocks are the common Silurian of central Maine metamorphosed by the Onawa pluton. Those bounding the Katahdin granite here may, or may not, be pre-Silurian but since their metamorphic character is attributed mainly to contact with the granite it is assumed, in the absence of paleontologic evidence to the contrary, that they are Silurian and the same age as the common slate series of central Maine.

#### THE BINARY SYSTEM: ALBITE (NaAlSi<sub>3</sub>O<sub>8</sub>)-SPHENE (CaTiSiO<sub>5</sub>)

A. T. PRINCE

The liquidus curve of the binary system, albite-sphene, has been determined as part of an investigation of the ternary system, albite-anorthite-sphene. The character of the curve and its petrological significance are discussed.

#### THE CRYSTAL SYSTEM AND UNIT CELL OF ACANTHITE, Ag<sub>2</sub>S

LEWIS S. RAMSDELL

Preliminary data obtained from twinned acanthite crystals by means of Weissenberg photographs indicate a monoclinic unit cell, with  $a=4.20$ ,  $b=6.93$ ,  $c=9.50$  Å, and  $\beta=55^\circ$ .

#### CRYSTALLOGRAPHY OF DOLEROPHANITE

W. E. RICHMOND AND C. W. WOLFE

Dolerophanite,  $Cu_2SO_5$ , from the type locality has been re-examined. An  $x$ -ray study establishes the validity of the Goldschmidt orientation. The mineral is figured in this position.

## ZONES, ZONE-BUNDLES, AND CRYSTAL SYSTEMS

AUSTIN F. ROGERS

Zones are not sufficiently emphasized in elementary work. The use of a linear projection combined with a front elevation provides a simple method of showing the relation between face-indices and zone-indices.

All the possible zones of crystals are included under four types: clinogonal, orthogonal, hexagonal, and tetragonal, which are defined in terms of the interfacial angles that remain constant with a change of temperature.

A zone-bundle is a series of zones with one face in common and may be defined by its interzonal angles. Six kinds of zone-bundles are recognized: tetragonal, hexagonal, orthogonal of two kinds, and clinogonal of two kinds.

Zones furnish a simple, accurate method of defining crystal systems:

- Triclinic: All zones are clinogonal.  
 Monoclinic: A symmetry direction (a symmetry axis or a line normal to a symmetry plane) is a clinogonal zone-axis.  
 Orthorhombic: Three orthogonal zones at right angles to each other.  
 Tetragonal: A single tetragonal zone.  
 Hexagonal: A single hexagonal zone.  
 Isometric: Three tetragonal zones and four hexagonal zones.

All crystals of a given crystal system have the same kind of normal zone-pattern, which may be defined as the complex of nine zones with the simplest indices or 13 zones if four axes of reference are used.

Since the 12 symmetry classes with a single hexagonal zone all have the same kind of normal zone-pattern, there are six crystal systems and not seven.

## THE RARER METALLIC CONSTITUENTS OF SOME AMERICAN IGNEOUS ROCKS

E. B. SANDELL AND S. S. GOLDICH

This paper is a preliminary report of an investigation of the less abundant heavy metals in igneous rocks. Copper, lead, zinc, cobalt, nickel, and molybdenum were determined in 31 samples using semi-micro-chemical methods. The analyzed samples represent three igneous areas in central United States and are distributed as follows: from the Llano (Central Mineral) region of Texas, 7; from the St. Francois Mountains of Missouri, 7; from central and northern Minnesota, 17. In addition cobalt and nickel determinations were made on 19 samples of the Keweenaw flows from the Michigan copper district. The distribution of cobalt and nickel in the Kearsarge and in the Greenstone flows is discussed and correlated with Broderick's findings for copper and for the major rock constituents. The data are presented in tables and in a series of diagrams.

## A PROBABLY NEW PHOSPHATE-SULPHATE OF ALUMINUM FROM UTAH

WALDEMAR T. SCHALLER

A scaly white mineral, like alunogen in appearance and in its properties, was collected in the Tintic Standard mine, Dividend, Utah, along with many other secondary sulphates. The mineral, intimately associated with halotrichite, siderotile, and szomolnokite, is readily soluble in cold water from which solution when warmed a curdy white precipitate forms. On cooling, the precipitate disappears, the solution becoming clear again.

Analyses of two different samples yielded the same formula,  $2\text{Al}_2\text{O}_3 \cdot 4\text{SO}_3 \cdot \text{P}_2\text{O}_5 \cdot 24\text{H}_2\text{O}$  which might be interpreted as a phosphorian alunogen, with one-third of the sulphate replaced by phosphate on the basis of considering  $[\text{SO}_4]$  and  $[\text{HPO}_4]$  as equivalent, as follows:

Alunogen	$\text{Al}_2(\text{SO}_4)_3 \cdot 16\text{H}_2\text{O}$	or $2\text{Al}_2\text{O}_3 \cdot 6\text{SO}_3 \cdot 32\text{H}_2\text{O}$
Phosphorian alunogen	$\text{Al}_2(\text{SO}_4)_2(\text{HPO}_4) \cdot 16\text{H}_2\text{O}$	or $2\text{Al}_2\text{O}_3 \cdot 4\text{SO}_3 \cdot \text{P}_2\text{O}_5 \cdot 33\text{H}_2\text{O}$
Mineral	$\text{Al}_2(\text{SO}_4)_2(\text{HPO}_4) \cdot 11\frac{1}{2}\text{H}_2\text{O}$	or $2\text{Al}_2\text{O}_3 \cdot 4\text{SO}_3 \cdot \text{P}_2\text{O}_5 \cdot 24\text{H}_2\text{O}$

The mineral however contains less total water than a phosphorian alunogen, the ratio of  $\text{P}_2\text{O}_5$  to  $\text{SO}_3$  is definite (1:4), two different samples have the same composition, and most important, the mineral loses no water at  $105^\circ$  whereas alunogen loses 30 per cent or  $\frac{2}{3}$  of its total water at  $105^\circ$ . The mineral therefore seems to be a new species and not merely a variety of alunogen.

#### A METHOD FOR MAKING ACCURATE DRAWINGS OF CRYSTALS

WALDEMAR T. SCHALLER

Accurate crystal drawings may be made by photographing a crystal in the positions corresponding to the orthographic and clinographic projections. The crystal is adjusted in polar position on the goniometer and its correct position before the camera determined by various means. The photographs are enlarged to the proper size and the lengths of the intersection edges measured and transferred to the drawing, or they may be inked in on the enlargement and the crystal drawing traced off. Illustrated by examples.

#### LARGE SANIDINE CRYSTALS FROM UTAH

BRONSON STRINGHAM AND NORMAN C. WILLIAMS

Sanidine is often present in small monzonite intrusives of the Stockton-Tooele area of the Oquirrh Mountains, Utah. Two localities are of special interest because of the large size of the crystals and the ease with which they are separated from the parent rock. One mile south of Tooele in a small sill, sanidine crystals averaging three centimeters in length are easily procured. These crystals, grayish in color, exhibit faces conventional to orthoclase which is elongated parallel to  $a$ . Carlsbad twins are abundant and of unusual shape since the elongation of  $a$  is not sacrificed for elongation parallel to the prism. The gray color is due chiefly to inclusions consisting of calcite and small andesine crystals. The latter are often grouped in rows parallel to the growth lines of the host.

The second occurrence has been exposed by a water development tunnel in Pine Canyon north of Tooele. Large single crystals elongated parallel to  $a$ , and Carlsbad twins are abundant. They are gray in color and average eight centimeters in length with some reaching eleven centimeters. Although most crystals exhibit excellent forms, many are rounded due to resorption.

#### THE MORPHOLOGY OF COLUMBITE CRYSTALS

E. D. TAYLOR

By the morphological method of Donnay (1938), the space-group of columbite (Fe, Mn) (Nb, Ta) $_2\text{O}_6$  is found to be  $Pman$ , in a new setting ( $a:b:c=0.4023:1:0.3580$ ) chosen so as to comply with the convention  $c < a < b$ . (Transformations: Taylor to Dana= $010/300/00\bar{3}$ . Taylor to Sturdivant= $00\bar{1}/0\bar{1}0/\bar{1}00$ .) According to x-ray results (Sturdivant, 1930; confirmed by Peacock, 1939, unpublished), the space-group is  $Pcan$  (in the same setting). The conflict lies in the interpretation of the zone [100]: the morphology indicates (100) to be a mirror plane of symmetry, whereas x-rays unquestionably show it to be a  $c$  glide-plane. This is the first clear case of disagreement between the morphological and the structural results.

Although the available data concerning the faces (0 $kl$ ) are scarce, they cannot be reconciled with a  $c$  glide-plane at all. That the structural arrangement might simulate a

mirror plane where a glide-plane actually exists is a plausible hypothesis which, however, cannot be substantiated at present.

As to the prediction of relative form importances, the classical Law of Bravais does not agree with the observed facts as well as the generalized law (Donnay-Harker, 1937) which, although not perfect, is decidedly better.

#### SLIDES SHOWING MINERAL ASSOCIATIONS OF CORUNDUM

W. HAROLD TOMLINSON

Three slides showing association of corundum in ultra-basic rocks.

Three slides showing association of corundum in syenites.

#### THE RELATIONSHIP BETWEEN THE CRYSTAL STRUCTURES OF THE GOLD-SILVER TELLURIDE MINERALS, SYLVANITE, KRENNERITE, AND CALAVERITE

GEORGE TUNELL

The crystal structures of the gold-silver telluride minerals, sylvanite, krennerite, and calaverite, are fundamentally related, although they crystallize in three different space-groups. In all three minerals pairs of tellurium atoms occur between metal atoms (gold or silver) along a set of parallel lines. The coordination is octahedral in all three minerals, but the nearest neighbors of a tellurium atom are in some cases three metal atoms and three telluriums, in others one metal and five telluriums, and finally in others five metal atoms and one tellurium; the nearest neighbors of each metal atom are in all cases six telluriums. New chemical analyses\* of krennerite and new pycnometric determinations of its density have been carried out on pure faceted crystals identified by measurement on the two-circle reflection goniometer in order to clear up uncertainties in the literature concerning these points.

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\* The chemical analyses were made by K. J. Murata in the U. S. Geological Survey.

#### CONTACT METAMORPHISM AT RYE PATCH, NEVADA

CHARLES J. VITALIANO

The area under discussion is situated in the west central part of the Humboldt Range. Westward dipping sediments occur, consisting largely of Triassic (?) limestone interbedded with an occasional thin layer of a more shaly nature. These sediments have been intruded by two different types of igneous rocks. The earlier intrusive is of a granitic nature. It occurs as a small, irregular intrusive, sill-like in part, probably connected in depth with the Rocky Canyon intrusive which occurs farther south in the Humboldt Range. The second intrusive type is a porphyry of a basic nature occurring in dikes which cut across the bedding of the limestone.

Both types of intrusives are surrounded by an aureole of contact metamorphism. In addition, a long narrow area of contact metamorphism extends northward a considerable distance from the granitic intrusive. The changes produced in the sediments range from the recrystallization of the limestone to the development of typical contact silicates. The area has been mapped in detail in order to establish the areal distribution of metamorphism with relation to the intrusive. Microscopic studies have been made to establish the sequence of mineralization and selectivity of metamorphism for certain strata.

## GEM CORDIERITE FROM THE GREAT SLAVE LAKE AREA, N. W. T. CANADA

ROBERT E. FOLINSBEE

Transparent cordierite, pleochroic from an intense blue to clear yellow, occurs north of Great Slave Lake in garnet sillimanite gneiss and associated lens-like pegmatitic injections. Single prismatic crystals attain a size of 4 by 2 by 2 inches. These crystals are fractured but yield many fragments of gem size and quality.

New complete chemical analyses of the garnet and of the cordierite are presented. An endeavor is made to establish a correlation in the chemical composition of these minerals and to relate the optical and physical properties of each with their chemical composition. An unusual type of lamellar twinning in the cordierite, resembling albite twinning in the plagioclase series, is noteworthy.

Among those who were present at the scientific sessions of the Society were:

Adam, P. A. M.	Grim, R. E.	Parsons, W. H.
Alexander, H. S.	Grout, F. F.	Peacock, M. A.
Allen, V. T.	Gruner, J. W.	Philbrick, S. S.
Ayres, V. L.		Prince, A. T.
	Ham, W. E.	
Bateman, A.	Hurlbut, C. S.	Quinn, A.
Bennett, M. G.		Quirke, T. T.
Bergquist, S. G.	Johnson, C.	
Berman, H.	Johnston, W. D.	Ramsdell, L. S.
Berry, L. G.		Rinn, H. W.
Bowen, N. L.	Keppel, D.	Robertson, H.
Bradley, W. F.	Kerr, P. F.	Rogers, A. F.
Bruce, E. L.	Koschmann, A. H.	Rowan, J. J.
Buddington, A. F.	Kraus, E. H.	Rutherford, R. L.
Buerger, N. W.		
Bullard, F. M.	Lamar, J. E.	Sandell, E. B.
	Larsen, E. S.	Schwartz, G. M.
Chapman, C. A.	Lonsdale, J. T.	Singewald, Q. D.
Church, V.	Louisell, J.	Slawson, C. B.
	Lovering, T. S.	Stanley, W.
Donnay, J. D. H.		Stewart, D.
	Mather, L. B.	Syme, O. T.
Eckman, P.	Mayo, E. B.	
Emmons, R. C.	McConnell, D.	Tatge, E.
	Moore, E. S.	Thomson, E.
Fisher, D. J.	Morton, J. F.	Tolman, C.
Foster, W. R.	Murdoch, J.	Tunell, G.
		Turner, D. S.
Gardiner, L.	Nelson, G.	
Gates, R. M.		Upton, C. G.
Goldich, S. S.	Ohle, E. L.	
Graton, L. C.	Osborn, E. L.	Williams, M. E.
Grawe, O. R.	Park, C. F.	Winchell, A. N.