# MINERALOGICAL SOCIETY (LONDON)

A meeting of the Society was held on Thursday, January 27th, 1955, at 5 P.M., in the apartments of the Geological Society of London, Burlington House, Piccadilly, W.1 (by kind permission).

The following papers were read:

## (1) SPACE LATTICES OF THE CRYSTALLINE ELEMENTS IN RELATION TO THE PERIODIC TABLE

By Dr. S. I. Tomkeieff

By combining the space lattices of the crystalline elements into four groups it is possible to map them over the spiral periodic table. The field of high-symmetry lattices covers the region of metals and inert gases, while the field of low-symmetry lattices covers the region of non-metals. The transition zone between the two fields includes the diamond type structure. Packing density, symmetry, and coordination number, like the lattices themselves, show a regular distribution over the field of the periodic spiral and are shown to have a direct relation to the electronic structure of the elements.

A new arrangement of the fourteen Bravais space lattices is also proposed, and a comparison is made of a statistical distribution of crystalline elements, minerals and other compounds among the seven crystal systems.

## (2) AN ACCURATE DETERMINATION OF THE CELL DIMENSIONS OF BULTFONTEINITE, $Ca_4Si_2O_{10}H_6F_2$

By Dr. H. D. Megaw and Miss C. H. Kelsey

The cell dimensions and interaxial angles of bultfonteinite, $Ca_4Si_2O_{10}H_6F_2$, which is triclinic but markedly pseudo-orthorhombic, have been determined with fairly high accuracy from $x$-ray photographs with an oscillation camera. The values are: $a=10.992 \pm 0.004$ Å, $b=8.183\pm0.002$ Å, $c=5.671\pm0.001$ Å, $\alpha=93°57'$, $\beta=91°19'$, $\gamma=89°51'$. The method is outlined. Some tentative suggestions about the structure of the crystal are put forward; it is related to afwillite, $Ca_3Si_2O_{10}H_6$, as originally suggested by Parry, Williams & Wright (1932).

## (3) THE PHASE RELATIONS IN SANIDINE- AND ORTHOCLASE-PERTHITES

By Dr. J. V. Smith and Mr. W. S. MacKenzie

A routine $x$-ray method for studying perthitic feldspars has been developed. From a single-crystal oscillation photograph the symmetry, twinning and unmixing can be seen at a glance. The lattice angles $\alpha^*$ and $\gamma^*$ of twinned triclinic phases can be accurately determined from the photograph. Using this method the lamellar structure of a number of sanidine- and orthoclase-perthites has been investigated in detail. The angles $\alpha^*$ and $\gamma^*$ determined for the soda phases provide information on their composition.

Sanidine-cryptoperthites have a monoclinic potash phase and a soda phase with lattice angles equal to those of anorthoclases of composition near $Or_{20}Ab_{80}$.

Orthoclase-microperthites always contain a soda phase whose lattice angles correspond to low-temperature albite or oligoclase. The potash phase may be either monoclinic or triclinic (microcline).

Specimens from the Beinn an Dubhaich granite of Skye consist of a monoclinic potash phase together with an anorthoclase and a low-temperature albite-oligoclase. The evidence clearly demonstrates that orthoclase-perthites may be derived from sanidine-perthites by slow cooling.

### (4) THE STRUCTURES OF THE PLAGIOCLASE FELDSPARS. VI. NATURAL INTERMEDIATE PLAGIOCLASES

By Dr. P. Gay

Specimens from some 40 different localities over the composition range from about 20% An to about 70% An have been examined by *x*-ray single-crystal methods. The majority of these specimens show the normal intermediate plagioclase pattern characterized by weak pairs of subsidiary layer lines of variable separation. It has been found that the separation of these layer lines is a linear function of composition over the *whole* composition range. Further, this range is found to extend to more soda-rich compositions than was formerly believed, whilst the limits of the range are approximately defined by the compositions at which the separations of the subsidiary layer lines about either the *a* or *b* axes become zero.

The anomalous patterns shown by some specimens are discussed, and it is shown that most of these may be interpreted in terms of the previous geological history of the specimens.

A comparison of the present results with those obtained by previous workers in this field is made, and it is shown how the principal points of difference may be resolved. An account of the phase relationships of the low-temperature plagioclase series is given, and the problems arising from the present work are discussed.

### (5) THE STRUCTURAL FORMULA OF A HYDROUS AMPHIBOLE

By Dr. G. D. Nicholls and Dr. J. Zussman

The analysis of a hornblende presented by Buddington and Leonard has been re-examined using the direct method of formula derivation described by Hey in 1939. The mineral is seen to contain hydrogen in excess of that needed to make (OH, F, Cl) = 2, unaccompanied by excess oxygen, so that neither (OH) ions nor water molecules can be occupying the normally vacant "A" sites in the structure.

Some aspects of the method are discussed and its possible application to incomplete and partial analyses is noted.

### (6) THE VARYING ROLE OF WATER IN SILICATES AS ILLUSTRATED BY HYDROUS ANTHOPHYLLITE; AND ON THE CORRELATION OF PHYSICAL PROPERTIES AND COMPOSITION IN MULTIVARIATE SYSTEMS AS ILLUSTRATED BY ANTHOPHYLLITE

By Mr. G. H. Francis and Dr. M. H. Hey

A gedrite from Glen Urquhart contains nearly 99 oxygen atoms per unit cell instead of the normal 96, and is highly hydrous; methods of establishing the true unit-cell contents are discussed, and all the available data on the unit-cell contents of anthophyllite are reviewed. A procedure for deriving equations correlating physical data with composition where the composition involves several variables is described, and applied to the *b*-axis cell-dimension and the refractive indices of anthophyllite and gedrite.

The following papers were taken as read:

### (1) DEHYDRATION OF THE MONTMORILLONITE MINERALS

By Dr. R. Greene-Kelly

Neither of the two closely related systems, Li-montmorillonite-beidellite and Li-Na-montmorillonite is a uniform one. In the former it seems that there must be differences in composition between silicate sheets bound in the same crystallite, and in the latter the majority of the sodium ions aggregate to form a sodium-rich "phase." The effect of heating on the internal surface available to glycerol of the Li-saturated montmorillonite-beidellite is shown to be correlated with the amount of octahedral substitution, less than 70% leading to some glycerol penetration. In the Li-Na-montmorillonite system, if there is less than 70% Li ions in the interlamellar spaces, expansion also occurred after heating. No evidence was found of an intermediate state of expansion at 14 Å.

### (2) THE STRUCTURE OF WADEITE

By Mr. D. E. Henshaw

The complete structure of wadeite has been determined by $x$-ray methods. It has the space group, $P6_3/m$, unit cell dimensions $a=6.893\pm0.004$ Å, $c=10.172\pm0.002$ Å, and may be represented ideally by the formula $Zr_2K_4Si_6O_{18}$.

The fundamental structural unit is the $(Si_3O_9)^{6-}$silicon-oxygen ring. The only previously known silicate mineral to be built up on this unit is benitoite from St. Benito, California, having the formula Ba Ti $Si_3O_9$ and space group $P\bar{6}c2$ ($D^2_{3h}$).

There is evidence of some distortion in the individual silica tetrahedra. This distortion causes two-thirds of the oxygen atoms in wadeite to be closer to the positively charged zirconium and potassium ions than would be the case for regular tetrahedra, and it does not alter the Si-O distances or the average O-O distances in each tetrahedron.

### (3) AUSTRALITES FROM HARROW, VICTORIA

By Mr. George Baker

Description of a collection of 34 specimens from the north bank of the Glenelg river, of various types (buttons, lenses, boats, dumb-bells, cores), giving weights (2–29 grams), specific gravity (2.39–2.47, mean 2.42), dimensions in different directions, and radii of curvature of surfaces. Radii of curvature are related to ablation during flight. Specimens from more easterly areas in S.W. Victoria have on the average a slightly lower specific gravity.

### (4) THE THERMAL REACTIONS OF NACRITE AND THE FORMATION OF METAKAOLIN, γ-ALUMINA, AMD MULLITE

By Dr. G. W. Brindley and Mr. K. Hunter

The thermal transformation of single crystals of nacrite heated progressively to 1250° C. are followed by $x$-ray single-crystal techniques. Persistance of residual crystalline order in the metakaolin phase up to 880° C. is established. After heating to 950° C., an oriented diagram of $\gamma$-alumina superposed on a random powder diagram of mullite is obtained; silica occurs as cristobalite. The $\gamma$-alumina has (110) parallel to the $a$-axis of nacrite. A second recrystalliaztion occurs at about 1150° C. when the $\gamma$-alumina reacts with silica to yield more mullite. The present results are discussed in relation to those obtained for kaolinite and kaolin clays. The formation of $\gamma$-alumina is considered to be a significant stage in the reaction series but not an intermediate stage for mullite formation at 950° C. The exothermic reaction at 950° C. is considered to arise from mullite formation and the fact that mullite is not always observed in $x$-ray diagrams is attributed to slow growth of the mullite nuclei.

*(Titles and abstracts kindly submitted by G. F. Claringbull, General Secretary)*

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A meeting of the Society was held on Thursday, March 24th, 1955, at 5 P.M. in the apartments of the Geological Society of London, Burlington House, Piccadilly, W.1 (by kind permission).

The following papers were read:

### (1) *Isokite, $CaMgPO_4F$, a new mineral from Northern Rhodesia*

By Mr. T. Deans and Mr. J. D. C. McConnell, with a chemical analysis by Mr. R. Pickup

Small white spherulites of this new mineral occur in the ankeritic dolomite rocks which form the carbonatite plug of Nkumbwa Hill, near Isoka, Northern Rhodesia. The radiating platy crystals are monoclinic, biaxial positive with $Bx_a$ normal to the one very good cleavage. $\alpha=1.590$, $\beta=1.595$, $\gamma=1.615$ (all $\pm 0.002$), $2V=51°$, dispersion $r>v$. G.=3.27, H.=roughly 5, soluble in acids. The chemical analysis conforms closely to $CaMgPO_4F$, with only minor substitution of Sr for Ca and OH for F.

The mineral is not pyroelectric. *X*-ray single crystal photographs indicate monoclinic symmetry, cleavage (010), $a=6.52\pm.05$ Å, $b=8.75\pm.05$ Å, $c=7.51\pm.05$ Å, $\beta=121°28' \pm 12'$, space group $C2/c$. Unit cell contains $4CaMgPO_4F$, calculated density 3.29. Optical orientation $\gamma=b, \alpha:c=+32°$. *X*-ray powder data are presented. The mineral belongs to the tilasite group. Strunz has suggested that cryphiolite from Vesuvius has this composition and is isostructural with tilasite, but *x*-ray investigations in the British Museum, Department of Mineraolgy, do not support this view.

The associated minerals are dolomite and strontian fluorapatite, with minor amounts of monazite, pyrochlore, barite, and rare sellaite. Conditions of formation are discussed.

### (2) *Grovesite, the manganese-rich analogue of berthierine*

By Dr. F. A. Bannister, Dr. M. H. Hey, and Dr. W. Campbell Smith

A dark brown micaceous mineral from the Benallt mine, Rhiw, Carnarvonshire, with the same chemical composition as pennantite, gives an *x*-ray powder photograph closely resembling those of berthierine and cronstedtite. It is evidently related to pennantite as berthierine is to chamosite. The optical properties are very near to those of pennantite.

### (3) *Additional notes on rhodonite deposits in Devonshire*

By Sir Arthur Russell

### (4) *The powder patterns and lattice parameters of soda-rich plagioclases*

By Dr. J. V. Smith

Geiger-counter powder records of soda-rich plagioclases have been carefully measured and indexed. The lattice parameters of the synthetic specimens are almost independent of the lime content; the largest variation (that in $\beta^*$) amounting to only 0.2°. After strong heating the powder patterns of the natural specimens closely approached those of the synthetic specimens.

Eight out of the nine natural plagioclases gave lattice parameters which fall within experimental error on a continuous line. There is a fairly large variation in lattice parameters especially for $\gamma^*$ which changes by 2°. As the lime content increases the lattice parameters of the natural plagioclases approach those for the high-temperature synthetic and heated natural specimens until at $An_{50}$ the separation is only one-fifth of that at $An_0$. The ninth specimen (from a dacite) gives parameters midway between the curves, thus exhibiting a state of partial inversion.

The partially-heated natural plagioclases and the dacite give parameters indistinguishable within experimental error from the parameters of unheated plagioclases containing a higher lime content. There is, therefore, no reliable powder *x*-ray method for the determination of composition in the region $An_0$–$An_{50}$. If the composition is known, the powder method may be used for the determination of the thermal state. If the plagioclase can be judged to be in the low-temperature state from geological evidence the powder method can be used to estimate the composition with an accuracy of 2% An.

### (5) *A first attempt at a determination of feldspars by activation analysis*

By Dr. J. E. S. Bradley and Dr. Olive Bradley

Small crystals (2 mg) of plagioclase and potassium feldspar were irradiated for four weeks in an atomic pile. Subsequent analysis of the radiation for sodium and potassium content gave promising results, and the method would appear capable of further development in this direction. It has not been possible to obtain satisfactory values for the calcium content.

The following papers were taken as read:

### (1) *Wairakite, the calcium analogue of analcime, a new zeolite mineral*

By Mr. A. Steiner (communicated by Dr. D. S. Coombs)

A new zeolite mineral having the formula $CaAl_2Si_4O_{12} \cdot 2H_2O$, the calcium analogue of analcime, has been named wairakite after the locality Wairakei in the North Island, New Zealand. Wairakite has been discovered in hydrothermally altered cores from holes drilled during exploration for geothermal steam, and in rocks ejected by steam from some of these drill holes. Indices of refraction, optical character, dispersion, and specific gravity of wairakite are given and its diagnostic lamellar twinning is described. The temperature at which wairakite forms in nature has been measured and the prevailing hydrostatic pressure calculated. The conditions of formation of the new mineral are discussed and compared with the attempted syntheses of calcium analcime. The possible existence of an isomorphous series analcime-wairakite is examined.

### (2) *X-ray observations on wairakite and non-cubic analcime*

By Dr. D. S. Coombs

Wairakite is monoclinic and pseudo-cubic with cell dimensions and optical orientation as follows: $a$ (near optical $\beta$) 13.69 Å, $b$ (optical $\alpha$) 13.68 Å, $c$ (near optical $\gamma$) 13.56 Å, $\beta = 90.5°$, $8CaAl_2Si_4O_{12} \cdot 2H_2O$, probable space group I$a$ or I2/$a$. The powder pattern confirms that the mineral is structurally related to analcime ($a_0$ 13.72 Å). The complex lamellar twinning can be explained on the assumption that wairakite crystallized in the cubic system, but subsequently inverted to the lower-symmetry modification with secondary twinning on the cubic dodecahedral planes. On the basis of powder data and optical properties, at least two modifications of analcime are recognized and a third inferred ($a$) inferred strictly cubic and isotropic, space group I$a$3$d$; ($b$) birefringent and biaxial, departures from cubic lattice dimensions not detectable although weak anomalous reflections may appear, e.g. Flinders, Australia; ($c$) trigonal or nearly trigonal, the body-centered rhombohedral cell having a 13.71 Å, $\alpha = 90°31'$, e.g. Laven, Norway.

### (3) *The effect of isomorphous substitutions on the intensities of (001) reflections of mica- and chlorite-type structures*

By Mr. G. Brown

The effect of isomorphous substitutions on the structure factors of the 001 reflections has been calculated for mica type and chlorite type structures. In the micas (including illites) variations in diffracted $x$-ray intensities occur due to variations in the composition of the octahedral cation sheet and the interlayer cation sheet. The calculations for dioctahedral micas deal with compositions which lie within the field whose corner members are

$$K_2 \quad (Al, Si)_8\ Al_4\ O_{20}\ (OH)_4$$
$$K_2 \quad (Al, Si)_8\ Fe_4\ O_{20}\ (OH)_4$$
$$(H_2O)_2(Al, Si)_8\ Al_4\ O_{20}\ (OH)_4$$
$$(H_2O)_2(Al, Si)_8\ Fe_4\ O_{20}\ (OH)_4$$

and similar calculations have been made for trioctahedral micas. In the chlorite structure there are two kinds of sites for octahedrally co-ordinated cations, and both the kind of octahedral cations and their distribution between the two types of site affects the 001 intensities. The structure factors for 001 reflections of chlorite type structures with compositions between

$$\{(Mg, Al)_{12} \quad\}\{(Si, Al)_8\}\ O_{20}\ (OH)_{16} \text{ and}$$
$$\{(Mg, Al)_4Fe_8\}\{(Si, Al)_8\}\ O_{20}\ (OH)_{16}$$

have been calculated for both symmetrical and asymmetrical distributions of the octahedrally co-ordinated cations between the two types of octaheral sites. The effect of variations in intensities due to isomorphous substitution on the standard mineral method of quantitative mineralogical analysis is pointed out and an alternative method is suggested.

### (4) *Projector for interference figures and for direct measurement of 2V*

By Mr. H. C. G. Vincent (communicated by the Editor)

A simple instrument for the demonstration and study of the optical properties of crystals is described. Without microscope or lens system, the interference figure is displayed in focus over the surface of a ground glass hemispherical screen with both optic axes in view for an angular separation of 120 degrees. The spherical surface of convergent interference phenomena surrounding the whole of the crystal may be explored while the specimen is revolved in its mount, giving, in effect, a working model of the crystal with its indicatrix. The parts of the figure retain their true relationship; 2V may be directly measured and a reverse set of readings is available. The instrument may also be used for orthoscopic studies, and its simplicity renders it suitable for individual student operation.

### (5) *The constitution of voltzite*

By Dr. A. A. Moss

A re-examination of voltzite shows that it contains arsenic, but no oxygen; the unit-cell contents are approximately $Zn_3As_{\frac{1}{2}}S_3$. The *x*-ray powder photograph closely resembles that of blende, but the mineral is strongly birefringent.

*(Titles and abstracts kindly submitted by G. F. Claringbull, General Secretary)*

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## SUMMARIES OF PAPERS GIVEN BEFORE THE CLAY MINERALS GROUP OF THE MINERALOGICAL SOCIETY (LONDON)—APRIL 15 AND 16 (1955)

### S. J. GREGG: *Some observations on the aggregation of kaolinite*

The specific area ($S_A$) determined by sorption of nitrogen at −183° C. has been compared with the specific area ($S_D$) calculated from the equivalent spherical diameter as determined by sedimentation, for a series of six fractions prepared from each of four different kaolins. For each series $S_A$ agrees reasonably with $S_D$ for the finer fractions but considerably exceeds it for the coarser fractions on account of the presence in these of vermicules. Bulk densities indicate the presence, particularly in the finer fractions, of temporary aggregates due to inter-particulate adhesion. Since this adhesion is weakened by adsorption, the bulk density is greater in presence of water vapor than in vacuum, whilst the modulus of rupture of kaolin compacts is less. The aggregation of kaolin at elevated temperature, i.e. sintering, is only important at temperatures above about 800° C., $S_A$ being surprisingly little affected by the loss of structural water at 400–500° C.

### A. Auskern and R. W. Grimshaw: *The hydroxyl region of the infra-red spectrum of kaolin minerals*

Absorption bands in the hydroxyl region of the infra-red spectra of kaolin minerals are quite distinctive and can be correlated with those of other hydroxide minerals, where the nature of the hydroxyl groups has been definitely established. Two regions of hydroxy absorption can be established and controlled dehydration experiments have shown that these can be assigned to surface and to internal groups. There is no evidence of hydrogen bonding between the surface layers.

### G. Brown and F. Smithson: *The dickite in certain sandstones in North Wales and Northern England*

The present authors have previously reported the occurrence of dickite in sandstones of the Lower Carboniferous Series, the Millstone Grit and the Middle Jurassic. In view of the comparative paucity of data on this mineral, six samples were selected, purified, and examined by *x*-ray diffraction methods; a dehydration curve, a partial *d.t.a.* curve, and a partial chemical analysis were also obtained for the purest sample (about 97% dickite). The *x*-ray data agree with those of previous investigators but are more extensive; the dehydration curve is similar to that of Ross and Kerr, and the *d.t.a.* curve shows what may be a partially resolved double endothermic peak in the region 470°–700° C., the individual peaks being at 590° C. and 660° C. The optical properties of the mineral were studied, and other minerals observed during the microscopical examination were recorded.

### R. J. W. McLaughlin: *The effect of grinding on dickite*

Data are presented for the effect of wet and dry grinding on dickite from Ouray, Colorado. With increase in time of dry grinding the endothermic *d.t.a.* peak becomes broader and is moved towards a lower temperature, while the exothermic reaction is greatly sharpened. Weight-loss data show a greater water loss over a wider temperature range for ground material. *X*-ray powder photographs show little change after a relatively short period of grinding; destruction of the lattice appears only to proceed to a certain stage, high order (*hkl*) spacings being very persistent.

### R. Greene-Kelly: *Ion fixation by kaolinite*

The effect of drying kaolinite at temperatures up to 300° C. upon the availability of cations introduced by exchange is described. Fixation effects similar to those found for montmorillonite are shown to occur, and the influence upon water sorption measurements is discussed.

### G. Nagelschmidt: *Kaolinite in human lungs*

Rare cases of pneumoconiosis after exposure to kaolinite dust have been described in the literature. Results are given of mineralogical analyses of two such lung residues in which kaolinite was found to be the chief constituent.

### C. Lippi-Boncambi, R. C. Mackenzie and W. A. Mitchell: *The mineralogy of some Italian soil clays*

A set of seven soil clays from Central Italy recently examined provided some interesting results, the clays from a Mediterranean *terra rossa* and a rendzina showing features of particular interest. The mineralogical analyses are briefly described and discussed.

G. Brown: *The report of the Nomenclature Sub-Committee of the Clay Minerals Group*

What appears to be a reasonably logical classification of the various types of minerals likely to be found in clays is described. Introduction of new names has been cut to a minimum, existing names being adopted for minerals, possible minerals, or groups of minerals, wherever names are extant. Suggestions are made as to when minerals should, and should not, be given specific names, and also as to the naming of mixed-layer minerals.

R. L. Stone and E. J. Weiss: *Examination of four coarsely-crystalline chlorites by x-ray and variable-pressure d.t.a. techniques*

In variable-pressure *d.t.a.* gases of known composition (here water vapor) are forced through the specimen during the *d.t.a.* determination; variation of pressure causes some simple peaks to develop into multiple ones, some multiple ones to coalesce, and some thermal reactions to be suppressed completely (e.g. the chlorite exothermic peak at about 870° C.). The results are interpreted in the basis of Pauling's structure of chlorite, and the chemical identities of the minerals concerned.

R. C. Mackenzie, *Secretary*

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Dr. John Putnam Marble, geochemist, died June 6, 1955, at the age of 58 years, following a heart attack. He was chairman of the Committee on Geological Time of the National Research Council, secretary of the Geophysical Association at the National Museum and a member of numerous scientific organizations.