

THE CRYSTAL STRUCTURE OF PSEUDOMALACHITE

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ABSTRACT

Pseudomalachite, $\text{Cu}_5(\text{PO}_4)_2(\text{OH})_4$, is monoclinic with $a=4.49$, $b=5.76$, $c=17.06 \text{ \AA}$, $\beta=91^\circ 02'$; space group $\text{P}2_1/c$, $Z=2$. The interpretation of sharpened Patterson projections on (100) and (010) yielded the three independent copper and one phosphorus positions. Successive structure factor calculations and Fourier summations brought out the six oxygen atoms.

The structure consists of the two types of Cu-octahedrel chains running parallel to b . The first type of chain is composed of one Cu_1 - and two Cu_2 -octahedra and is similar to the chain found in lindgrenite and azurite. The second chain is composed of Cu_3 -octahedra sharing square edges. These two types of chains are bonded together to form sheets parallel to bc ; these sheets again are tightly bonded to each other by means of isolated (PO_4) groups. As a result there is no distinct cleavage in the mineral. Erinite is isostructural with pseudomalachite.

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LIGHT EXTINCTION AND SCATTERING BY SUSPENSIONS OF FINELY-DIVIDED MINERALS

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ABSTRACT

The true total extinction and the absolute angular distribution of scattered intensity from 0 to 90 degrees have been measured for aqueous suspensions of quartz, flint, diamond, ilmenite and coal as size-graded fractions in the diameter-range $\frac{1}{2}$ to 15 microns. Due to the irregular shape and spread in size of the particles, their behavior differs from that of mono-disperse spheres on the Mie theory. The extinction coefficient shows a constant value 2 down to 1 or 2 microns particle-size, the precise lower limit depending on refractive index and absorption coefficient. The angular scattering coefficient is more or less independent of particle-size within the same size-range, for angles outside the forward diffraction lobe, and agrees well with the scattering calculated from geometrical optics. The measurements were made to ascertain the conditions under which extinction and scattering could be used to estimate the surface-area concentration and composition of airborne dust causing pneumoconiosis, but the results are of general application.

ACCURATE DETERMINATION OF OLIVINE COMPOSITION USING STANDARD SMALL-DIAMETER X-RAY POWDER CAMERAS¹

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ABSTRACT

Olivine composition can be rapidly and accurately obtained by using standard (Straumanis mounting) 57.3 mm x-ray powder cameras. A determinative curve based on analyzed natural olivines has been constructed by plotting the mol per cent Fo against the spacing of a $\text{K}\alpha_1$ back-reflection line which has been variously indexed as (0.10.0) and (450). The new graph deviates from the generally accepted straight line relationship of d-spacing versus composition, but corresponds instead to the slightly curved graphs derived from specific gravity measurements by Bloss and from x-ray powder measurements by Eliseev.

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The powder camera technique was developed for use with the small amounts of olivine normally found in thin sections of altered ultramafic rocks, thereby avoiding the task of preparing concentrates as is generally required in the diffractometer method. Olivine composition determinations can be made where only one or two grains are present in a thin section, and the method can therefore be applied to rocks that are almost completely serpentinized, to olivine-bearing gabbros, meteorites and other rocks with a low olivine content.

The camera method has been successfully utilized in outlining the pattern of olivine variation in the Mount Albert ultramafic pluton, Gaspé, Quebec, and is now being applied to the study of olivines from the Muskox intrusion, Northwest Territories, by Smith. On the basis of 125 determinations, a range in composition of approximately F_{060} to F_{090} has been established. All determinations were made on material removed from thin sections.

INFRARED STUDY OF SULFATE MINERALS

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ABSTRACT

The cations Na, K, NH_4 , Ca, Mg, Mn and at times, Ba, Sr and Pb combine with the anion SO_4 to form some 58 mineral species, which may be considered as belonging to six groups, as follows:

Group I. Anhydrous sulfates with Na, K, NH_4 , Ca, Pb, Sr or Ba—thenardite, apthitalite, mascagnite, glauberite, langbeinite, palmierite, anhydrite, celestite and barite.

Group II. Alkali hydrous sulfates with Na, K, NH_4 , Ca, Mg, Cu or Fe—kroenkite, bloedite, ferrinatrium, syngenite, picromerite, polyhalite, kalinite, valtite and tschermigite.

Group III. Hydrous sulfates with Ca, Cu, Fe, Co, Mg, Zn or Al—gypsum, epsomite, goslarite, siderotil, melanterite, coquimbite, pisanite, chalcantite, bieberite, alunogen, halotrichite and pickeringite.

Group IV. Sulfates with (OH) or (F, Cl) and oxysulfates—natroalunite, alunite, natrojarosite, zincalunite, jarosite, raimondite, plumbojarosite, beaverite, sulfohalite, antlerite, brochantite, linarite and dolerophanite.

Group V. Hydrous sulfates with (OH) or (F, Cl)—sideronatrium, natrochalcite, metavoltine, kainite, botryogen, copiapite, fibroferrite, langite, ettringite, aluminite, johannite, zippeite and uranopilite.

Group VI. Alkali sulfates to carbonates—burkeite, hanksite, leadhillite and calcite.

Infrared adsorption spectra of most of these species have been obtained with a split beam infrared spectrophotometer. The identity of each species examined has been verified optically and by means of x-ray diffraction for further confirmation.

Examination of the spectra indicates that the sulfates yield infrared curves that fall naturally into several groups. These groups have been outlined, and the relative ranges in absorption characteristics are given for each.

STUDY OF TRANSLUCENT TINY GRAINS USING THE INTERFERENCE MICROSCOPE

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ABSTRACT

Special measures have to be taken to carry out microscopic examination of fine-grained material in order to make the particles visible with sufficient contrast. For that purpose the author proposed the phase contrast method, and he found that by combining this method with the well-known embedding methods the accuracy of the determination of refractive indices is increased. Furthermore, this showed that by using suitable embedding media with very high dispersion properties, transparent particles of a certain refractive index could be imaged with characteristic colors and were thus differentiated from other particles of different refractive index. On the basis of a newly developed supplementary device for the polarizing microscope it

it now possible to examine transparent particles by means of interference microscopy. As in the case of phase contrast microscopy, here too contrast is increased; however with the difference that it can be adjusted to an optimum extent depending on the optical thickness of the particle. The simple relation between the image contrast and the difference of the optical thickness of the object to that of its surrounding can be used to ascertain refractive indices and thicknesses in the microscopic specimen. The following possibilities are observed:

1. Determination of the refractive indices of smallest particles by means of compensator and using but one (in some cases a second) embedding liquid. Therefore, repeated embedding, as is necessary in the case of conventional immersion methods, is not needed.
2. Determination of refractive indices exceeding that of the embedding media; this is of special importance when examining heavy minerals.
3. Ascertainment of the thickness of each individual particle present in the embedding media.
4. Possibility of application of interference phenomena combined with dispersion staining methods for routine identification of individual components in mineral complexes.

A big advantage of interference microscopy is that continuously changing optical thicknesses, as for instance with a change in concentration or in the cross section of a crystal "weathering" from its external surfaces, can be made visible and the corresponding refractive indices measured at any position.

STUDIES OF ROCK-FORMING MICAS¹

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ABSTRACT

An extensive age determination program by isotopic dating of micas at the Geological Survey of Canada has made available for mineralogical study several hundred concentrates of micas from rocks of diverse age, origin and history. The present study is concerned with determining the homogeneity of each mica concentrate, establishing the type or types of micas present, and correlating physical and chemical properties of the micas with their mode of occurrence in rocks. The study is confined largely to unaltered micas.

Spectrochemical and α -ray spectrographic analyses and complete chemical analyses have been made on about 20 selected samples of micas. Chemical formulas, negative and positive charges of tetrahedral and octahedral layers, and occupancy of the octahedral layer have been calculated. These data are discussed in relation to the following experimental data: (1) intensities of (001) reflections in α -ray diffractometer patterns; (2) optical properties—color, refractive indices, $2V$; (3) specific gravity; (4) behavior on heating from 20° C. to 1200° C. in air, in argon and in vacuum; (5) loss of weight on heating to 1400° C.; (6) trace element content.

As a result of these studies, interesting relationships have been found between the varieties of micas and the types of their host rocks. Furthermore, in rocks containing two or more generations of trioctahedral micas, the difference in composition between an early and a late mica has been established and confirmed by different content of trace elements in these micas.

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THE COMPOSITION OF QUARTZ-FORMING FLUIDS IN NATURE

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ABSTRACT

A microscope freezing stage has been developed with which qualitative and semi-quantitative data may be obtained on the composition of individual fluid inclusions as small as ten microns. Although the technique can be used to obtain a variety of geologically useful data, the major application has been in the determination, under equilibrium conditions, of the depression of the freezing point of the fluid; in ordinary water solutions, this depression varies directly with the total concentration of salts. Both primary and secondary inclusions in quartz crystals that formed in a variety of geological environments have been examined. The freezing temperatures obtained range from -20° to 0° C., although most samples from alpine-type veins, and from

pegmatites, range only from -8.5° to -2.5° C. Large and consistent differences are found between different genetic groups of inclusions in single samples, indicating gross changes in the composition of the fluids that have bathed the samples during their growth and at subsequent stages in their history.

THE CRYSTAL STRUCTURES AND CRYSTAL CHEMISTRY OF VARIOUS MEMBERS OF THE METATORBERNITE GROUP

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ABSTRACT

A large number of minerals and synthetic compounds belonging to the torbernite and metatorbernite mineral group can be represented by the formula $A^{+z}(UO_2XO_4)_z \cdot nH_2O$, where A may be almost any monovalent or divalent cation and X = P or As. In order to learn more of the crystal chemistry of these phases, detailed crystal-structure studies of (I), $K(UO_2AsO_4) \cdot 3H_2O$ (abernathyite); (II), $NH_4(UO_2AsO_4) \cdot 3H_2O$; (III), $K(H_3O)(UO_2AsO_4)_2 \cdot 6H_2O$; and (IV), $Cu(UO_2PO_4)_2 \cdot 8H_2O$ (metatorbernite) have been carried out. The structures were refined by two- and three-dimensional least-squares analysis of intensity data measured on Buerger precession photographs made with $MoK\alpha$ radiation. The well-known waffle-like $(UO_2XO_4)_n$ sheet structure proposed by Beintema is confirmed, and details of the interlayer structure are also revealed through a complete resolution of all except the hydrogen atoms in the electron density maps. In all four structures studied, the positions of the interlayer water molecules are based on an ideal arrangement in which four molecules are hydrogen-bonded together to form squares about the four-fold rotation axes, lying between the uranyl ions of successive layers. On Phases I and II, K^+ and NH_4^+ substitute randomly for one out of four water molecules and in Phase III, K^+ and H_3O^+ substitute randomly for two out of eight water molecules. An isomorphous series probably exists between the end members $K(UO_2AsO_4) \cdot 3H_2O$ (abernathyite) and $H_3O(UO_2AsO_4) \cdot 3H_2O$ (troegerite) and also between $NH_4(UO_2AsO_4) \cdot 3H_2O$ and troegerite. The ratio of cation (including hydronium) to water of 1:3, required by the cation replacement of water found in these structures, has been confirmed by careful chemical analysis.

In metatorbernite (IV) cation substitution of water does not occur, but rather Cu_2^+ occupies special positions at the center of half of the square groups of water molecules, thus giving a cation-water ratio of 1:8.

In all four structures each water molecule of a square group is also hydrogen-bonded in a nearly tetrahedral manner to a water molecule in an adjacent square and to an arsenate or phosphate oxygen atom. The latter bond causes a slight distortion of the $(UO_2XO_4)_n$ sheet from ideal symmetry and accounts for the doubling of the ideal one-layer c axis.

THE SIGNIFICANCE OF SAPPHIRINE IN THE GRANULITE TERRAINS OF WESTERN AUSTRALIA

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ABSTRACT

Several new analyses of sapphire $(Mg, Fe)_4Al_{10}Si_2O_{23}$, spinel, bronzite, and phlogopite have been made from a restricted Archean area 10 miles south of Quairading which is 100 miles east of Perth, Western Australia. A normal "parent rock" is phlogopite-spinel-bronzite. Spinel (and also phlogopite and bronzite) is replaced by sapphire. In rocks rich in cordierite, spinel is always separated from cordierite by a reaction rim of sapphire. Chemical analyses indicate that the formation of sapphire is favored by replacement (in reducing conditions) of Al, Fe, Mg and Ca by Si, K, P and rare earths. The spinel-bronzites and associated cordierite gneisses and pyroxene-plagioclase granulites form mappable bands and boudins in a biotite-microcline gneissose granite. The sapphire, cordierite and phlogopite have no preferred orientation, and in many rocks the "parent" spinel and bronzite are likewise in random orientation, thus suggesting growth in a

non-shear environment. A survey of the regional geology suggests that these sapphirine-bearing rocks form a zone (2620×10^6 years old) in an immense area which is dominated by rocks of granulite facies and of granites. These granulites show preferred orientation of the two pyroxenes and plagioclase and are the result of regional metamorphism in which shearing was important.

It appears that sapphirine can form only in areas of granulite facies and as the result of release of pressure and granitization of massive rocks rich in Mg and Al and deficient in Si. However, "granulite facies-granitization" of such rocks is common yet in most cases without the formation of the rare mineral sapphirine. A granitization process in which there is an abnormally low partial pressure of oxygen together with a plentiful supply of rare earths may be necessary for its formation.

IRON-FELDSPAR POLYMORPHS IN THE SYSTEM $K_2O-FeO-Fe_2O_3-SiO_2-H_2O$

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ABSTRACT

Potassium-iron feldspar, $KFe^{3+}Si_3O_8$, has been synthesized hydrothermally in two distinct polymorphs. The form stable at low temperatures, analogous to microcline, was synthesized directly from a mixture of crystallized $K_2O \cdot 6SiO_2$ glass and Fe_2O_3 at gas pressures of 1000 to 2000 bars and temperatures below $690^\circ C.$; above $710^\circ C.$, a form analogous to high-sanidine was synthesized. At $600^\circ C.$ and 2000 bars gas pressure iron-sanidine was completely converted to iron-microcline, whereas at $770^\circ C.$ and 1000 bars gas pressure iron-microcline was completely converted to iron-sanidine. No "intermediate" states were observed in hydrothermal experiments.

Iron-microcline is triclinic, $C\bar{1}$; $a = 8.69 \text{ \AA}$, $b = 13.11$, $c = 7.33$ (all $\pm 0.15\%$); $\alpha = 90^\circ 36'$, $\beta = 116^\circ 02'$, $\gamma = 86^\circ 30'$ (all $\pm 10'$); optical orientation $X \approx b$, $Z \wedge c = 20^\circ \pm 5^\circ$. Iron-sanidine is monoclinic, $C2/m$; $a = 8.69 \text{ \AA}$, $b = 13.12$, $c = 7.32$ (all $\pm 0.15\%$); $\beta = 116^\circ 06' \pm 05'$, optical orientation $Y = b$, $Z \wedge c = 16^\circ \pm 4^\circ$.

The relationship between the $KFeSi_3O_8$ polymorphs is strikingly similar to that between the $KAlSi_3O_8$ polymorphs. This increases the probability that crystal-structure studies of the Fe-Si distribution in $KFeSi_3O_8$ will elucidate the crystal-chemical and phase-equilibria behavior related to Al-Si distribution in the natural potassium feldspars.