PRESENTATION OF PAPERS

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METHODS AND INSTRUMENTS USED IN MINERALOGY

FRED. E. WRIGHT

Experience has shown that progress in any branch of science involving measurement and experiment depends in large degree upon the development of methods and apparatus appropriate to the attack on specific problems as they arise. Mineralogy is no exception to this rule. Its record shows that with the introduction of each important new method or instrument new fields of research have been opened and deeper insight into its problems has been obtained. Mineralogy, on the one hand, describes and classifies the various kinds of minerals that occur in the earth's crust and in meteorites; to that extent is is a branch of natural history. On the other hand, in the study of minerals many of the methods of physics and chemistry are employed and these imply measurements with the aid of suitable apparatus; to this extent mineralogy enters the field of exact science. The data obtained by mineralogists by use of physical and chemical methods are subject to the same criteria that apply to research work in exact science. In this paper a brief survey will be made of the more important methods and instruments used in mineralogy with special reference to their range of application, their degree of accuracy, and their usefulness.

THE LEAD-URANIUM-THORIUM RATIOS OF VARIOUS ZONES OF A SINGLE CRYSTAL OF URANINITE FROM SPRUCE PINE, NORTH CAROLINA

CHESTER M. ALTER AND EARL S. McCOLLEY

It has been shown by investigations in our laboratory that the lead-uranium-thorium ratio may vary in different regions of a single crystal of uraninite. This fact has important bearing on the usefulness of such data for calculating the age of minerals. By a technique of removing successive layers or zones from the surface of crystals and analyzing the removed material, it has been possible to study these variations. Work already published indicates that this variation may be quite substantial as in the case of uraninite from Wilberforce, Ontario.

In order to further study this phenomenon, a selected crystal of uraninite from Spruce Pine, Mitchell County, North Carolina, was treated by the method described by Alter and Yuill. In this case, the crystal was divided into three zones, namely, outside, middle, and core. Each zone was analyzed separately for acid-insoluble material, lead, uranium, and thorium. From these data the lead-uranium-thorium ratio and the age of the mineral can be calculated.

The following table gives a summary of analytical data:

Zone	% acid-insol.	% Pb	% U	% Th	$\frac{Pb}{U+0.36\,Th}$	Approx. Age (million years)
Outside	2.06	3.19	67.65	0.03	0.0471	358
Middle	1.78	3.40	69.92	.14	.0486	369
Core	1.52	3.50	69.65	.04	.0503	382

The results show fair agreement with analyses of Spruce Pine uraninite reported by Hillebrand and by Boltwood many years ago. The variation in the thorium content of the middle zone and the core is of the same type as that already noted in the Wilberforce crystals, although the thorium content here is much smaller.

THE SYSTEM $CaO-SiO_2-P_2O_5$

RICHARD L. BARRETT AND WILLIAM J. McCAUGHEY

The system contains in addition to the binary phases previously described in the literature, two ternary phases, nagelschmidtite and silicocarnotite which have been previously known as constituents of certain slags. The equilibrium diagram presents some features of special interest. The field of cristobalite is very large. There is an extensive region of liquid immiscibility in which two liquids in equilibrium with cristobalite are formed. Very extensive solid solution prevails in the four phases, calcium orthosilicate, nagelschmidtite, silicocarnotite, and tricalcium phosphate, which form a binary system with the first and last named as end members. Calcium orthosilicate may contain up to 10% P_2O_5 in solid solution, and nagelschmidtite, the formula for which may be expressed $Ca_7Si_2P_2O_{16}$, can have a P_2O_5 content varying between 12% and 24%. The solid solution seems to be of the substitution sort with PO_4 groups replacing SiO_4 groups. In both phases refractive indices decrease as P_2O_5 content increases.

NATURE AND ORIGIN OF THE EDWIN CLAY, IONE, CALIFORNIA

THOMAS F. BATES

The Edwin clay occurs near Ione, California, thirty miles southeast of Sacramento. It is a residual clay of commercial importance found in but two places near Ione. On the east it is separated from the Mariposa formation, which forms the Sierra Nevada foothills, by a linear, northwest-southeast trending trough containing the anauxite-bearing sedimentary clays and sands of the Ione formation of Eocene age. West of the Edwin clay and forming the western limit of the trough is a prominent outlying ridge of greenstone of the Mariposa formation. It is separated from the clay by a narrow belt of red laterite.

The Edwin clay is a highly refractory kaolin clay used for the manufacture of fire brick. It varies from white to various shades of pink, blue, or gray; and is crumbly, brittle, or plastic.

Heretofore, it has been regarded as one of the sedimentary clays of the Ione formation. However, recent field work, microscopic study, and evidence secured from firing tests show that the Edwin clay has been derived directly from the laterite. Transitions observed in the field, similar textures, and other evidence suggest that the laterite is intimately connected with the greenstone.

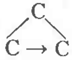
THE STRUCTURE OF METHYLENECYCLOBUTANE AND HEXAMETHYLETHANE

L. H. BAUER AND J. Y. BEACH

We undertook this electron diffraction study with the view of verifying the presence of 90°C.-bond angles in methylenecyclobutane, and establishing the relative orientation of the methyl groups in hexamethylethane. Our results may be summarized as follows:

Methylenecyclobutane:—the carbon atoms are coplanar, four of them situated at the corners of a square (1.56±.03 Å on side), the fifth on an extension of one of the diagonals (1.34±.02 Å from the carbon atom in the ring).

Although some investigators expressed doubt as to the possible synthesis of spiropentane, stating that such attempts generally lead to methylenecyclobutane, it is clear from a comparison of our curves with the data of Rogowski (who claims he obtained electron diffraction photographs of the spiro compound), that he did not have methylenecyclobutane, and that very likely he did have spiropentane. However, due to the incomplete description of his photographs, it is not possible to state definitely that he did not have either vinylcyclopropane or 2-methylcyclobutane (1).

Hexamethylethane:—the radial distribution curve shows two sharp peaks, one at 1.53− Å (as expected for C–C), and another at 2.55 Å (somewhat larger than expected for  $\begin{smallmatrix} & C & \\ \diagup & & \diagdown \\ C & \rightarrow & C \end{smallmatrix}$), suggesting that the central C–C bond distance is somewhat stretched. Due to the possibility of hindered rotation about this bond, we made careful intensity calculations, using (Z–f) and temperature factors, and the approximate formulas developed by

Debye for free rotations and tortional oscillations. Although the curves for free rotation, eclipsed and staggered configurations differ by very little, agreement with observation is slightly better for the staggered model. However, regardless which of these models one uses, assuming that the central C–C bond is somewhat stretched (1.58±0.02 Å) improved the correlation with the observed curve. The other distances are: C–C=1.54±.02 Å; carbon valence angles 110°±2°; C–H=1.09 Å (assumed).

The approximations made in the above calculations will be enumerated and a more accurate graphical method will be presented for discussion.

EVALUATION CRITERIA

HARRY BERMAN

Significant phases of the papers on diamond will be briefly summarized. The various factors that may lead to the formulation of criteria for the evaluation of industrial diamonds will be discussed. Problems involving further study and research will be suggested.

ANALYSIS AND AGE OF MONAZITE FROM DEER PARK NO. 5 MINE, SPRUCE PINE, NORTH CAROLINA

ALLEN D. BLISS

The above-named sample of monazite collected by Professor Adolph Knopf has been analyzed for uranium, thorium, and lead by Fenner's procedure, giving for thorium 4.81 and 4.86%; lead, 0.131 and 0.134%; and a very small amount of uranium (if any), 0.01%. Calculation of the age by the use of the logarithmic formula gives 600 million years.

DISTRIBUTION OF MINOR CHEMICAL ELEMENTS IN TERTIARY DIKE ROCKS OF THE FRONT RANGE, COLORADO

JOSEPH M. BRAY

Qualitative and quantitative spectrographic analyses determining the minor chemical constituents in a number of Colorado Front Range Tertiary dike rocks and their constituent minerals revealed a number of interesting relationships. The rocks analyzed were mainly monzonites and latites.

Rock analyses (qualitative) showed some regional differences in the number and quantity of minor elements present. Slight variations with rock type also were found. Elements of special significance in the rock analyses are: Co, Cr, V, and La.

Analyses of plagioclase, biotite, groundmass, and magnetic concentrate samples (both qualitative and quantitative) showed systematic differences in the number and quantity of minor elements in each of the minerals. A few significant elements in the mineral analyses are: Sc, Y, La, Ce, Nd, Ti, V, Cr, Mn, Fe, and Co.

Comparison of analytical results obtained for the Tertiary dike rocks with those obtained for other Front Range igneous rocks of pre-Cambrian and Tertiary ages (not dikes) revealed definite points of difference. It is the author's firm belief that the spectrographic method, when properly applied, will prove a definite aid in correlation problems involving igneous rocks anywhere.

X-RAY EXAMINATION OF CRYSTALLINE FORMS OF ANHYDROUS SODIUM STEARATE AT ROOM TEMPERATURE

ALEXANDER DE BRETTEVILLE, JR.

There are three known polymorphic forms of sodium stearate. If sodium stearate is prepared from stearic acid, it exhibits the monoclinic B form. The rhombic form can be obtained from the B form by slow crystallization from a 1% solution in 95% alcohol and air drying. The monoclinic A form is produced by heating the rhombic form above 54°C. and cooling. The processes are represented diagrammatically:

Stearic Acid——→	Na Stearate——→	Na Stearate——→	Na Stearate
Eastman #402	Mon. B	Rhombic	Mon. A

A sample of thallous palmitate representing yet another monoclinic form, to which we will refer as monoclinic C, was given to us by Dr. A. S. C. Lawrence of Cambridge, England. A sample of rhombic soap was also given to the author by J. Stauff of Berlin and found to be identical with the Eastman above and with J. Stauff and P. Thiessen's results.[1] The monoclinic A form does not agree with the results of Stauff and Thiessen and a different equation for the indices is given. The tilt of the chain is 62.9° for the A form.

The monoclinic B form is the most stable and is shown to be due to a shortening of the *c* axis by 2.4 Å due to a rearrangement of the dipole COONa group. There is a shift of alternate molecules of 180° around the *c* axis. The tilt of the carbon chain for the monoclinic B form is assumed the same as the monoclinic A form, namely 62.9°. This is supported by two other indirect experimental measurements.

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[1] *Zeit. Physik. Chemie* (A), p. 397, **176** (1936).

THE UNIT CELL AND SPACE GROUP OF CLAUDETITE, As_2O_3

M. J. BUERGER

The unit cell and space group of the Jerome, Arizona, claudetite has been determined. The diffraction record consists of one rotation photograph and the zero, first, and second level photographs taken by the method of de Jong and Bouman. The diffraction symmetry is clearly $2/m$. The lattice is simple monoclinic and the reduced cell has the dimensions:

	Absolute	Ratio
$a=$	5.25 Å	.408
$b=$	12.87	1.
$c=$	4.54	.353

This cell contains approximately $4As_2O_3$. The diffraction symbol is $2/mP2_1/n$, which uniquely fixes the space group as $P2_1/n$ (C_{2h}^5).

STRUCTURAL RELATIONS BETWEEN HIGH- AND LOW-CHALCOCITE

M. J. BUERGER AND NEWTON W. BUERGER

It has been recently shown[1] that what has passed for high-chalcocite is really digenite, Cu_9S_5. In order to investigate the character of the true high-chalcocite, a delicate furnace was designed to maintain single crystals at a definite elevated temperature on a Weissenberg apparatus.[2] With the aid of this, the structural characteristics of the Bristol chalcocite were investigated at 112°C. by the equi-inclination Weissenberg technique. The diffraction symmetry of true high-chalcocite is $6/mmm$. It is based upon a hexagonal lattice described by the following cell:

$$a=3.89 \text{ Å}$$
$$c=6.68 \qquad c/a=1.717$$

This cell contains $2Cu_2S$. The diffraction symbol is $6/mmmC-/--c$. This embraces space groups $C62c$, $C6mc$, and $C6/mmc$. It is likely that the last is the correct one. This symmetry, the cell constants, and the thermal evidence[1] for the disorder transformation from low- to

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[1] Buerger, Newton W., The chalcocite problem: *Ec. Geol.*, **36**, 19–44 (1941).

[2] See abstract by Newton W. Buerger, *Weissenberg controlled-temperature technique.*

high-chalcocite suggest a structure composed of sulfur atoms in hexagonal close-packing, within whose interstitial channels copper atoms are flowing.

The structure of the same chalcocite was investigated at room temperature by means of the usual equi-inclination Weissenberg technique and also by the de Jong and Bouman method using the equal-cone technique. Low-chalcocite has the diffraction symmetry *mmm*. It is based upon an *A*-centered orthorhombic cell of the following dimensions:

absolute	ratio
$a = 11.90$ Å	.4365
$b = 27.28$	1
$c = 13.41$	.492

This cell contains 96 Cu_2S. The diffraction symbol is *mmmAb*---. This embraces space groups *Abmm* and *Ab2m*. It is likely that the latter is the correct symmetry, because the holohedral symmetry *Abmm* contains a mirror which could not be derived from the more symmetrical high-chalcocite, which is a very unlikely possibility. Because of the strong resemblance between the *x*-ray photographs of the high- and low-chalcocite, it is likely that the latter is based upon hexagonal close-packed sulfur atoms within whose interstices the copper atoms have fixed positions. The matrix of the transformation from high-chalcocite to low-chalcocite is

$$\begin{Vmatrix} 3 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 2 \end{Vmatrix}, \text{ modulus } 24.$$

The multiplicity of the superstructure of the low-chalcocite is accordingly 24.

A TEMPERATURE-CONTROLLED *X*-RAY POWDER CAMERA

M. J. BUERGER, NEWTON W. BUERGER AND FRANK G. CHESLEY

An *x*-ray powder camera has been designed and constructed for investigating various systems or substances under the influence of controlled elevated temperatures. The main features of this instrument embody facilities for disassembly in stages. The light-tight film-holding device is completely removable without disturbing the thermal environment of the specimen. This feature permits the taking of an indefinite series of photographs of a specimen under controlled rising or falling temperature conditions without heat treating the specimen. The camera itself is of the usual 57.3 mm. diameter and is provided with a film expansion device which assures contact of the film with the camera body. The heating unit may be removed without disturbing the position of the sample. This feature permits the instrument to be used as an ordinary powder camera. A small, efficient, and sensitive electric furnace maintains the specimen under investigation at an elevated temperature by means of radiation insulation. A water cooling system protects the film against undesirable heat effects from the electric furnace. The calibration of the furnace is accomplished by systematically taking a series of photographs of selected high-low polymorphic inversions. The advantage of this method of calibration is that it gives a rather precise indication of the temperature at the particular spot where the sample is bathed in the incident *x*-radiation; therefore the actual temperature at the origin of diffraction is measured. The camera has been successfully employed in studying heat effects on salts, organic materials, and mineral substances and has been operated at temperatures near 600°C.

WEISSENBERG CONTROLLED-TEMPERATURE TECHNIQUE

NEWTON W. BUERGER

A heating accessory has been developed which permits the investigation of single crystals at any desired temperature. The heating chamber is built into a tube which slips over the spindle housing of a Weissenberg *x*-ray goniometer. This in no way interferes with the normal flexibility of the instrument, so that cell constants and structures can be determined by the equi-inclination method at controlled elevated temperatures. This technique has been applied successfully to high chalcocite. The attachment serves a dual purpose, since it makes possible an improved method of recording powder photographs of a substance which is being subjected to various temperatures.

X-RAY EVIDENCE OF THE EXISTENCE OF THE MINERAL DIGENITE, Cu_9S_5

NEWTON W. BUERGER

X-ray studies of the system Cu_2S–CuS have shown the existence of the compound Cu_9S_5 as a separate phase. The diffraction pattern produced by this intermediate compound corresponds with that obtained from a type specimen of digenite, a mineral apparently among Dana's discredited species. There is no longer room for doubt that the mineral exists, and is indeed the familiar "isometric chalcocite." This is obvious from a comparison of the diffraction pattern of digenite, or Cu_9S_5, with those obtained by Kerr on three specimens of "isometric chalcocite" from Kennecott, Alaska, and by Kurz on the same material; the patterns are identical. Since digenite is in fact a rather common mineral occurring with chalcocite and other copper ore minerals, it must be re-established as a species.

ORIGIN OF SULPHIDES IN THE NICKEL DEPOSITS OF MOUNT PROSPECT, CONNECTICUT

EUGENE N. CAMERON*

Nickel-bearing deposits occur at a number of places in the intrusive complex of Mount Prospect, near Litchfield, Connecticut. The ores are noritic and pyroxenitic rocks containing varying amounts of pyrite, pyrrhotite, pentlandite and chalcopyrite. The rocks are largely free from characteristic hydrothermal alteration products. This feature and the textural relations of sulphides to silicates in the ores have previously been taken to indicate that the sulphides are of magmatic or late magmatic origin.

A detailed study of the intrusive complex has furnished field data and new microscopic evidence which relate to the problem of sulphide origin. Mapping has shown that the principal ore-bearing rocks comprise intrusives of three different types: mafic norite, norite and hypersthene pyroxenite, intruded in that order. The nickel deposits are concentrations of sulphides at or near the margins of these intrusives. Apart from the sulphides, the rocks consist essentially of hypersthene, clinopyroxene, plagioclase, hornblende and biotite. Indications have been found that hornblende, at least in part, and biotite developed after solidification of the rocks. The sulphides appear to have been introduced later and to have formed chiefly by fracture filling and by replacement of the various silicates. No specific conclusions have been reached as to time of sulphide deposition for the deposits as a group, but the presence of introduced sulphides in fine-grained dikes cutting mafic norite and norite at two deposits suggests that a considerable interval elapsed between solidification of the latter rocks and development of sulphides.

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* Presented through the Geological Society of America.

ORBICULAR GABBRO FROM BLACK BUTTE, LOS ANGELES COUNTY, CALIFORNIA

IAN CAMPBELL

Black Butte is a small, isolated desert dome in northeastern Los Angeles County, California. A dark hornblende gabbro forms a capping; adamellite, intrusive in the gabbro, forms the lower portions of the butte.

The gabbro is somewhat variable in texture and composition. One facies, of very limited development, shows pronounced orbicular structure. The "orbicules" are ellipsoidal, with median diameters of six to ten centimeters. Their concentric development is well marked.

It consists of a nucleus of medium-grained hornblende gabbro; surrounding this is a shell dominantly of hornblende and fine-grained magnetite; succeeding this is a zone, varying slightly in mineral proportions in different orbicules, but characterized throughout by fine grain and composed of thin shells of labradorite-magnetite, hornblende-magnetite and labradorite-sphene-magnetite; last is an outermost shell of medium-grained hornblende. The external matrix of the orbicules is hornblende gabbro, similar to the nucleus. Except for a rude radial arrangement of hornblende in the outer layer, the minerals of the orbicules show no obvious orientation.

Feldspar is calcic labradorite showing little change in composition throughout the rock. Hornblende is green, uralitic, and commonly contains residuals of colorless pyroxene. Much of the magnetite is believed to be early, some may be deuteric. It is frequently rimmed by sphene. None of these features seems to be related to position within an orbicule.

Of the many hypotheses that seek to explain orbicular structures that of Loewinson-Lessing and Vorobjeva seems most nearly to fit the present case.

X-RAY CRYSTALLOGRAPHIC STUDIES UPON ETIOPORPHYRIN-1

CHARLES L. CHRIST AND DAVID HARKER

Goniometric and *x*-ray measurements show that etioporphyrin-1 has the point group $2/m$. Oscillation photographs with Cu$K\alpha$-radiation of the single crystals yield the structure: monoclinic, $a_0 = 10.3 \pm 0.1$ Å; $b_0 = 19.5 \pm 0.1$ Å; $c_0 = 6.75 \pm 0.05$ Å; $\beta = 98° \pm 1°$; $Z = 2$ molecules $C_{32}H_{38}N_4$; d. (*x*-rays) 1.17; space group $P2_{1/c}$.

The probable structure of the *porphin* molecule, based on the data of organic chemistry[1] and on the structure of phthalocyanine[2] is discussed. A model for the etioporphyrin-1 molecule is proposed and this is tested by a combination of trial and error and Fourier series methods. As a result of this testing it is shown that the model proposed is in agreement with the data at hand, but that these are insufficient to test the details of the structure.

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[1] Corwin and Quattlebaum, *Jour. Am. Chem. Soc.*, **58**, 1081 (1936).

[2] Robertson, J. M., *Jour. Chem. Soc.*, 1195 (**1936**).

CLAY MINERALS IN RECENT MARINE SEDIMENTS

ROBERT S. DIETZ

A study was made of the clay fraction of 39 sediment samples from the various oceans of the world.

Particle size analyses of these clays showed that the clay particles of the red clay samples are coarser than those of the green and blue muds which in turn are usually coarser than clays in tidal estuaries, bays, inland seas, river sediments and soil clays. Consequently, marine clays probably undergo a post-depositional increase in grain size.

X-ray and petrographic analyses showed that the three common groups of clay minerals present in soils, namely, illite, kaolin, and montmorillonite are also the main constituents of marine clays. Although illite and kaolin are present in all of the samples, illite usually predominates. Small amounts of montmorillonite were found in the near shore sediments but were not detected in those from the deep sea.

Kaolin and montmorillonite were found to have formed on the sea floor by the alteration of the feldspars in granite. Other considerations suggested that illite may also form by the alteration of some primary minerals and, especially, by the alteration of montmorillonite. This latter change involves the absorption into montmorillonite of potassium from sea water. Such a process of illitization might account for (1) the post-depositional increase in the size of clay particles in marine clays, (2) the general absence of montmorillonite in marine clays, (3) the absence of montmorillonite in most shales, and, (4) the low potassium to sodium ratio in sea water as compared to that of river water. Illitization is probably an extremely slow process which goes to completion only in areas of slow deposition. The formation of the illite mineral, glauconite, may be a special case of the process.

DERIVATION OF THE 32 POINT-GROUPS

J. D. H. DONNAY

(1) Symmetry is redefined. A crystal is said to lack, or to have, symmetry, according as all, or not all, directions in the crystal are singular and polar.

(2) It is proved by elementary mathematics that symmetry operations are of two kinds only: rotation and rotatory-inversion.

(3) The general theorems on symmetry are recast in the form of eight propositions conforming with the concept of inversion axes (instead of the previous reflection axes or planes of alternating symmetry).

(4) A simplified derivation of the 32 point-groups, following the dichotomous principle, is based on the above eight theorems. The elements considered are the axes (rotation axes: 1, 2, 3, 4, 6; inversion axes: $\bar{4}$, $\bar{6}$), the center ($\bar{1}$), and the mirror (m). They are the independent symmetry elements, save $\bar{6}$, which is added for convenience. The method consists in establishing first all the axes and possible combinations of axes, then in combining them with the center and mirrors.

(5) The derivation claims the following advantages: (a) Foremost it leads to the international (Mauguin) symbols. (b) Although based on simple mathematical prerequisites, it skips no single step. (c) The 32 groups are established with a minimum of duplication. (d) They are derived in such a sequence as to fall naturally into the 6 crystal systems, the 7 lattice symmetries, and the 11 "Laue symmetries." (e) The derivation brings out the parallelism of the two cases where a unique singular axis is an inversion axis with an even period ($\bar{4}$ and $\bar{4}2m$ on the one hand, $\bar{6}$ and $\bar{6}2m$ on the other).

THE MORPHOLOGICAL EXPRESSION OF TETRAGONAL SPACE-GROUPS

J. D. H. DONNAY

The 68 tetragonal space-groups are distributed among 31 morphological aspects: 23 in the $P-C$ lattice and 8 in the $I-F$ lattice.

In the *initial pattern* of the P lattice (no glide-planes, nor screw-axes), every zone is simple with unit face dominant; all indices are co-prime. The base may have its indices doubled or quadrupled by a screw axis (4_2 or 4_1). The prism (010) may be doubled by a 2_1-axis. A double zone for the ($hk0$) or ($0kl$) faces indicates an n glide-plane; the zone of the ($0kl$) faces may remain simple, while its dominant is shifted toward c(001) or b(010), indicating respectively a c or a b glide-plane; the zone of the (hhl) faces may have (112) dominant, the shift toward c(001) indicating a c glide-plane.

In the *initial pattern* of the I lattice, the zones of the ($hk0$) and ($0kl$) faces are doubled, with (110) and (011) dominant; the zone of the (hhl) faces is simple, with (112) dominant; the zone of the (hkh) faces is simple, with (121) dominant; two forms are doubled, (002) and (020). The base may be quadrupled by a 4_1-axis. The zones of the ($hk0$) and ($0kl$) faces may become simple with all indices doubled, indicating respectively an a or a c glide-plane. The zone of the (hhl) faces may become double, (112) remaining dominant; this indicates a d glide-plane.

Similar rules can be stated (in the other orientation) for the C and F lattices.

PEGMATITES NEAR CUSTER, SOUTH DAKOTA*

D. JEROME FISHER

There are hundreds of pegmatite dikes in the southern Black Hills (Custer County), southwest of the famous Keystone district. Although by no means limited to this strip,

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* Work done under the auspices of the South Dakota Geological Survey.

these are especially common in a belt of mica schist between Custer and Pringle, where locally they appear as a series of steeply-dipping en echelon walls, like some great natural tank trap. Cursory field examination of a dozen of these dikes indicated that they run the gamut from nearly simple intrusions of microcline-quartz pegmatites to complex albitized examples that have undergone much replacement. This paper reports on the results of detailed field mapping and laboratory study of three of these dikes (Tip Top, High Climb, and Beecher Lodes), substantiating this point of view.

CHROMITE DEPOSITS OF THE PHILIPPINE ISLANDS*

DEAN F. FRASCHE

The chromite deposits of the Philippines occur in isolated masses of ultra-basic rocks which are in general found along the eastern and western borders of the Island group. The ultra-basic rocks are highly serpentinized and are difficult to distinguish in the field but petrographic studies reveal them to be composed essentially of three intergrading rock types, dunite, saxonite and pyroxenite. Of these three types, saxonite occurs in greater volume than either dunite or pyroxenite. Varying amounts of chromite are found in the different rocks but the known commercially important deposits appear to be confined entirely to the serpentinized dunite. Locally in the Zambales area, gabbro and diorite intrude the chromite deposits, but these less basic rocks appear to be confined to the refractory grade ore bodies. The chromite is considered to be genetically related to the dunite and is probably of early magmatic origin.

Although chromite occurs in commercial quantities on several of the islands, the largest deposits are found in Zambales Province, Luzon. The individual deposits vary greatly in size, ranging from a few hundred to more than ten million metric tons. The grades of chromite now being produced in the Zambales area are classified according to their industrial uses, namely, metallurgical ores, chemical ores and refractory ores.

Philippine reserves of chromite of all grades are estimated to be 10,890,500 metric tons. Of this total 10,120,000 metric tons are refractory grade, 450,500 tons are chemical grade, and 320,000 tons are metallurgical or submetallurgical grade.

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* Presented through the Society of Economic Geologists.

MINERALOGY OF PINCHI LAKE

A. C. FREEZE

Recent studies at Pinchi Lake show the existence of a late Paleozoic-early Mesozoic mountain range previously unrecognized in any part of British Columbia.

Detrital chromite derived from post-Sakmarian serpentines and found in sediments of Upper Triassic age indicates a period of orogeny accompanied by a period of erosion between the early Permian and the late Triassic.

Glaucophane is widespread and appears to be confined to early Permian rocks suggesting a closer relationship to the pre-Upper Triassic-post-Sakmarian metamorphism than to later Mesozoic-early Tertiary disturbances. The mineral is present in rocks of both sedimentary and igneous origin and probable mixtures of both.

The glaucophane occurs in an area containing serpentinized peridotite, but shows no distinct spatial relationship to these intrusions. In the sequence of minerals developed during the metamorphism, hornblende, clinozoisite, chlorite, muscovite, and vein quartz precede glaucophane, and glaucophane crystallization is succeeded by veins of oligoclase, calcite, late chlorite, and (?) allanite.

An introduction of soda is considered necessary to account for the distribution and amount of glaucophane. Later calcite oligoclase veinlets lend support to this hypothesis.

The cinnabar mineralization and accompanying mineral suite are much younger (post Upper Triassic) than the glaucophane and related minerals.

BISMUTH-OCHER, BISMUTITE, BISMUTOSPHAERITE, BASOBISMUTITE, BISMITE AND BISMOCLITE

CLIFFORD FRONDEL

Forty-one specimens from 34 localities of bismutite, bismuth-ocher and bismutosphaerite were examined by *x*-ray, optical and chemical methods. Bismutite supposedly is a hydrated bismuth carbonate but all of the specimens examined contained only non-essential water and proved to be identical with bismutosphaerite (Bi_2CO_5). Basobismutite also is identical with Bi_2CO_5. So-called bismuth-ochers that afforded both Bi and CO_2 tests all proved to be Bi_2CO_5; others were bismuth arsenate, cerussite, etc. Artificial hydrous bismuth carbonates and bismutite give a smooth dehydration curve to about 290°, where the CO_2 is lost and α-Bi_2O_3 remains. Efforts to synthesize definite hydrates were unsuccessful.

The identity of bismite, supposedly Bi_2O_3, long has been uncertain. Twenty-two specimens labelled bismite from 15 localities were examined. Neither $Bi_2O_3 \cdot 3H_2O$ nor any of the four polymorphs of Bi_2O_3 were represented. $Bi_2O_3 \cdot 3H_2O$, however, probably occurs in nature (Schaller (1911) and others). Of the specimens examined, 8 were Bi_2CO_5, 2 were bismoclite, and 4 were a new carbonate of Bi and Ca. The latter mineral occurs very sparingly at Schneeberg, Saxony, as tiny yellow tetragonal plates, optically negative, $\omega = 2.13$; this mineral was recognized and partly described by Arzruni and Thaddéeff (1899). Bismoclite, BiOCl, hitherto known only from South Africa, is described from two new localities: Bygoo, New South Wales, and Tintic, Utah. The bismite reported from Goldfield, Nevada, also is bismoclite (Schaller. priv. comm., 1940). Reported syntheses of $Bi_2O_3 \cdot H_2O$ (or BiO(OH)) and some other hydrates could not be verified; most are α-$Bi_2O_3 \cdot nH_2O$.

PLEONASTE FROM MINERAL COUNTY, NEVADA

VINCENT P. GIANELLA

As pleonaste has not been reported from Nevada, other than in thin sections, its recent discovery in macroscopic crystals is of interest. This occurrence is in the Garfield Hills in Mineral County, Nevada, about one and one half miles southwest of Kinkead siding. The mineral has developed in roughly lenticular masses up to two feet wide and fifty feet long in dolomite of the Upper Triassic Luning formation. The color is dark green to black and it is found in finely granular aggregates as well as in well-formed octahedra some of which are four, or more, millimeters in length.

MINERALIZATION OF THE AJO COPPER DISTRICT, ARIZONA*

JAMES GILLULY

The new Cornelia orebody at Ajo is a deposit of chalcopyrite with subordinate bornite and other minerals disseminated in a mass of quartz monzonite porphyry of early Tertiary (?) age. Petrographic study shows that the orebody lies in part of the porphyry with a peculiar groundmass texture that is believed to date from a time prior to consolidation. Pegmatites of probable replacement origin were formed later, and the monzonite surrounding them was heavily impregnated with finer-textured potash feldspar and quartz. Sulphide impregnation, which followed, is heaviest in and near the pegmatites, and fades out into a zone of sericitization peripheral to the zone of feldspar impregnation. The mineralization is believed to have been by an unbroken continuation of magmatic evolution into a hydrothermal stage. No discontinuities are recognized in the sequence of alterations that linked

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* Presented through the Geological Society of America.

the magmatic stage with that of sulphide mineralization, although specular hematite, which is very abundant, seems clearly governed by different controls, and may record a discontinuous-pneumatolytic-stage. It is uncertain, but appears probable that sulphide mineralization and hydrothermal alteration reverted to their former controls after the period of specularite formation.

Weathering of the deposit has taken place in two stages: an earlier, during which there was notable downward enrichment, and a later, during which the copper was oxidized essentially in place. Between the two periods, the block containing the deposit was tilted about 60°. No satisfactory explanation of the different behavior during the two erosion cycles has been discovered.

AUTORADIOGRAPHY OF ORES

CLARK GOODMAN AND GEORGE A. THOMPSON

Using stray slow neutrons from the M. I. T. cyclotron on elements having large nuclear cross-sections for (n, γ) reactions and yielding radioactive isotopes of convenient half-periods, autoradiographic studies of a number of ores have been made. The locus and relative concentrations of these elements in the constituent minerals is determined by placing polished sections of the activated ores in direct contact with photographic film. The source of the effective β-radiation is ascertained from the decay rate and intensity of the activity. Manganese, gold, cadmium and phosphorus bearing ores have been studied by this method. Further investigations are in progress with the purpose of extending the method to other elements, of making the method quantitative, and of applying the method to thin sections.

DIFFERENTIAL THERMAL ANALYSIS OF CLAY MINERALS*

RALPH E. GRIM AND RICHARDS A. ROWLAND

Differential thermal curves are presented for a large number of clay minerals and related silicates. The characteristics of the thermal curves of illites, kaolinites, and montmorillonites, and other clay minerals are discussed. The significance of the thermal data with regard to the lattice structures of the clay minerals, and to the changes they undergo when subjected to heat is considered. On the basis of these considerations certain clay mineral names are discredited.

Thermal curves are presented also for natural and artificial mixtures of clay minerals, and the use of differential thermal curves for identifying clay minerals and estimating their relative abundance in conjunction with x-ray, optical, and chemical methods is critically analyzed.

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SODIUM MICA SYNTHETIZED

JOHN W. GRUNER

Since it is relatively easy to synthesize muscovite in weak HCl solutions at 400°C., it was thought that the existence of paragonite might be proved or disproved by attempting its synthesis in the laboratory. The bomb experiments were made at 400°C. in 1/10 N HCl solutions. $Al(OH)_3$, hydrated silica, and NaCl (the latter in large excess) were used. The resultant product contained two minerals as found by x-rays, paragonite and boehmite. Paragonite was much more abundant. The height of its unit cell is 19.32Å as compared with the 20.0Å for muscovite. Its width (b_0) is 8.90 Å. These values agree well with the expected magnitudes. An analysis for Na_2O of the carefully washed sample gave 5.4%, which is $\frac{2}{3}$ of the theoretical value of 8.1%. Since an unknown amount of boehmite was mixed with the paragonite, the deficiency of Na is not very large, especially when compared with natural Na micas.

DIAMONDS IN THE WIRE DRAWING INDUSTRY

PAUL L. HERZ

Wire drawing dies made from diamond crystals are superior to other types of dies for drawing metallic wire. The price of the rough diamond, die manufacturing costs, diameter of the drawn wire, kind of wire, and allowable tolerances are related factors which, in any given operation, determine whether diamond should be used in preference to other die material.

The kind of rough material most suitable for dies and its desirable and undesirable characteristics are discussed. Limitations in the use of diamond are pointed out.

The peculiar problems presented in the manufacture and use of dies of capillary diameter are stressed.

APPARATUS FOR DIRECT MEASUREMENT OF LINEAR STRUCTURES

EARL INGERSON

A compass is mounted with a graduated semi-circle that is weighted so that it remains vertical, and the compass is provided with a weighted pointer that keeps it horizontal. This arrangement is swung on pivots in a frame that has a straight edge that can be placed on, or parallel to, a linear structure in the field. Direction of pitch is read on the compass, and angle of pitch is read on the vertical circle. Dip and strike of planar structures can also be measured with the apparatus.

ORIGIN OF SHAPES OF QUARTZ SAND GRAINS

EARL INGERSON AND JOSEPH L. RAMISCH

Wayland concluded from a study of the St. Peter and Jordan sandstones that "it is probable that clastic quartz grains are longer and harder in the direction of the optic axis."

To check this conclusion three sets of experiments have been carried out, with the following results:

1) No relation between *c*-axes and elongation of fragments could be established for crushed quartz.

2) Quartz grains from weathered (but undisturbed) quartzose rocks show a tendency to be elongate parallel to prismatic and rhombohedral faces.

3) Abrasion tests on oriented prisms show that quartz is harder on faces parallel to the *c*-axis than normal therto.

It is concluded that the elongation of quartz sand grains parallel to the *c*-axis is due to original shape rather than to differential abrasion during transport.

CUTTING OF GEM DIAMONDS

LAZARE AND LEO KAPLAN

With the closing of European sources of supply of finished diamonds, unusual demands have been made upon the American cutting industry. Labor costs have risen with unusual rapidity. The price rise in rough material and the changes made in the channels of distribution are considered.

Because of the disproportionate rise in labor costs the price rise in the finished products has been most pronounced in smaller diamonds. The situation in the case of melee is given special attention. The role of the refugee as a source of supply is also discussed.

RADIOACTIVE AUREOLES AROUND SOME ORE DEPOSITS

NORMAN B. KEEVIL

Mineral deposits are sometimes less, sometimes more radioactive than country rock. When the ore body is relatively high in activity, concentrations of radioactive material in the vicinity of the deposit have been observed in some instances. At Gilman, Colorado, where a series of samples collected during a Lundberg geophysical survey were examined, the activity was observed to be higher near radioactive ore and to decrease in concentration away from the ore body. Some of the activity appeared to be due to diffused radon, but spectrochemical concentrations of silver, copper, lead, and zinc associated with the radioactivity suggested that much of the radioactive material was introduced during mineralization. The results suggest that sample analysis may be useful in indicating proximity to ore in some instances.

ORIGIN OF THE QUARTZ DEPOSIT AT FAZENDA PACÚ, BRAZIL

PAUL F. KERR AND ALBERTO ERICHSEN

The deposits of crystal quartz now being worked at Fazenda Pacú, Minas Geraes, Brazil, provide the most important source of commercial crystals in Brazil. Crystals occur in a deeply weathered zone along the contact between the Archean and overlying Silurian sediments. Decomposition of the matrix obscures direct evidence of origin, but the quartz is believed to have been formed originally by coarse crystallization in veins. In addition to deposits formed in situ, clay and gravel deposits occur in which the gravels are rounded quartz crystals.

BONDED DIAMOND WHEELS

A. A. KLEIN

The growth in the use of cemented tungsten and tantalum carbide tools for shaping metals has resulted in the development of grinding wheels containing diamond grain bonded with resinoid or metal bonds. These function to form, shape and sharpen the cemented carbide article. Such operations were economically quite impossible to accomplish with the usual bonded silicon carbide wheels. Since diamond wheels have become commercially available other interesting uses have developed.

This presentation will discuss briefly the kind of diamond used and its preparation, the manufacture of bonded diamond wheels, and their applications in industry.

DIAMOND PRODUCTION

SYDNEY H. BALL

In the past generation diamond production has undergone one of its major cyclical changes in the long history of the diamond industry. From 1907 to 1930, important alluvial diamond fields were successively found in the Belgian Congo, South West Africa, Angola, Gold Coast and Sierra Leone. These virgin fields have, on the average, low operating costs and their production has expanded rapidly. The pipe mines of South Africa, which 25 years ago were the dominant producers, are now, due to economic factors in the industry, shut down.

Production today is, by weight, over 14,000,000 carats worth some $31,000,000, as opposed to an average of 7,200,000 carats worth about $75,000,000 for the four years 1927 to 1930—a change mainly due to the large bort production of a single Belgian Congo company. The weight of fine cutable material is today but 70% of that of ten years ago.

Twenty years ago all of the African production came from the South African pipes or from alluvial deposits derived from them; these intrusions are of Cretaceous age. Today about 75% of Africa's production comes from alluvial deposits derived from sources of pre-Cambrian age.

AMERICAN SYNTHETIC RUBIES AND SAPPHIRES

EDWARD H. KRAUS AND CHESTER B. SLAWSON

The chemical, physical, and optical properties of American-made boules and their relationship to the strained conditions within the boules are discussed.

PARAGENESIS OF THE McDONALD PEGMATITE NEAR HYBLA, ONTARIO

KENNETH K. LANDES

The McDonald spar mine is in Monteagle township, Hastings County, Ontario, about 2 miles southeast of Hybla and 10 miles north of Bancroft. The district is noted for its great variety of rocks, and the McDonald deposit for the radioactive minerals found there. The main pegmatite at the McDonald mine is a dike up to 50 feet in width and several hundred feet in length. It is in large part a truly giant granite, consisting of huge masses of feldspar and quartz. In parts of the dike are large bodies of soda feldspar (with subordinate smoky quartz), and coarse pink or salmon colored calcite. Invariably the rare-earth minerals allanite and cyrtolite are with the soda feldspar, and ellsworthite and zircon with calcite. The calcite group is definitely later in age than the soda feldspar group, as both feldspar and smoky quartz are traversed by calcite veins. The paragenesis appears to be: (1) crystallization of the main granite pegmatite; (2) an early hydrothermal stage during which soda feldspar and associated minerals were deposited; and (3) a late hydrothermal stage during which calcite, ellsworthite, and zircon were formed. Contamination of the pegmatite magma by limestone is suggested.

THE SIZE OF THE UNIT CELL AND THE COEFFICIENT OF EXPANSION OF HIGH-CRISTOBALITE

JOSEPH S. LUKESH

The length of the axis of the unit cell of high-cristobalite was found on artificial material to be 7.031_7 Å at 275°C. and 7.044_0 Å at 480°C. This corresponds to an increase in length per unit length per degree Centigrade of 8.53×10^{-6}, which is of the order of magnitude of the two coefficients of quartz. The values were obtained from back reflections on films taken in the camera described by Buerger, Buerger and Chesley,[1] and a modified Bradley and Jay extrapolation was employed in the computations. The values for the axial length are appreciably smaller than those reported by Wyckoff (7.12 Å at 290°C.) and by Barth (7.16 Å at 500°C.). The discrepancy may be due to any or all of three causes: material used, previous thermal history of the sample, or technique used in measurements.

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[1] See abstract, *A temperature-controlled x-ray powder camera.*

THE UNIT CELL AND SPACE GROUP OF KALIOPHILITE

JOSEPH S. LUKESH AND M. J. BUERGER

An *x*-ray investigation has been made of kaliophilite, $KAlSiO_4$, using a de Jong-Bouman type camera. The hexagonal nature of the cell and the lattice constants as determined by Bannister have been confirmed. The reciprocal lattice was recorded directly for the zero, 1st and 2nd layers for both *c* and *a* axis rotations. The only systematic absences were found to be $(000l)$ halved when l was odd. The diffraction symbol is $6/mmmC6_3/---$. The only possible space group is $C6_32$ (D_6^6). Tests were made for both piezo- and pyroelectricity, and in both cases positive results were obtained. The results for pyroelectricity, however, were less conclusive than for piezoelectricity and may have been due to a pseudo-pyroelectric effect resulting from strains in the crystal.

The lattice constants of the hexagonal unit are:

$$a = 26.94 \text{ Å}$$
$$c = 8.55 \text{ Å}$$
$$c/a = 0.317$$

Considering the specific gravity to be 2.60 and the formula to be ideally $KAlSiO_4$, there are 54 formula weights per unit cell.

Work is being continued to determine the structure.

GRIPHITE, A HYDROPHOSPHATE GARNETOID

DUNCAN McCONNELL

Griphite is cubic and its structure is similar to that of garnets. The unit cell contains $8[(Na, Al, Ca, Fe)_3\ Mn_2(PO)_{2.5}(OH)_2]$ and represents a complex example of the formula $X_3Y_2(ZO_4)_{3-m}(OH)_{4m}$, the latter being a variation of $X_3Y_2(ZO_4)_3$ which is necessary to accommodate the hydro-garnets and plazolite. The cell edge is 12.26 Å and ρ is 3.399. An alternate formula is suggested and cannot be eliminated as a possibility, namely, $8[(Na, Ca, Fe, Mn)_3\ (Al, Mn)_2(PO_4)_{2.5}(OH)_2]$. The space group could not be determined but appears to have lower symmetry than that of garnet ($O^{10}_h = Ia3d$).

Garnetoids are substances other than simple silicates which have structures similar to garnets, including: berzeliite, Ca-Al- and Ca-Fe-hydrogarnets, plazolite and griphite.

NOMOGRAPHIC SOLUTIONS OF OPTIC ANGLE FORMULAE

JOHN B. MERTIE, JR.

Nomograms are presented herewith for the solution of several well-known formulae, that are used in the measurement of optic angles. To solve for any one of the four variables V, α, β, and γ, when three of them are known, a grid type nomogram has been prepared; and a similar chart has been drawn to show the relationships between the variables E, α, β, and γ. Two nomograms are also presented for the solution of the equations $\sin E = \beta \sin V$ and $d = k \sin E$ (Mallard's formula). The method of preparing these charts is outlined, and their uses given.

GOLD MINERALIZATION IN MINOR IGNEOUS INTRUSIONS*

WILSON W. MOORHOUSE

The association of gold mineralization with or in prophyry dikes and bodies is known in many parts of the Canadian shield. This relationship has frequently been considered to be purely structural or genetic only in the sense of derivation from the same magmatic source. Evidence of a much more intimate connection is given from an occurrence of auriferous pyrite as disseminations and in quartz-carbonate veins in albitite porphyry in Bryce township, Ontario. The porphyry is in part a normal dike, in part a replacement of associated schists. Stringers extending into the schists are enclosed by a zone of albitization which resembles the porphyry itself. This, with other examples from the same area, is believed to indicate that replacement and intrusion by albitic material were accompanied by the gold-pyrite mineralization. Comparisons are given with other gold deposits associated with porphyry and albitite dikes and bodies in Canada.

Auriferous quartz-sulphide mineralization which has been discovered in small altered dioritic bodies in relationships of the veins to these intrusives suggests a rather close genetic connection. Reference is made to comparable gold deposits described in the literature.

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* Presented through the Geological Society of America.

SOLUBILITY OF SOLIDS IN "GASES" OR "VAPORS"*

GEORGE W. MOREY AND EARL INGERSON

The transport in significant quantity of solid material by means of a gas or vapor at high temperature and pressure is dependent on solubility of the solid in the vapor. By this is meant that in unit volume of the vapor the content of solid is greater than corresponds to its own vapor pressure at the temperature and total pressure under consideration. In our work we have found transport and deposition of corundum, rutile, sillimanite, quartz and amorphous silica by water at temperatures from 500 to 1000°, and at pressures from 3000 to 15,000 pounds. These experiments and products will be described.

The consideration of problems of solubility of solids in vapor requires rigid definition of the terms "gas," "vapor," and "fluid" as applied to phases coexisting in several component systems under conditions in which definitions which are logical and complete for a one component system no longer are applicable. Definitions of "gas" and "vapor" are proposed.

The further discussion of the problem of the solubility of non-volatile solids in a vapor will be made with the aid of diagrams illustrating the variation of temperature, pressure, and composition in binary systems in which different types of critical end-points are assumed.

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* Presented through the Geological Society of America.

CONTRIBUTIONS TO THE CRYSTALLOGRAPHY OF HUREAULITE

JOSEPH MURDOCH

Hureaulite formed close to the end of a sequence of phosphate minerals at Pala, California, shows measurable crystals. These crystals are unusually good, and measurements warrant some modification of the crystallographic elements. The amended values correspond very closely to those for pure synthetic crystals. It is suggested that the Dana setting be retained, but that the *c* axis be doubled, resulting in a considerable simplification of indices. The new values for axes and axial angle, as compared with Dana's, are as follows:

	a *b* *c*	
New	1.9035:1:1.0383	β 96° 44½′
Dana	1.9192:1:0.5245	β 95 59

The crystals are ordinarily thick tabular parallel to (100), and usually show the following combination: *c* (001), *a* (100), *m* (110), α $(\bar{2}01)$, δ (112), ϵ $(\bar{1}11)$, *k* $(\bar{5}12)$. The form *q* $(\bar{5}34)$ was seen on one crystal. In addition a number of new forms were observed, doubtful ones indicated by a question mark: (230?) (540?), (011), (012?), (111), (211), (311), (511), (611), (12.1.1?), $(\bar{6}13?)$.

EQUILIBRIUM STUDIES ON MIXTURES OF PYROXENES, PYROXENOIDS, MELILITES, AND OLIVINES CONTAINING LIME, MAGNESIA, ALUMINA, AND SILICA

E. F. OSBORN

Data are now complete for the system $CaSiO_3$—diopside—anorthite. In this system wollastonite ($\beta CaSiO_3$ with diopside in limited solid solution) has a field of stability, but the alleged compound $5CaO \cdot 2MgO \cdot 6SiO_2$ does not appear. The diopside in this system is aluminous. Recently the results on the ternary system $CaSiO_3$—akermanite—gehlenite were reported. This system depicts the relations between liquids, pseudowollastonite, and melilite. The various investigations now in progress at the Geophysical Laboratory on phase relations in the quaternary system CaO—MgO—Al_2O_3—SiO_2 are briefly reviewed.

BOULANGERITE

CHARLES PALACHE AND HARRY BERMAN

Boulangerite, a lead sulfantimonide, has been studied on new material, the first which has proved suitable for detailed crystallographic examination. It is monoclinic, prismatic,

$2/m$, pseudo-orthorhombic. Elements $a:b:c:=0.9158:1:0.3456$; $\beta=100°39\frac{1}{2}'$. Some 60 crystal forms were observed. Lattice constants (Berry) $a_0=21.14$ Å, $b_0=23.46$ Å, $c_0=8.07$ Å, $\beta=100°48'$. New analyses by Gonyer on Washington boulangerite confirmed Shannon's earlier analysis and Berry's cell content of $Pb_{40}Sb_{32}S_{88}$.

DIFFUSE DIFFRACTION AND DISORDER IN MAUCHERITE

M. A. PEACOCK

Rotation and Weissenberg photographs of the tetragonal mineral maucherite give series of normal diffractions (*hkl*) with intercalated bands of continuous diffractions (*hk*-). The normal diffractions lead to the unit cell with the symmetry $D^{19}{}_{4h}=I4/amd$ and a_0 3.422, c_0 21.83; the continuous diffractions indicate horizontal layers with $a'=2a_0$ and no vertical periodicity. The crystal as a whole has the composition $Ni_{11}As_8$ or $Ni_{12-1}As_8$, and presumably the disorder is related to shortage in Ni. The exact nature of the disorder in maucherite has not been determined. It is thought, therefore, that a review of the evidence, with reproductions of the films, may be of interest and may prompt suggestions leading to a full solution of the problem (*Zeits. Krist.*, **90,** 273, 279, 1935; *Mineral. Mag.*, **25,** 557, 1940).

ON STERNBERGITE AND FRIESEITE

M. A. PEACOCK

Fair crystals of sternbergite (sp. gr. 4.25) from Jáchymov (Joachimsthal), Bohemia, show *c*(001), *e*(011), *d*(102), *t*(111), *r*(263), *s*(131), twin plane (130), on $a:b:c=0.572:1:1.092$ (from *x*-ray measurements). The plane of perfect cleavage and tabular development is (001) and the striations on (001) are parallel to [100]. Rotation and Weissenberg photographs of a good untwinned crystal give the unit cell with a_0 6.62, b_0 11.58, c_0 12.65 Å, containing $8[AgFe_2S_3]$; space group $D^{21}{}_{2h}=Cmma$, or $C^{15}{}_{2v}=C2ma$ or $Cm2a$. (*Am. Mineral.*, **21,** 103, 1936; **22,** 847, 1937.)

A typical crystal of frieseite (sp. gr. 4.18–4.31) from the same locality, with *c*(001), *b*(010), and a striated zone [010], gives the unit cell with a_0 6.60, b_0 11.59, c_0 12.61 Å; space group as in sternbergite. Powder photographs of frieseite show only the pattern of pyrite with weak extra lines corresponding to the strongest lines of sternbergite. In keeping with a warped exterior and a cryptocrystalline interior, frieseite appears to have altered by atomic rearrangement to oriented sternbergite and pyrite, as follows:

$$Ag_2Fe_5S_8 \text{ (frieseite)} \rightarrow 2AgFe_2S_3 \text{ sternbergite)} + FeS_2 \text{ (pyrite)}.$$

MIAROLITIC PEGMATITES IN MONZONITE, BEAVER CREEK STOCK, BEARPAW MOUNTAINS, MONTANA

WILLIAM T. PECORA AND BERNARD FISHER

Thousands of miarolitic pegmatites in monzonite are exposed in a quarry on Beaver Creek, in the Bearpaw Mountains, about 22 miles south of Havre, Montana. The pegmatites are individual bodies having well-defined contacts with host rock, are commonly spheroidal or ellipsoidal in form, and are less than 4 inches in diameter. Each pegmatite is composed of a pegmatitic shell enclosing its miarolitic cavity.

Microperthite tablets and hastingsite prisms are essential minerals of the pegmatitic shell, and biotite, magnetite, and sphene accessory. Epidote, actinolite, chlorite, prehnite, datolite, calcite, analcime, thomsonite, pyrite, galena, and a few unidentified minerals are attached to the inner surface of the shell and extend into the cavity. A crystallographic description and chemical analysis of hastingsite are given.

MINERALOGY OF THE MISSOURI HEMATITE SINKS

FREDERICK H. POUGH

The minerals of the oxidized zones, and so far as possible, the minerals of the unoxidized sulphides, of the filled sink holes of the Central Ore District, centering around Rolla, Missouri, were studied. These deposits have been worked both for the hematite and for the underlying iron sulphides. The hematite formed through the oxidation of the sulphides and varies in texture from soft red "paint ore" to crystallized specularite. Associated with the hematite are numerous other minerals, but in very minor quantities. Among them are azurite, malachite, brochantite, olivenite and native copper. Small quantities of a still unidentified copper vanadate were also found. Calcite, dolomite, siderite, barite and gypsum were common. Chalcanthite, pisanite and melanterite formed in the drifts on the timbers. Amethystine and colorless quartz line many of the geodes.

The origin of these deposits presents an interesting problem to which no satisfactory solution has as yet been offered. Among the obviously untenable theories are those based upon the presence of specular hematite, which is shown to be the result of the oxidation of sulphides after deposition, rather than upon initial hypogene solutions. A theory is proposed which involves the deposition of FeS, by anaerobic bacteria, below the floor of a Pennsylvanian swamp, making the original sulphide deposit. The oxide ore is the result of later, and still continuing, supergene alteration.

SETTLING OF HEAVY MINERALS IN A GRANODIORITE DIKE AT BRADFORD, RHODE ISLAND

ALONZO QUINN

A granodiorite dike at Bradford, Rhode Island, has a thickness of sixty-five feet, an east-west strike, and a dip of 28° south. Heavy mineral separations of samples from different parts of the dike indicate that the proportion of heavy minerals increases systematically toward the base of the dike. This is shown also by thin-section studies of specimens from different parts of the dike and by studies of a dark zone at the base of the dike.

The systematic increase of heavy minerals toward the base seems to be due to crystal settling for several reasons. (1) The minerals which are concentrated toward the base crystallized early in the solidification of the rock. (2) These minerals were considerably heavier than the granodiorite magma. (3) They are distributed through the body of the rock and are not concentrated along permeable zones as they would be if deposited by later hydrothermal solutions. (4) The heavy minerals are especially concentrated in a dark zone along the base and appear to fill depressions in the slightly irregular floor.

The settling appears to have occurred when the magma was moving upward along the dike, as is indicated by the fact that the zones of equal proportions of heavy minerals are almost parallel to the base instead of horizontal. The small size of the settled grains, with zircon crystals as small as .10 millimeters by .03 millimeters, indicates a low viscosity of the magma.

X-RAY CRYSTALLOGRAPHY OF BURKEITE, $2Na_2SO_4 \cdot Na_2CO_3$

LEWIS S. RAMSDELL

Rotation and Weissenberg photographs of single crystals of synthetic burkeite showed strong reflections indicative of an orthorhombic unit cell with $a_0=5.16$, $b_0=9.21$ and $c_0=7.05$ Å. There are no characteristic absences, although all $h0l$ reflections with $h+l$ odd are either absent or else very weak. This means that the structure must be such as to approximate a diagonal glide plane parallel to 010. If such a glide plane were actually present, the space group would be either *Pmnm* or *Pmn*. The axial ratio of this unit cell agrees with that from the morphological data.

This indicated cell, however, contains $4/3(2Na_2SO_4 \cdot Na_2CO_3)$; hence it must be a pseudo-cell. Longer exposed rotation photographs about the *c* and *b* axes show very faint layer lines trisecting the previously observed strong ones. Weissenberg photographs taken at these new positions are very faint, even after long exposures, but give positive evidence of these layers. Accordingly, the true unit cell has both the *c* axis and the *b* axis tripled, with respect to the pseudo-cell. This large unit contains 12 formula weights.

The contents of the pseudo-cell, $4/3(2Na_2SO_4 \cdot Na_2CO_3)$, may be written as $4Na_2X$, where $X =$ either SO_4 or CO_3. The reason that this pseudo-cell is not the true structural unit must lie in the lack of equivalence of the SO_4 and CO_3 groups. However, these groups are so nearly alike that the evidence for the larger unit is barely apparent. This lack of complete equivalence also probably accounts for the departure from a true glide plane parallel to 010 in the pseudo-cell.

THE MEASUREMENT OF ANGULAR DOMAINS OF REFLECTION IN POLYCRYSTALLINE SAMPLES

ALFRED REIS

Principle of the method: *x*-ray beam parallelized by reflection on relatively perfect single crystal, powder lines spotted, each diagram made with 2 or more exposures, between 2 subsequent exposures the orientation of sample is given small, definite change ω, ω is varied systematically in a series of experiments.

By shifting the film with each change of sample orientation results are improved. Multiple exposures give more details about different angular domains in sample than double exposures.

Exact theory considers intensities of spots and wavelengths of multiplett *x*-ray lines.

Details are given on influence of conditions upon number of spots in powder lines and desirable properties of *x*-ray beam.

Construction of instrument for carrying out measurements is described—type double spectrometer with 2 independent axes.

For measurement of large angular domains (fatigue control) in immovable pieces another instrument is described—type shifting slit.

2 phenomena give their contribution to angular domains of reflection: mosaic structure and fluctuations of lattice constant within a crystallite. The first is independent of the glancing angle, the second increases with $1/\cos\theta$, hence separate evaluation is possible.

By the new method, systematic study of imperfections in crystal structure has become accessible. Interesting applications can be made in metallurgy, especially in the fields of heat treatment (diffusion, transformation, precipitation, age hardening) and fatigue.

INESITE, $Mn_7Ca_2Si_{10}O_{28}(OH)_2 \cdot 5H_2O$

W. E. RICHMOND

The chemical composition of inesite, based on a complete *x*-ray investigation together with existing analyses is represented by the formula $Mn_7Ca_2Si_{10}O_{28}(OH)_2 \cdot 5H_2O$. Inesite is considered to be a hydrous rhodonite.

A new orientation is adopted.

RANCIÉITE, A VALID MINERAL SPECIES

W. E. RICHMOND AND MICHAEL FLEISCHER

An extensive *x*-ray, optical, and chemical study of the manganese oxide minerals is now under way at the U. S. Geological Survey. Ranciéite, usually listed as a variety of psilomelane, is a distinct species. A new analysis of material from Cuba leads to the formula $(Ca, Mn)O \cdot 4MnO_2 \cdot 3H_2O$. Most of the water is lost below 250°, with the formation of a new phase.

SPHALERITE-DOLOMITE ORIENTATION RELATIONS

FORBES ROBERTSON

The orientation of dolomite and metasomatic sphalerite in two coarsely crystalline, slightly foliated dolomite specimens from the Renfrew Zinc Prospect, Ontario, shows the following features. The crystallographic axes C_v of dolomite are normal to the foliation. There is remarkable development of $(02\bar{2}1)$ twin doublets which, with the crystal axis orientation, fixes the position of the grains. The orientation pattern supports Fairbairn's assumption of a direction-sense of twinning in dolomite which is the reverse of that known for calcite, and also the hypothesis that the chief stress acted approximately normal to the foliation. Measurement of the dodecahedral cleavage planes of scattered sphalerite grains in the rock reveals a high degree of orientation of their isometric axes, one being parallel to the S-surface, the other two inclined at 45 degrees on either side of the S-surface. The spalerite is in part elongated parallel to the foliation as a result of movement along cleavage planes. The marked symmetrical relation between the dolomite and later sphalerite suggests an inherited orientation modified by later deformation.

ORDER OF SILICATES IN SYSTEMATIC MINERALOGY

AUSTIN F. ROGERS

The work of structural crystallographers led by Machatschki, Pauling, and W. L. Bragg has furnished a satisfactory classification of silicate minerals based upon the characteristic linkages of silica tetrahedra. While there is general agreement upon the division of the silicates into discrete silica silicates (orthosilicates), chain silicates (metasilicates), sheet silicates (metadisilicates), and network silicates (polysilicates), there is a difference of opinion as to the order of arrangement of these groups. This difference is illustrated in two valuable papers published in the *American Mineralogist* in 1937. In the paper by Swartz the discrete silica silicates are placed first and the network silicates last. In the paper by Berman this order is reversed.

A careful study convinces me that it is better to start with the discrete silica silicates and end with the network silicates. The fact that the network silicates which include the feldspar group are closely related to the silica minerals in structure is of course important, but it does not seem to be a sufficient reason for adopting an order so unsatisfactory in other respects.

In a treatment of silicates, the orthosilicates or discrete silica silicates seem to furnish the logical starting point. Olivine then instead of feldspar takes the position of first place. It is a very important mineral and one much simpler than the feldspars in its chemistry and physical properties.

The order of silicates here advocated is the one preferred by Bayley, W. L. Bragg, Donnay, Escher, Ramdohr, Schneiderhöhn, Strunz, and Wyckoff.

AMERICAN SYNTHETIC EMERALD

AUSTIN F. ROGERS AND FRANCIS J. SPERISEN

The synthetic emerald here described has been made by Carroll F. Chatham, San Francisco chemist, although the method of manufacture cannot be disclosed at present. Cut stones made of the material are small but of very good quality.

The emerald crystals are short prismatic in habit, and in color are comparable to good Colombian emeralds. The chemical analysis shows silica, alumina, beryllia, some chromium oxide, small amounts of alkalies, and small amounts of other constituents.

Optical tests prove that the crystals are emerald. They are slightly pleochroic and show certain optical anomalies.

The synthetic emerald is distinguished from natural emerald by the character of the inclusions.

EXTREME HYDROTHERMAL ALTERATION IN THE BUCK CREEK, NORTH CAROLINA, DUNITE BODY

CLARENCE S. ROSS

A dunite body on Buck Creek, Clay County, North Carolina, is in many ways the most interesting of the many similar bodies distributed from Quebec to Alabama. It is a wedge-shaped mass about $1\frac{1}{2}$ miles long, and $\frac{3}{4}$ of a mile in greatest width. A small part has been described as a troctolite—a rock composed of olivine and calcic plagioclase, but most of the mass appears to have been originally an almost pure olivine dunite. All variations are observable between this and rocks in which olivine has been completely replaced. The secondary minerals are actinolite, chlorite, serpentine, magnesite and magnetite, and less commonly zoisite, indicating an unusually complete degree of replacement of a dunite.

In many of the dunite bodies extreme alteration is related to the introduction of pegmatites and is localized along their contacts; but at Buck Creek, alteration seems to have resulted from the introduction of hydrothermal solutions along closely spaced shear zones. These solutions introduced alumina and lime, and removed magnesia. A rock composed of actinolite, zoisite, and corundum, may have been formed by the same process [though the alteration of a felspathic rock cannot be excluded].

MUTUAL MELTING RELATIONS OF PYROXENOIDS, MELILITES, AND OLIVINES IN THE QUATERNARY SYSTEM $CaO—FeO—Al_2O_3—SiO_2$

J. F. SCHAIRER

Liquidus data are complete for five planes (joins) through a tetrahedron used to represent the quaternary system $CaO—FeO—Al_2O_3—SiO_2$. The joins studied were SiO_2—anorthite—FeO, anorthite—Al_2O_3—FeO, $CaSiO_3$—anorthite—FeO, gehlenite—anorthite—FeO, and $CaSiO_3$—gehlenite—FeO. These data give the approximate temperatures and locations of eleven of the quaternary invariant points. It is possible to follow the direction of change in composition of the liquid phase during crystallization in all regions of any geological interest and the incompatibility of certain mineral assemblages at equilibrium is indicated.

AN UNUSUAL SPECIMEN OF GRAPHIC GRANITE

WALDEMAR T. SCHALLER

In a specimen of graphic granite from New Hampshire, the quartz has been completely removed without any change in the microcline. Three similar specimens have been found in California. From specimens from Maryland only a little quartz has been removed.

DIAMOND DIES IN THE NATIONAL DEFENSE PROGRAM

ALEXANDER SHAYNE

The importance of diamonds in the national defense program and the steps taken by the government to develop adequate facilities are discussed. Special attention is given to the wire drawing industry.

The supply, sources of supply, and the industrial requirements of the United States of finished diamond dies in 1940 is presented. The steps taken by the United States Government in cooperation with the British Diamond Die Controller has alleviated the situation. The outlook for the immediate future is discussed.

DIAMOND SET TOOLS

CHESTER B. SLAWSON

The use of shaped cutting tools formed from single crystals is discussed. In forming the contour of the cutting edge a knowledge of the variation in hardness with direction is necessary. In the utilization of the superior hardness of the diamond and the consequent ability "to cut" the other physical characteristics become the primary consideration.

The structural strength of the diamond is due to the absence of fracture and parting, and to its difficult though perfect octahedral and imperfect dodecahedral cleavages. The variation of structural strength with direcion is far more pronounced than the variation of hardness with direction. Some evidence seems to indicate that structural strength varies with crystal habit. Industrial practice is correlated with theoretical considerations of maximum structural strength.

Thermal conductivity, thermal expansion, and inversion to graphite are discussed.

MOVEMENT OF MINERALIZING SOLUTIONS IN THE PICHER DISTRICT, OKLAHOMA-KANSAS*

RICHARD E. STOIBER

The direction of flow of the mineralizing solutions was studied at many localities in the mines of the Picher lead-zinc district in Oklahoma and Kansas. Direction of flow was determined from a study of crystals deposited in open space by noting preferred growth on the stoss side of crystals, overgrowths of later crystals on the stoss side of earlier ones and crystal deposition on the stoss side of irregularities in cavity floor or roof. The horizontal components of the flow directions indicate movement of the solutions away from the Miami Shear Trough approximately NE and NW to the NW of the trough and SE and SW to the SE of the trough, with little local variation. These directions are believed to indicate the pattern of the fractures along which solutions traveled in this area. Ore runs appear to have formed when the solutions reached the structures favorable for ore deposition described previously by other investigators.

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IDOCRASE MORPHOLOGY

ABBE J. ARTHUR TREMBLAY

From a statistical study of 227 figures in Goldschmidt's *Atlas*, it is possible to list 47 crystal forms in order of decreasing importance (frequency and size). The Donnay method of morphological analysis, applied to these data, yields the space-group $C4/acn$ and the axial ratio $c/a=0.5372$ (or $P4/nnc$, with $c/a=0.7597$), in agreement with x-ray results (*Strukturbericht*). The classical Law of Bravais enabled Mallard to determine the lattice mode and axial ratio.

The observed order of importance of the forms is compared with the theoretical order, both in the Law of Bravais and in the generalized law (Donnay and Harker). The agreement is better in the latter, although some anomalies persist.

NOTE ON THE TERMINOLOGY OF CRYSTAL DRAWINGS

GEORGE TUNELL

In order to obtain crystal drawings of a more solid appearance than the ordinary plan, front elevation, and side elevation, two methods have been widely used. In one the drawings are constructed by laying off intercepts of crystal faces on an axial-cross; in the other the drawing is constructed from a gnomonic projection. The greater part of the drawings made by the axial-cross method have been clinographic projections, that is, the projection lines from the crystal to the drawing plane are not perpendicular to the drawing plane. The method of preparing a solid-appearing crystal figure from the gnomonic projection, which was discovered by V. Goldschmidt, leads to an orthographic projection of the crystal on a plane not parallel to any of the principal planes of the crystal. Such a drawing has frequently been called a parallel-perspective drawing by crystallographers. It has been pointed out by A. F. Rogers, however, that this term is used in architectural and engineering drawing in an entirely different sense. A term has long existed for orthographic projections on planes not parallel to any of the principal planes of the object, namely, axonometric projection. Since this term is generally used in engineering drawing and descriptive geometry, it should be used for crystal drawings made by the method of V. Goldschmidt, as well as for some drawings made by the axial-cross method that are orthographic projections. The term axonometric is derived from the Greek *αξων* axis and *μετρον* measure. The axonometric projection is one in which measurements can be made along directions parallel to the three axes of the object, scales of foreshortening determined by the angles made by the plane of the projection with these three axes being applied in the axial directions.

X-RAY STUDY OF CHRYSOTILE ASBESTOS

B. E. WARREN

A previously proposed structure for chrysotile asbestos involving Si_4O_{11} chains is considered now to be improbable. It appears that a ribbon structure involving long but narrow Si_4O_{10} sheets is more probable than one involving the double amphibole chains. The composition $Si_2O_5\ Mg_3(OH)_4$ has a silicon-oxygen ratio indicating a sheet structure, and it was only the fibrous nature of the material which suggested a chain structure.

Chrysotile from Thetford Mines has been re-examined using crystal monochromated CuKα and MoKα radiation. All reflections can be indexed in terms of a monoclinic cell $a = 14.66$ Å, $b = 9.24$ Å, $c = 5.33$ Å, $\beta = 93°16'$, with c the fiber axis. Except for two or three weak reflections half this value of a will suffice. The most obvious layer structure is one built up by the sequence 3O, 2 Si, 2O OH, 3 Mg, 3 OH. The two dimensions $b = 9.24$ and $c = 5.33$ are identity periods in such a layer. Satisfactory intensity agreement is obtained for eight observed orders of $h00$ only if the layers all face the same way.

All of the definite reflections are of the type $h0l$ or $0kl$. All $h0l$ reflections are of the sharp crystalline type, most of the $0kl$ reflections are smeared out along the layer lines resembling two-dimensional lattice reflections (kl). The diffuse reflections are due to a randomness in the stacking together of successive layers. Although the main features of the structure seem to be fairly definite, a complete treatment of the intensities of the diffuse and the sharp reflections has not been finished.

FURTHER STUDIES IN THE LEPIDOLITE SYSTEM

A. N. WINCHELL

Detailed study of all the best analyses of the lepidolite system, including five new ones, together with *x*-ray and optic studies of the samples analyzed, leads to the conclusion that the system has three end-members, namely polylithionite, $K_2Li_4Al_2Si_8O_{20}F_4$, protolithionite, $K_2LiFe_4Al_3Si_6O_{20}F_4$, and $K_2Li_3Al_5Si_6O_{20}F_4$, for which the name paucilithionite is suggested. But on this basis alone practically all the analyses show a deficiency of lithia which is too constant and too large to be ignored. No change in the end-member molecules has been discovered which will reduce this deficiency. All the evidence leads to the tentative conclusion that it is due to muscovite, not in crystal solution in the lithia mica, but submicroscopically interleaved with it. Diagrams are presented showing the relations between variations in composition and variations in the optical properties.