

PRESIDENTIAL ADDRESS

The address of Dr. William S. Bayley, retiring President of the Mineralogical Society of America, was given Tuesday, December 29, 1936 at 11:40 A.M. in the Hall of Mirrors, before the joint assembly of all societies. Dr. Bayley's address was entitled "Mineralogy's Contribution to the Other Sciences and to Industry."

PRESENTATION OF PAPERS

MINERALOGY, PHYSICAL-CHEMICAL MINERALOGY, AND CRYSTALLOGRAPHY

Tuesday Afternoon, December 29th

(1) THE SYSTEM, $\text{NaAlSiO}_4\text{-FeO-SiO}_2$, by Norman L. Bowen.

In a system with the above components fayalite and albite are binary compounds. The results of a study of mixtures of fayalite and albite have already been published. The join, fayalite-albite, divides the general triangle into two parts in one of which there is a ternary eutectic between fayalite, albite and silica, with a temperature of 980° and containing only some 5 per cent fayalite. In the other portion of the triangle there are certain complications due to the appearance of the oxide phases wustite and hercynite but in the area where these phases do not appear there is a ternary eutectic between nepheline, albite and fayalite with a temperature of 990° and containing only some 10 per cent of fayalite. These mixtures are not unrelated to certain soda-rich rhyolites, trachytes and phonolites and the determinations throw some light on the genesis of such rocks.

(2) OBSERVATIONS ON THE PRODUCTION OF SYNTHETIC GEMS, by Edward H. Kraus.

Observations made at the plants at Locarno, Switzerland, and Bitterfeld, Germany, where synthetic gems are manufactured, were summarized. Certain phases of the process of manufacture and some of the characteristic properties of synthetic ruby, sapphire, spinel, and emerald, were discussed.

(3) FURTHER STUDIES OF THE ZEOLITES, by A. N. Winchell.

The square diagrams previously used to represent the variations in composition in zeolites have been corrected and modified to include new data. As before, they show that zeolites vary in composition chiefly in the same way as feldspars. They also show that the variation consists essentially in the addition of silica. Accordingly, it is possible to consider these variations in terms of the *three* molecules: CaAl_2O_4 , $\text{Na}_2\text{Al}_2\text{O}_4$, and Si_2O_4 . This makes it possible to represent the composition of all zeolites on ternary diagrams, which are more satisfactory than the square ones previously used. Finally, variations in optical properties corresponding with these variations in composition are not easily defined, because variations due to other causes are commonly present, but a diagram for thomsonite has been prepared.

(4) THE TREND OF MINERALOGICAL RESEARCH, by W. A. Tarr.

The attempt is made in this paper to determine the trend in mineralogical research by an analysis of the leading articles in *The American Mineralogist* and the *Mineralogical Magazine* for the last two decades. The material in the two journals is classified under several heads, such as physical properties, crystal structure and x-rays, chemical mineralogy, origin, and descriptive mineralogy. The analysis reveals an interesting distribution of the subject matter, and evidence of certain fairly definite trends.

- (5) UNGEMACHITE AND CLINO-UNGEMACHITE—NEW MINERALS FROM CHILE, by M. A. Peacock and M. C. Bandy.

Ungemachite is rhombohedral— $\bar{3}$; $a:c=1:2.2966$; $\alpha=62^\circ 51\frac{1}{2}'$; thirty forms. Habit, thick tabular {0003} {111}. Cleavage {0003} {111} perfect. $a_0=10.84 \pm 0.02 \text{ \AA}$, $c_0=24.82 \pm 0.05 \text{ \AA}$; $a_0:c_0=1:2.290$; V_0 (rhombohedral cell) = 842 cubic \AA . Cell content: $\text{Na}_8(\text{K}, \text{Fe}''')_4(\text{OH})_2(\text{SO}_4)_6 \cdot 10\text{H}_2\text{O}$, with $\text{K}:\text{Fe}'''$ about 3:1. $\text{H}=2\frac{1}{2}$. $G=2.287 \pm 0.003$ (Berman). Colourless, transparent; uniaxial, negative; $nO=1.502$, $nE=1.449$. Analysis (Gonyer): Na_2O 21.61, K_2O 11.35, Fe_2O_3 7.69, SO_3 40.23, H_2O 16.69, N_2O_6 trace, insol. 2.07, sum 99.64. Occurs with sideronatrite in massive altered iron sulphates at Chuquicamata, Chile. Named in honour of the late Henri Ungemach of Strasbourg.

Clino-ungemachite is monoclinic; $a:b:c=1.6327:1:1.7308$; $\beta=110^\circ 40'$; twenty-four forms; lattice {100} centered. The simple lattice is pseudo-rhombohedral, very like that of ungemachite, with which it is intimately associated. The properties are close to those of ungemachite, but the material is insufficient for a chemical analysis.

- (6) PARAGENESIS OF THE URANIUM-BEARING AND ASSOCIATED MINERALS OF THE RUGGLES' PEGMATITE NEAR GRAFTON CENTER, NEW HAMPSHIRE, by Benjamin M. Shaub.

Recent work in mining for feldspar at the Ruggles' pegmatite has exposed numerous uranium-bearing and rare-earth minerals. The uraninite occurs as a three-dimensional dendritic intergrowth in plagioclase feldspar and closely associated with apatite. The alteration of these is attended with a group of hydrous uranium-bearing phosphates. Galena and other sulphides are sparingly present with the original minerals of this group. Beryl is apparently absent, however, in lower openings along the strike down the mountain, but undoubtedly a continuation of the main pegmatite mass, it occurs sparingly. On an older dump pieces of lithiophyllite intimately associated with pyrrhotite, chalcopyrite and other sulphides weighing up to 50 pounds were found. More than 30 mineral species are already known from this mineral deposit. The pegmatite mass is intruded into strongly metamorphosed schists along their strike, but it often cuts sharply across the foliation. Both are cut by later diabase dikes.

- (7) THE CRYSTAL STRUCTURE OF KRENNERITE, by George Tunell and C. J. Ksanda

Well-developed faceted crystals of krennerite from Cripple Creek, Colorado, previously measured by Dr. M. A. Peacock on the two-circle reflection goniometer, were investigated by means of the Weissenberg X-ray goniometer. The dimensions of the unit cell were found to be: $a_0=16.51 \text{ \AA}$, $b_0=8.80 \text{ \AA}$, $c_0=4.45 \text{ \AA}$, all $\pm 0.03 \text{ \AA}$. The unit cell contains 8 "molecules" of AuTe_2 . The systematically missing spectra limit the space-groups possible for krennerite to three, namely, $Pmc-C_{2v}^2$, $Pma-C_{2v}^4$, and $Pmma-V_h^8$. From an analysis of the intensities of the diffraction spots on our Weissenberg negatives, from consideration of the close relationship between the structural lattices of krennerite and calaverite as determined by our Weissenberg studies of single crystals, and from the close similarity of the powder photographs of the two minerals both as to positions and intensities of the diffraction lines, the atomic arrangement in krennerite must be one that is isomorphous with the space-group $Pma-C_{2v}^4$. The values of the 18 parameters were determined from the intensities alone. The structure of krennerite is closely related to that of calaverite although the two minerals crystallize in different systems.

- (8) A MINERALOGIC STUDY OF SILICOSIS, by R. C. Emmons and R. Wilcox.

The observation has been made repeatedly that certain mineral associations with quartz render dusts harmless from the silicosis viewpoint. An attempt has been made to learn the

underlying principles. Experiments have also been carried out to learn what other minerals may cause silicosis.

(9) AN UNUSUAL FELDSPAR FROM THE NORTHERN INYO RANGE, by George H. Anderson and Donald D. Maclellan. (Geological Society Project.)

In studying thin sections of Boundary Peak granite from the Northern Inyo Range Dr. Anderson noted the occurrence in considerable abundance of an untwinned optically positive feldspar of lower birefringence and index than albite. These grains are commonly fringed with myrmekite wherever they are in contact with plagioclase.

Dr. Maclellan undertook a detailed study of the optical properties of the feldspar with the aid of the universal stage. This yielded the following results:

Crystal system, triclinic. Extinction angles: X on best cleavage (probably 001), 7° to 10° ; Z on second best cleavage (probably 010), 10° to 15° . Optic angle variable, mostly ranging from 80° to 86° but in a few grains as low as 64° and in one or two as high as 89° . Indices: $N_g = 1.524$, $N_m = 1.520$, $N_p = 1.518$. Birefringence = .006.

An x -ray study undertaken by Dr. Linus Pauling and Dr. J. H. Sturdivant confirmed the triclinic character of the mineral and showed that it is distinctly different in several respects from both microcline and orthoclase.

Since the mineral can be distinguished from ordinary feldspars only in thin section, material for analysis could be secured only by digging individual grains from sections slightly thicker than standard. It was practically impossible to secure sufficient amounts for chemical analysis, but a quantitative spectroscopic determination by Dr. Maurice Hassler showed the following composition: K_2O , 11%; Na_2O , 2.7%; CaO , 0.3%; BaO , approximately 0.5%; SrO , approximately 0.01%; MgO , approximately 0.02%; Fe_2O_3 , approximately 0.04%.

The mineral is therefore a positive triclinic potassic feldspar different in several respects from any other described species.

(10) THE VALENCES OF IRON IN PYRITE AND MARCASITE, by M. J. Buerger.

A determination of the crystal structure of arsenopyrite has shown that the iron atom has a radius of 1.13 Å, which is smaller than its generally accepted radius, 1.24 Å, while the sulfur atom has a radius of 1.10 Å, which is correspondingly larger than its generally accepted radius, 1.04–1.06 Å. The sulfur and iron radii in arsenopyrite are the same as those found in marcasite and löllingite. They differ from the values found in any other group of crystals including the pyrite group. An extrapolation of the radii of transition metals given in tables by Pauling and Huggins shows that the radius of iron in the marcasite packing is just what would be expected if the iron atom were in the ferric state rather than in the ferrous state as it is in pyrite.

The parameter values for sulfur in marcasite which control the calculated sizes of the atoms in that crystal have been criticized by Pauling and Huggins because the atom radii values do not correspond with the accepted values. The marcasite parameters have therefore been completely redetermined using the unequivocal new Weissenberg methods. All possible planes $hk0$ and $h01$ which can be recorded with $MoK\alpha$ radiation have been registered on both underexposed and overexposed Weissenberg equator films for the purposes of comparing strong and weak reflections respectively. A complete study of the variation of these intensities with parameter change has also been carried out. The results completely confirm the earlier study of marcasite, and it can be confidently affirmed that marcasite has a small iron atom and a large sulfur atom.

It therefore appears that the iron in pyrite and marcasite is in different valence states: pyrite is ferrous disulfide while marcasite is ferric disulfide. This gives an entirely new

meaning to the Stokes test for pyrite vs. marcasite, and a possible new significance to the differential genesis of these two forms from different chemical environments.

- (11) A RARE-ALKALI BIOTITE FROM KINGS MOUNTAIN, NORTH CAROLINA, by Frank L. Hess and Rollin E. Stevens.

The paper concerns the occurrence of biotite containing rare alkali metals, associated with mica schists bordering pegmatites. Dark mica, developed notably in mica schist at the contact with a pegmatite, both at Tin Mountain, South Dakota, and Winterham, Virginia, were found to contain small quantities of lithium, caesium, and rubidium. These two occurrences suggested that where dark mica was found developed at the border of a pegmatite, especially one carrying lithium minerals, it should be examined for rare alkali metals.

In the examination of spodumene bearing pegmatites, enclosed in mica schists, from Kings Mountain, North Carolina, brownish mica was found which was supposed to have come from the schist at its contact with the pegmatite. The pegmatite with which the mica is associated is unusual in that dark minerals are exceedingly scarce. Spodumene makes up 15 to 20% of the mass.

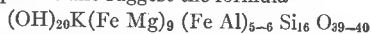
The composition of the Kings Mountain biotite as compared to that from Tin Mountain, South Dakota, shows less iron and more silica. The percentages of alkali oxides present are almost identical. The quantity of fluorine present seems to explain why the border biotites carry the alkali metals usually found in the zones of highest temperature. Some fluorides are notably soluble at comparatively low temperatures and it seems probable that the alkali metals were carried as fluorides to the sides of the pegmatites and there entered into the biotites of the enclosing schists.

- (12) THE SYMMETRY OF ICE, by Austin F. Rogers.

A careful study of ice and snow crystals and their solution forms indicates that ice belongs to the dihexagonal pyramidal class ($A_6 \cdot 6P$) of the hexagonal subsystem. This determination of the symmetry is confirmed by the x -ray work of Bernal and Fowler.

- (13) SOME NOTES ON THE STRUCTURE OF STILPNOMELANE, by John W. Gruner.

Eight analyses of stilpnomelane suggest the formula



Five of the eight were x -rayed, three of them not being available. The photographs suggest a layer structure similar to chlorite and mica with the following dimensions: $a = 5.4 \text{ \AA}$, $b = 9.3 \text{ \AA}$, $c = 24.1 \text{ \AA}$. This unit cell contains two molecules of the formula above. So far it has been impossible to arrange sheets of the mica, brucite, or kaolinite type in such a way that the intensities of the basal reflections in the photographs can be explained satisfactorily. Many plausible combinations have been tried. Also heating of the mineral up to 740°C . has offered no clue. It is stable at temperatures at least as high as 500°C ., but at 600°C . the structure is partly destroyed. A shrinkage from 24.1 \AA to about 22 \AA in the direction normal to the cleavage occurs at this temperature.

- (14) CRISTOBALITE AT CRATER LAKE, OREGON, by Carl E. Dutton.

Although cristobalite is not uncommon in the andesites of the Cascade Mountains, the occurrence at Crater Lake is somewhat unusual because of the well developed complete and skeletal octahedrons.

- (15) THE CRYSTALLOGRAPHIC SERIES OF BAUMHAUER AND UNGEMACH, A THEORETICAL CONSEQUENCE AND FACTUAL CONFIRMATION OF THE LAW OF BRAVAIS, by J. D. H. Donnay.

Ungemach, after Baumhauer, showed that, if the axial elements are correctly chosen, the main faces of a crystalline species are distributed in "series" covering the principal

half-zones. E.g.: series (011), (021), (031), (041), . . . covers the segment of zone [100] that extends from (011) to (010); series (011), (012), (013), (014), . . . covers the segment (011)–(001) of the same zone. Such “simple primary” series are obtained by adding the indices of the “pole,” i.e. (001) in the latter case and (010) in the former, to the indices of the starting face, i.e. (011) in both examples. The series may be of different types, according to Ungemach’s observations. Example of a double primary series: 011·031·051· . . . , with (020) as its pole. Example of a simple secondary series: 032·052·072·092· . . . ; forms of the secondary series are obtained by addition of indices of two consecutive faces in a primary series. Secondary forms have been observed among the first members of otherwise normal primary series. The type of series found depends on the mode of centering of the (morphological) lattice.

Such empirical observations are shown to be direct consequences of the Law of Bravais. It is possible to predict what types of series are to be expected in the various half-zones, for different lattice modes. This affords easy criteria for the determination of the (morphological) lattice and “correct” axial elements.

(16) CHECKING INDEX LIQUIDS WITH THE MICROSCOPE, by C. B. Slawson.

The index of refraction of a liquid is measured with a microscope so constructed that the tube can be inclined to the side through an arc of 10°. The range of the index of refraction determinations extends from 1.330 to 1.880. A slit diaphragm placed in the condenser converts it into a collimating system and the microscope with the Bertrand lens inserted and an objective of proper focal length becomes a telescope. It then functions as a goniometer. A microscope slide with an accurately beveled edge placed upon a second slide forms the hollow glass prism which holds a few drops of the liquid.

(17) ON NORMAL TRICLINIC FACE-SYMBOLS AND THE HARMONIC-ARITHMETIC RULE, by M. A. Peacock.

If the Law of Bravais were strictly true, as applied to the simple structural lattice, the gnomonic projection points of the faces in a zone-quadrant would form the simultaneous series:

$$\begin{array}{cccccccc}
 0 \cdots \frac{1}{3} & & & \frac{1}{2} & & & & 3 \cdots \infty \\
 0 & \cdots & & \left(\frac{2}{4}\right) & & & & \infty \\
 0 & & \cdots & \frac{2}{5} & \frac{3}{4} & \frac{3}{3} & \frac{4}{3} & \frac{5}{3} \cdots \infty \\
 & & & \cdots & & & & \infty
 \end{array}$$

in which the end terms represent the planes with the greatest and second greatest spacings while the unit term represents the plane with the third greatest spacing in the quadrant. These *normal series*, corresponding to *normal face-symbols*, are harmonic from unity to zero, arithmetic from unity to infinity. The Law of Bravais predicts the relative extent of the several series in any one zone, and the degree to which either the harmonic or the arithmetic part may preponderate.

Analysis of a sufficient number of highly developed triclinic zones reveals a fair approach to the ideal series. In spite of irregularities, which constitute exceptions to the Law of Bravais, the proposed *Harmonic-Arithmetic Rule* leads unambiguously to the structural lattice, when applied to the gnomonic projection of the forms of a triclinic crystal on the plane normal to the axis of the main zone.

(18) THE WEISSENBERG TREATMENT OF CRYSTALS BELONGING TO THE OBLIQUE SYSTEMS, by M. J. Buerger.

The angles between planes in a crystal may be determined in a number of ways by the Weissenberg method. These include (1) the direct determination of the angle on the Weissenberg film, between the Z lines containing the orders of reflection of the two planes on

the equatorial photograph, and (2) the determination of the offsets of dome reflections on n -layer films as compared with the lines of corresponding pinacoid reflections on the equatorial film. Neither of these methods is accurate unless the Weissenberg translation motion is impracticably long. A method of extreme precision is the following: In a monoclinic crystal, the reciprocal lattice vectors, a^* , c^* , c^*-a^* , form a triangle, one of whose angles is the crystallographic element β . Measurements of the Bragg angles of reflection from the planes (100), (001), and (101) will therefore yield data which will permit a calculation of β with the same precision as the other cell constants. A similar method may be used to calculate any interfacial angle. In triclinic crystals, this calculation does not yield the angles α , β , and γ directly, but rather the polar angles λ , μ , and ν , from which α , β , and γ may be calculated by the familiar Goldschmidt polar form relation. The development of a new instrument (mentioned in another abstract) for the extremely accurate determination of lattice spacings, now makes it possible to determine not only the cell edges, but also their angles of inclination and, of course, the axial ratio, with an accuracy exceeding that of optical goniometer methods. The new x -ray methods have the additional advantage that they can be applied to crystals with incomplete form development and crystals whose perfection is too low to permit ordinary optical goniometer work with any accuracy.

(19) ENANTIOMORPHOUS QUARTZ IN TECTONITES, by H. W. Fairbairn.

A statistical analysis was made of the orientation of quartz from a Cambrian quartzite in southern Quebec. Approximately 10,000 grains were measured from 19 thin sections, collected over a strikewise distance of 14 miles. The most prominent maxima in the orientation diagrams (loci of greatest orientation of quartz axes) correspond to Maximum IV of Sander (see D. 61 in *Gefügekunde der Gesteine*), and all four are symmetrically placed with respect to the projection line of the quartzite foliation surfaces. This maximum has not yet been satisfactorily explained and the following interpretation is offered. Gliding occurred parallel to rhombohedral planes of the quartz. The glide directions in these planes are not, as is usual, in a plane containing the vertical crystallographic axis, but are oblique, with a statistical arrangement which corresponds to the trapezohedral symmetry of enantiomorphous quartz. Two of the maxima in the diagrams originate from right-handed grains; two from left-handed. Since the structure of low-quartz is still uncertain it is not yet possible to correlate these assumed glide directions with known directions of greatest atomic density.

(20) THE STAUROLITE BELTS OF PATRICK AND HENRY COUNTIES, VIRGINIA,* by Charles H. Moore, Jr.

The staurolites in these two counties occur in two roughly parallel belts. One belt begins at a point four miles southwest of Stuart and extends in an approximate N 50 E direction for a distance of about nineteen miles. The other begins at a point nine miles northeast of Stuart and one-half mile southeast of the first belt and extends to and beyond the Franklin County line. The belts are roughly lenticular in shape and have a maximum width of two and one-half miles.

The three principal rocks associated with the staurolites are a biotite chlorite schist, a sericite staurolite schist, and an iron-stained quartz mica schist. These rocks form a portion of the Wissahickon formation where the Martic overthrust block overrides the Lynchburg gneiss. They form a sharp contact with the Lynchburg gneiss along their western boundary and grade into less metamorphosed Wissahickon on the east.

The staurolites occur as reddish brown idioblastic crystals one-tenth inch to one and one-half inches in length in each of the three rock types, and are altered wholly or in part

* By permission of the Virginia Geological Survey.

to sericite or chlorite. They contain numerous inclusions of small garnets which weather out, giving the appearance of pits in the staurolite crystals. The staurolites appear to be most numerous near the ends of the lenticular belts.

(21) HELIUM RATIO OF FLORIDA ANHYDRITE, by William D. Urry. (Geological Society Project.)

The rate of production of helium from the radioactive elements uranium and thorium being constant, a determination of these elements and the helium in rocks and minerals affords a measure of their age. Determinations have so far been confined to igneous rocks with the exception of the anhydrite here reported. The anhydrite drill core was taken from the South Lake Well, Florida, from a deposit 180 feet thick, at a depth of 2560 feet, the well starting in the Ocala limestone. Stratigraphic evidence places it most probably in the earliest Eocene and the computed age 71 ± 6 million years—late Cretaceous to early Eocene compared with the time scale from the igneous rocks—is in good accord with the stratigraphic evidence. If such agreement is borne out in further work the application of the method to the field of minerals will greatly aid in the solution of chronological problems of mineralization.

MINERALOGY, PETROGRAPHY, AND PHYSICAL-CHEMICAL MINERALOGY

Wednesday, December 30th

(22) THE DISTRIBUTION OF LITHIUM IN ROCKS AND MINERALS AS REVEALED BY QUANTITATIVE SPECTRUM ANALYSIS, by Lester W. Strock.

The material presented is the result of a study of the Geochemistry of Lithium made in the Laboratory of Prof. V. M. Goldschmidt at Göttingen University. A specially accurate quantitative method of optical spectrum analysis was devised capable of determining lithium to an accuracy of $\pm 3\%$ in the range 0.0001 to 3.5% Li_2O . The method will be briefly outlined. The amount of Li_2O in all the various types of primary, sedimentary, and some metamorphic rocks was determined. After determining the Li_2O content of sea water, the geochemical balance was calculated by the method of Prof. V. M. Goldschmidt. The most interesting results were obtained by analyzing the individual mineral components of rocks separately, which furnish one of the most excellent examples known for the important manner in which the laws of crystal chemistry may be applied in explaining isomorphism in minerals. The entire study illustrates the excellent service which quantitative spectrum analysis can render to mineralogy.

(23) UNUSUALLY HIGH FELDSPAR CONTENT OF THE GLENWOOD FORMATION, by John W. Gruner.

The Glenwood formation is of Ordovician age. Near Minneapolis it consists of a number of beds of clayey material which contain well rounded quartz grains all of which appear to be larger than 1/10 mm. The material smaller than this size was analyzed chemically and by *x*-rays. This fine material of one of the beds consists chiefly of potash feldspar. As a matter of fact, enough potash is present for two-thirds of the material to be feldspar. *X*-rays give the feldspar pattern only, even for sizes as small as one micron. Below this dimension many of the diffraction lines become very broad. While the feldspar pattern still persists, diffusion bands common to amorphous substances appear. The extremely small size of the feldspar particles raises the question as to the genesis of them. It is not thought likely that they represent simply a disintegration product of large crystals. The feldspar is probably secondary like authigenic material though no nuclei were necessary for its formation.

(24) THE PLANTERSVILLE METEORITE, GRIMES COUNTY, TEXAS, by John T. Lonsdale.

The Plantersville meteorite fell on the afternoon of September 4, 1930, at a point $3\frac{1}{2}$ miles southwest of Plantersville, Grimes County, Texas. The locality of the fall is forested but several men were working nearby and recovered the specimen within a few minutes of its fall. The phenomena of fall included rumbling explosions and a noise like an airplane in flight. This find is a light gray friable aerolite, weighing 2084.9 grams, with a dense black crust showing oriented thread lines. The shape is sub-conoid faceted with a well developed *brustseit*. The dimensions are $5\frac{3}{4}'' \times 4'' \times 3\frac{3}{4}''$, measured in three directions at right angles.

The texture of the meteorite is largely crystalline but glass is present in chondrules and also as an interstitial material in the groundmass. A relatively small number of minute veins of metal occur. Many chondrules are present most of which are angular or fragmental. The minerals present include hypersthene, chrysolite, a monoclinic pyroxene, metallic iron, troilite, black and colorless glass, and a reddish-brown spinel. Chemical and spectrographic analyses are included in the paper.

(25) ORIGIN OF THE CANADIAN APATITE-PHLOGOPITE DEPOSITS, by Kenneth K. Landes.

Apatite-phlogopite deposits in the watersheds of the lower Gatineau and Lievre rivers in southwestern Quebec, and one deposit near Wilberforce in southeastern Ontario, were examined. The pre-Cambrian metamorphic complex has been intruded by bodies of diopside "pyroxenite" with microcline pegmatite, accessory scapolite, actinolite, and titanite, and veins consisting principally of calcite, phlogopite, and apatite. The theory is advanced that a granite pegmatite magma on its way upward became contaminated through the assimilation of dolomite. Diopside first crystallized from this magma, partially desilicating it, and then the microcline pegmatite with accessory scapolite, actinolite, and titanite was formed. Calcite, phlogopite, and apatite resulted from a hydrothermal phase. The pyroxenite bodies and the country rock are alike cut by much later dikes of white microcline-quartz pegmatite.

(26) CRYSTALLOGRAPHY OF SYNTHETIC BURKEITE, by Lewis S. Ramsdell.

Crystals of synthetic burkeite, $2\text{Na}_2\text{SO}_4 \cdot \text{Na}_2\text{CO}_3$, have been obtained by evaporation from solution at 70–80°C. The crystals are usually twinned, but single individuals occur occasionally. Goniometric measurements give an axial ratio of 0.534:1:0.750. The usual forms present are (110) and (111). The twins consist of trillings, with (110) as the twinning plane.

(27) THE TERNARY SYSTEM, LEUCITE-DIOPSIDE-SILICA, by J. F. Schairer.

The field of diopside occupies a large portion of the phase diagram of the ternary system and diopside is the primary phase in some compositions with less than two per cent by weight of that compound. The ternary eutectic (solid phases—diopside, tridymite, orthoclase) and the ternary reaction point (solid phases—leucite, orthoclase and diopside) lie at compositions very close to the binary eutectic and binary reaction point in the system, leucite-silica. The field of orthoclase is very small. Residual liquids in fractional crystallization are rich in alkali-alumina silicates.

(28) LAMPROPHYRES OF THE BAY OF EXPLOITS, NEWFOUNDLAND, by George R. Heyl.

A group of lamprophyre dikes, chiefly monchiquites and fourchites, occur in the Bay of Exploits area of northeastern Newfoundland. Their spatial distribution indicates that they are genetically connected with the granodiorite batholiths of the region. They are the youngest intrusive rocks in the area and represent the final stage of the batholith differentiation.

The large phenocrysts of biotite and hornblende present in these dikes show pronounced evidences of resorption and reaction, indicating that they were unstable in the magma at the time of its intrusion. One of these dikes contains a great number and variety of inclusions which likewise show marked reaction and resorption effects. The reactions are of a type which would occur with an abrupt drop in pressure. Many of these dikes show fine-grained or aphanitic selvages which are interpreted as the chilled facies.

The evidence indicates that the lamprophyres were intruded as a magma which in most cases contained some intratelluric crystals in suspension. The changes in thermodynamic conditions during the transfer and injection of the magma resulted in these crystals becoming unstable. The minerals that were stable at the time of freezing of the dikes were those which have crystallized in the groundmass. A relatively low temperature of freezing of these rocks is suggested by the abundance of primary analcite in them; this is corroborated by the lack of thermal metamorphism in the rocks immediately adjacent to the dike walls.

The lamprophyre magma is conceived to have formed by the interaction of the residual magma of a batholith with the more basic deep-lying portions of the batholith. A magma unusually rich in femic molecules and hyperfusibles would result. Of the hyperfusibles water was by far the most abundant; in addition there was a concentration of carbon dioxide, fluorine, chlorine, phosphorus and sulphur. Because of the concentration of hyperfusibles, the vapor tension would be high, and if it exceeded a certain limit the magma would be injected outward and upward into the surrounding rock. This would be accompanied by rapid transfer of material and an abrupt drop in pressure, and, upon freezing, lamprophyre dikes would result. Such a history is indicated by the lamprophyres of the Bay of Exploits.

(29) ORIGIN OF THE MARCASITE SINK-HOLE DEPOSITS OF CENTRAL MISSOURI, by W. A. Tarr.

There are ten known deposits of marcasite (and pyrite in small quantities) in sink-holes in Franklin, Crawford, and Phelps counties in the northeastern part of the Missouri Ozarks, and others probably exist. Only two are active producers, at present. These sulfide deposits occur in the lower part of the sink-holes, the upper part having been occupied by hematite which has been removed by mining. The sulfide reaches a maximum thickness of 30 feet in some deposits and may be approximately 200 feet wide. The overlying hematite was pseudomorphous after the sulfides. The marcasite is accompanied by masses of sandstone and quartz as the chief gangue minerals. The contact of the ore with the walls of the sink-hole is normally sharp, locally it is gradational. The marcasite is massive, mammillary, stalactitic, botryoidal, granular, crystalline, and porous.

It is believed that the deposits were formed by hydrothermal solutions which rose from a hidden igneous mass below and deposited sulfides in the sink-holes under a cover of Pennsylvanian shales. The hematite resulted from the oxidation of the upper portion of the sulfide mass.

(30) ORIGIN OF THE CHERT IN THE TRI-STATE (MISSOURI-OKLAHOMA-KANSAS) ZINC-LEAD DISTRICT, by Chalmer J. Roy.

Three types of siliceous rocks are found in association with the sulphide ores of the Tri-State district, namely, early chert, late chert and jasperoid. The early chert, occurring as nodules and nodular beds, is found in the Mississippian limestones throughout the Mississippi valley and is believed to have formed as a penecontemporaneous replacement of the limestone. The late chert, occurring as massive beds, veins and silicified fault zones in the mining area only, is definitely epigenetic. The jasperoid occurs in intimate association with the sulphides and is believed to be contemporaneous with them, but later than the late chert. The late chert and jasperoid are believed to represent two phases of the ore

mineralization, one (the late chert) early and barren of sulphides, the other later and containing abundant sulphides. Both are believed to be hydrothermal.

(31) THE MINERALOGY OF THE WISCONSIN LEAD-ZINC ORES, by Charles H. Behre, Jr.

Recent mineralogical studies of the Wisconsin lead-zinc ores have revealed relationships bearing on their origin. The recognized sequence, as in similar European districts, was iron sulphide (loosely designated "marcasite"), sphalerite, galena, late barite, accompanied by long-extended calcite and iron sulphide deposition. Banfield and Born showed that much of the "marcasite" was actually pyrite; both minerals are colloform and their relations and similarity in form suggest paramorphism of pyrite after marcasite. An almost constant feature is a thin film of pyrite between country rock and ore.

The zinc sulphide is also largely colloform and in long bladed crystals, thus resembling the Silesian "Schalenblende" (wurtzite). Its presence favors acid waters as depositing agents. Some arsenic is present but in what mineral is not known.

Barite is conspicuously late as compared with the sulphides, thus differing from that in peripheral deposits of typical meso- and epithermal ores. Some silicification is chert-like but whether primary or secondary is still uncertain. Calcite in scalenohedral forms cements shattered sphalerite or wurtzite and typifies the late form of the carbonate, as compared with the earlier, rhombohedral form.

The replacement ores are quantitatively negligible, fissure fillings preponderating. Structural relations of the ores are not here discussed in detail, but the resemblance to the Silesian zinc ores, both structurally and mineralogically, is striking.

(32) CLASSIFICATION OF THE NATURAL SILICATES, by Charles K. Swartz.

It is the author's purpose to bring together the results of *x*-ray analyses, thus far published, bearing upon the problem of the mutual relations and chemical composition of the natural silicates and to present a classification of the silicates based upon the data thus assembled.

The principles underlying the classification were briefly discussed. It was shown that there are five fundamental types of natural silicates whose character and composition were illustrated. It was shown further that these fundamental types may combine among themselves to produce more complex assemblages, a number of which have thus far been observed.

The relations of the classification here proposed to those of Bragg, St. v. Naray-Szabo and Machatschki were considered briefly.

A table was given showing the classification of the chief families of silicate minerals. A detailed table has been prepared and will be published later, giving the composition of the natural silicates whose structures have been determined by *x*-ray analyses up to the present time, together with literature citations.

(33) THE STRUCTURAL LATTICE AND CLASSIFICATION OF BUSTAMITE, by Harry Berman and Forest A. Gonyer.

Bustamite ($\text{CaMnSi}_2\text{O}_6$) was formerly regarded as a lime rhodonite; more recently it has been considered as a manganese wollastonite. Since bustamite does not occur in faceted crystals it was not possible to help settle the question by morphological comparisons. *X*-ray measurements on a cleavage fragment yielded the following triclinic lattice dimensions: $a_0=7.64 \text{ \AA}$, $b_0=7.16 \text{ \AA}$, $c_0=6.87 \text{ \AA}$; $\alpha=92^\circ 08'$, $\beta=94^\circ 54\frac{1}{2}'$, $\gamma=101^\circ 35'$; $a_0:b_0:c_0=1.067:1:0.959$. The values are close to those of wollastonite. An analysis of the studied material leads to the cell content: $\text{Ca}_3\text{Mn}_3\text{Si}_6\text{O}_{18}$, which compares with the cell content of wollastonite: $\text{Ca}_6\text{Si}_6\text{O}_{18}$. The present study thus shows that bustamite is a manganese wollas-

tonite, confirming the conclusion previously reached from optical study and powder photographs.

(34) VEIN-FILLING AT NEVADA CITY, CALIFORNIA,* by W. D. Johnston, Jr.

A grant from the Penrose Bequest made possible the continuation in 1934 of work begun at Nevada City in 1931.

The principal ore minerals in the gold-quartz veins of Nevada City are pyrite, arsenopyrite, sphalerite, chalcopyrite, galena, and tetrahedrite, with lesser amounts of molybdenite and gold. They were deposited in the earlier stages of vein-filling in a quartz gangue. In the later stages of vein-filling carbonates were the dominant gangue minerals. Galena, tetrahedrite, and gold were introduced late in the quartz sub-stage.

Unique in a district where most mines produce by weight more gold than silver, is the Central Mine of the Lava Cap Gold Mining Corporation where the ratio of gold to silver by weight is 1 to 12+ due to unusual abundance of argentiferous tetrahedrite. Pyrargyrite is found rarely in the Central Mine.

Quartz textures give some clue to vein history. Combs and massive homogeneous quartz indicate vein-filling without movement of the vein walls; breccias indicate movement with appreciable dilation of the interwall space; and shear structures, such as granulation zones in ribbon quartz and mortar structure, indicate movement without appreciable dilation of the walls.

Most veins show evidence of recurrent deposition of quartz alternating with movement of the walls. Thick veins have been built by alternation of quartz deposition and movement in which the hanging wall was at all times adequately supported.

*By permission of the Director, U. S. Geological Survey, Washington, D. C.

(35) HORNFELS-GRANODIORITE TRANSITIONAL FACIES AT CORNUCOPIA, OREGON, by G. E. Goodspeed.

Metamorphic and granodioritic rocks of pre-Tertiary age, form the core of the rugged Willowa mountains of northeastern Oregon. Near the mining town of Cornucopia, hornfels-granodioritic contacts are common and well exposed. In addition to excellent surface exposures these contacts have been intersected by several long adit tunnels at different elevations.

Transitional facies are found in irregular zones, dike-like and stock-like masses, breccias, and unusual occurrences of angular blocks of granodioritic rock surrounded by hornfels. Some of the transitional facies show first a gradual change from a porphyroblastic hornfels to a rock which would be classified as a porphyry. This grades into a gneissic granodiorite and finally to what would be called a normal granodiorite. In zones which have been affected by cataclastic metamorphism there may be relatively sharp hornfels-granodioritic contacts which may be explained by the selective recrystallization replacement of the crushed material.

It is believed that sufficient field and petrographic evidence has been accumulated to warrant the interpretation that these smaller granodioritic masses have been formed by recrystallization replacement incident to a process of additive dynamothermal metamorphism and that this interpretation may be extended to the larger granodioritic masses.

(36) THE UNIT CELL AND SPACE GROUP OF STERNBERGITE, AgFe_2S_3 , by Newton W. Buerger.

Sternbergite from Joachimsthal, Bohemia, has been studied by the equi-inclination Weissenberg method. Due to the very plastic nature of sternbergite crystals this study has been very difficult and the cell constants given below are probably rough values. The

flexible nature of the crystals has also rendered the *x*-ray reflections poor, and certain other revisions may have to be made.

The investigation leads to the following cell data:

Diffraction symbol: mmmC-c-
 Crystal class: C_{2v} or D_{2h}
 Crystal system: Orthorhombic
 Space group: Cmc or Cmcn
 Unit cell:

	Absolute	Ratio	Peacock's ratio
<i>a</i> =	11.7	1.74	.5913 ($\times 3 = 1.7739$)
<i>b</i> =	6.7	1.	1.
<i>c</i> =	12.67	1.88 ₆	.6250 ($\times 3 = 1.8750$)
Z =	8 AgFe ₂ S ₃ per cell.		

It is evident that the axial ratio derived by surface morphological study should be altered so that *b* has $\frac{1}{3}$ the length assigned to it by Peacock. This change also brings with it the necessity of interchanging the usual *a* and *b* axes in order to leave *b* the longer of the two.

The structural study of this crystal is being continued.

(37) 2E GONIOMETER, by Terence T. Quirke.

A goniometer is made in half-cylinder form, calibrated from 0° at the zenith to 90° at the base. It is used on the stage of an ordinary petrographic microscope using convergent polarized light for the sub-stage illumination. It is convenient to withdraw the barrel of the microscope so that the stage is clear of any obstruction to the placing of the goniometer. The mineral section to be measured must be cut at or near a plane normal to the acute bisectrix. The section is then placed in the 45° position so that the principal optic plane lies at 45° to the plane of vibration of transmitted light.

In the bottom of the goniometer there is a sheet of polaroid oriented at right angles to the vibration direction of the sub-stage polarized light. The polaroid is oriented in the position of the usual analyzer in the microscope but is placed immediately on top of the mineral section between the mineral section and the scale of the goniometer.

When this set up is placed in a dark room and strong light passed through the mineral section from the sub-stage polarizer the eyes of the two optic axes are projected onto the translucent scale of the goniometer where the angle 2E can be read directly.

(38) A UNIVERSAL STAGE METHOD OF DETERMINING BIREFRINGENCE, by R. C. Emmons.

With the purpose in mind of using birefringence as a determinative criterion of minerals when the identity is uncertain after other tests, a method has been developed for learning the birefringence in crystals unfavorably oriented for standard methods of measurement or in crystals of birefringence too high for standard accessories.

(39) SIMPLIFIED GRAPHIC METHOD OF DETERMINING APPROXIMATE AXIAL ANGLE FROM REFRACTIVE INDICES OF BIAXIAL MINERALS, by Harold T. U. Smith.

An adaptation of Wright's graphic plat for solution of the approximate equation makes possible the rapid determination of axial angle and optic sign directly from refractive indices. The necessity for first computing partial birefringences is eliminated. This method provides a convenient check on the consistency of laboratory determinations by the immersion method. Pedagogically, it serves to emphasize the mathematical interrelation between indices, axial angle, and optic sign.

- (40) A SYSTEM OF GRIDS FOR THE DETERMINATION OF NON-OPAQUE MINERALS, by J. D. H. Donnay and J. Mélon.

Existent determinative tables require that an unknown mineral be tested, at the outset of the procedure, for certain selected properties in a given order, e.g. optical anisotropy, optical character and sign, refractive index (Larsen-Berman); hardness, specific gravity (Rosenholtz-Smith); luster, fusibility (Brush-Penfield). Other properties serve only as a confirmation.

A new device (system of about 200 grids) extends the usefulness of existing tables: (1) It removes the necessity of adhering to any rigid order. (2) Any property may be used directly toward determination, which, therefore, rests mainly on the most striking properties. (3) All minerals in which any given set of properties co-exists are at once sorted out. (4) Even incomplete data regarding certain properties are usable. (5) At any point during the procedure one is guided in his choice of further tests. (6) The fact that a mineral is not included in the grids is automatically detected.

The device is applied to all non-opaque minerals (more than 1200). Its principle of construction has been described elsewhere.* Its chief advantage lies in the mechanical aid it affords in determining minerals.

- (41) AN APPARATUS FOR THE PRECISION DETERMINATION OF SINGLE CRYSTAL LATTICE CONSTANTS, by M. J. Buerger.

None of the methods developed for the precise determination of lattice constants by powder methods is applicable to crystals more complicated than isometric or hexagonal because the diffraction loci of non-equivalent planes are, in general, unresolved. For the more complicated crystals the diffracted radiation must be obtained from a single crystal and recorded by one of the moving film methods. The Weissenberg arrangement is ideally suited to this purpose because it may include the entire range of reflections and because it provides for focussed spots over the entire range. The Sauter method lacks these advantages.

The instrument constructed for this purpose is one of the back reflection, absolute variety which takes advantage of the strategy: film shrinkage and other corrections $\rightarrow 0$ as $\theta \rightarrow 90^\circ$. To do this, the x-ray beam must be introduced through the center of the Weissenberg film. To avoid film warping, the beam enters a small slot, and the translation motion of the film is reduced to 45 mm. A great deal of unused film is thus retained for strength, for a slot of only $1\frac{3}{8}$ inches is used in a 5x7 inch film. The camera proper has a radius of 57.26 mm. and the film is wrapped directly about the metal of the camera and unsupported only in the region of the one inch exposed section. The camera design is unique and avoids any accidental exposure of the film to light. The other features of the instrument design follow the standard equi-inclination Weissenberg apparatus, but simplified for this particular application, and made as rugged as possible. With the use of polychromatic radiation from duplex and triplex metal targets, extremely accurate lattice constants are determinable. A chart is presented for the purpose of identifying reflections on this type of instrument.

- (42) ON THE TIME REQUIRED TO FORM THE OLIVINE ZONE IN THE PALISADES SILL, NEW JERSEY, by John W. Butler, Jr.

Certain statistical petrologic studies offer quantitative information concerning differentiation and the consolidation history of igneous rocks. An application along this line reveals factors requiring consideration in computing the time necessary for gravitative

* J. D. H. Donnay, Système de grilles pour la détermination des minéraux: *Annales de la Société géologique de Belgique*, 59, B 250-257, 1936.

differentiation to develop the conspicuous olivine zone near the base of the Palisades Diabase Sill, New Jersey.

Several thousand olivine grains were measured in a suite of thin-sections through the olivine zone. Most crystals have diameters of 0.1 mm. or less, few exceed 0.25 mm., and diameters greater than 0.5 mm. are rare in numerical comparisons. Many olivine crystals of all sizes are euhedral. Kind, occurrence, paragenesis, and size of associated minerals are significant also and are recorded.

The importance of detailed statistical observations is illustrated by size of olivine alone. A calculation of the time necessary to form the olivine zone, offered by Bowen, following Stoke's formula assumes olivine grains 0.7 mm. in diameter settled 200–300 meters through magma having viscosity of either 4.0, or, like some basic Hawaiian lavas, 0.5. The respective results were 200–300, and 25–40 hours. Recalculation, after substituting the diameter 0.25 mm. for 0.7 mm., gives values of about 1495–2242 hours, and about 190–285 hours respectively; substituting diameter of 0.1 mm. increases these last values about six times. Mean factors may be derived from petrologic observations throughout the sill.

Statistical tables emphasize the longer time necessary for this phase of gravitative differentiation which, however, was not completed. Subsequent intrusions into the olivine zone of diabase containing less olivine, and occasional deuteric, and hydrothermal effects may be traced through stages of their development.

Thursday, December 31st

(43) REFRACTIVE INDICES OF VITRAINS, by Terence T. Quirke and Louis C. McCabe.

The physical qualities of vitrain appear to vary according to the rank of the common banded coals which contain it. Variations in quality of vitrain are indicated by corresponding changes in the refractive index. The refractive indices of various vitrains range from about 1.60 to above 1.80.

Indices of refraction were computed from the angle of maximum polarization reflected from polished surfaces of vitrain. This has the advantage of avoiding the use of oils of high index of refraction, which are not only difficult to handle in many cases, but awkward to calibrate because their index lies beyond the range of the usual Abbe refractometer.

Determinations were made by means of a reflecting goniometer equipped with an analyzing nicol prism. Measurements were made not only from coal, but also from a series of minerals both transparent and nearly opaque, the indices of which have been determined by other methods.

(44) ACCURATE ORIENTATION OF THIN SECTIONS, by Earl Ingerson.

Accurate orientation of thin sections is becoming increasingly important in geologic work. Such orientation may be accomplished by use of a recently devised apparatus consisting of a small flat plate that may be placed against a relatively flat surface of hand specimen, and whose dip and strike may be read on graduated vertical and horizontal circles. This procedure orients the hand specimen and the plane of a desired thin section may be marked by using three movable arms that are in the plane of the measuring plate, and the dip and strike may be read on the graduated circles. The apparatus can be used for the following purposes:

1. To orient a hand specimen for laboratory study.
2. To measure the orientation of a plane surface other than the one marked (e.g. a joint plane).
3. To measure the direction and angle of plunge of a lineation.
4. To mark a plane (of a thin section) in a given position.

5. To measure the orientation of an *s*-plane or other plane that does not form a flat surface on the specimen.

Remarks on the marking of oriented sections were included.

(45) FLEXIBLE CRYSTAL MODELS, by Isay A. Balinkin.

The classification of crystal forms into seven fundamental systems can be conveniently demonstrated by means of a single flexible crystal model. It is constructed of 12 pieces of square tubing in a form of an open-sided cube. The junctions at the corners are made of specially designed balls and the model is held together with springs attached to the balls and passing through the tubing. This allows a free motion at each corner so that by a proper deformation all the basic crystal systems can be illustrated. The same model can also be changed into an octahedron, hexahedron, tetrahedron, twin triangular prisms, and twin hexahedra. Finally, it shows the space arrangement of the carbon atoms in graphite as distinguished from that in diamond. Other flexible crystal models such as dodecahedron, tetrakaidecahedron, etc., can be made using the same method of construction.

At various times during the sessions of the Society, the following persons registered their attendance. In addition, there were many others who visited sessions whose names were not recorded.

C. C. Albritton, Jr.	C. A. Chapman	F. B. Hanley
H. R. Aldrich	N. E. Chute	E. P. Henderson
V. T. Allen	L. C. Conant	D. F. Hewett
B. Alvarado	M. E. Cooley	G. R. Heyl
T. G. Andrews	G. W. Crickmay	A. P. Honess
E. T. Apfel		W. F. Hunt
F. P. Atkins, Jr.	E. C. Dapples	C. S. Hurlbut, Jr.
V. L. Ayres	M. V. Denny	
	R. M. Dickey	E. Ingerson
G. W. Bain	J. D. H. Donnay	
I. A. Balinkin	H. F. Donner	W. B. Jewell
A. E. Barnes	C. E. Dutton	W. D. Johnston, Jr.
R. L. Barrett		I. W. Jones
E. S. Bastin	M. L. Ehrmann	J. Jones
A. M. Bateman	B. C. Elsley	E. P. Kaiser
W. S. Bayley	R. C. Emmons	A. Keith
C. H. Behre, Jr.	G. T. Faust	P. F. Kerr
H. Belyea	C. R. Fettke	R. S. Knappen
H. Berman	R. P. Fischer	A. Knopf
J. C. Bierer	D. J. Fisher	P. W. Koller
M. H. Billings	F. C. Foley	E. H. Kraus
K. E. Born	F. Foreman	
N. L. Bowen		J. E. Lamar
W. R. Bradley	J. J. Glass	C. A. Lamey
A. M. Brant	E. N. Goddard	K. K. Landes
E. L. Bruce	G. E. Goodspeed	H. C. Lee
A. F. Buckham	R. G. Grassy	J. T. Lonsdale
A. F. Buddington	O. R. Grawe	T. S. Lovering
M. J. Buerger	R. E. Grim	Mrs. T. S. Lovering
N. W. Buerger	J. W. Gruner	G. D. Louderback
F. Bullard	C. S. Gwynne	G. F. Loughlin

W. K. MacFarquhar	A. B. Peck	A. K. Snelgrove
J. P. Marble	J. W. Peoples	A. B. Sperry
R. W. Marsden	E. L. Perry	K. Spiroff
J. H. C. Martens	S. S. Philbrick	T. Stadnichenko
E. B. Mathews	R. S. Poor	R. C. Stephenson
C. S. Maurice	F. H. Pough	D. Stewart, Jr.
W. J. McCaughey	W. E. Powers	M. Stow
H. E. McKinstry	A. Pyre	L. W. Strock
B. W. Meek		J. L. Stuckey
G. R. Megathlin	T. T. Quirke	C. K. Swartz
P. L. Merritt		W. A. Tarr
P. M. Miles	R. E. Radabaugh	Mrs. W. A. Tarr
F. S. Miller	L. S. Ramsdell	E. Thomsen
R. B. Miller	H. Ries	E. Thomson
W. J. Miller	J. Rodgers	W. N. Tipka
E. S. Moore	A. F. Rogers	C. Tolman
G. W. Morey	R. R. Rosenkrans	G. Tunell
F. K. Morris	C. S. Ross	S. A. Tyler
J. F. Morton	E. P. Rothrock	
E. S. Munyan	J. T. Rouse	O. C. Von Schlichten
O. J. Myers	C. J. Roy	
W. M. Myers	J. J. Runner	A. W. Waldo
		D. C. Wellman
R. B. Newcombe	E. Sampson	A. M. Wellnitz
A. H. Norton	A. E. Sandberg	L. G. Westgate
	J. F. Schairer	R. W. Whipple
D. T. O'Connell	W. T. Schaller	R. Wilcox
A. R. Ostrander	B. M. Shaub	A. S. Wilkerson
	C. B. Slawson	S. S. Williamson
C. Palache	C. M. Smith	A. N. Winchell
W. H. Parsons	H. T. U. Smith	H. Wuestner
M. A. Peacock		

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By recommendation of the Council, a complete list of past officers is printed in the proceedings of the annual meeting of the Society.

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1921 Charles Palache	1921 Waldemar T. Schaller
1922 Thomas L. Walker	1922 Frederick A. Canfield
1923 Edgar T. Wherry	1923 George F. Kunz
1924 Henry S. Washington	1924 Washington A. Roebling
1925 Arthur S. Eakle	1925 Herbert P. Whitlock
1926 Waldemar T. Schaller	1926 George Vaux, Jr.
1927 Austin F. Rogers	1927 George L. English
1928 Esper S. Larsen	1928 Lazard Cahn
1929 Arthur L. Parsons	1929 Edward Wigglesworth
1930 Herbert E. Merwin	1930 John E. Wolff
1931 Alexander H. Phillips	1931 William F. Foshag
1932 Alexander N. Winchell	1932 Joseph L. Gillson
1933 Herbert P. Whitlock	1933 Frank N. Guild