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NOTES AND NEWS

ALLUAUDITES AND VARULITES

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These minerals may be described chemically as phosphates of Na, Ca, Fe'', Fe''', and Mn. The ideal formula may be taken as $W_{0-12}\,(X+Y)_{12}\,(PO_4)_{12}$, where W = Na, Ca; X = Mn'', Fe''; and Y = Fe'''; although if both W and X are zero, we would be dealing with heterosite, a mineral outside of this system. No success has been obtained in attempting to write a formula showing a simple coupling arrangement involving Ca-X and Na-Y. Thus the varulites are high in Na and low in Fe'''. Nevertheless it seems clear that these minerals are all members of one monoclinic isotypous series which has space group $I2_1/a$ with unit cell $a_0 = 11.0$, $b_0 = 12.5$, $c_0 = 6.5$ Å and $\beta = 97\frac{3}{4}°$ (Fisher, 1956). *X*-ray powder diffraction patterns are closely similar; differences are presumably explicable on the basis of the widely varying chemical composition. Except for the presence of Fe_2O_3 (which is as low as 5.3% in the varulites) these minerals are chemically very close to the dickinsonites (Fisher, 1954; 1955*a*); the latter however are readily differentiated optically or by *x*-ray photographs. The space group is $C2/c$ with $a_0 = 16.6$, $b_0 = 10.0$, $c_0 = 24.8$ and $\beta = 105°41'$. They invert to alluaudite on heating for a day in air at about 500° C. With the exception of hühnerkobelite, all known alluaudites (and varulites) are much richer in Na than Ca. It is thus suggested that the alluaudites be regarded as Na, Fe'', Fe''', Mn phosphates with generally minor Ca. The end members may be referred to as mangano-alluaudite, ferri-alluaudite, and ferro-alluaudite. FeO was not reported in the analysis of the type alluaudite (Chanteloube); it is relatively low in all minerals heretofore classified as alluaudite. On this basis the known alluaudites could be grouped as shown in the table.

The numbers of the samples in the table correspond to those of Fig. 1, where the composition is shown in weight percentages with the sum of Fe'', Fe''' and Mn recalculated as 100% (it is assumed that the Chanteloube and Buranga minerals lack FeO, though this oxide was not reported in these analyses nor in one of the Varuträsk analyses (7, Fig. 1)). The index of refraction (α) values used in plotting the isopleths in the figure are all taken from the literature except for the Chanteloube material which has $\alpha = 1.764$, $\beta = 1.779$, and 2V near 90°. The birefringence increases fairly regularly from 0.013 in the varulites to 0.060 in the Buranga alluaudite, though the low value (0.012) for the Sukula specimen seems out of line.

Mason (quoted in Quensel, pp. 46–51) considers that varulite is an alteration product of lithiophilite [but note that this involves replacement of Li by (Na, Ca); also oxidation of part of the iron] and that it in

NOMENCLATURE OF THE ALLUAUDITES

Ferroan-alluaudites	Manganoan-alluaudites	Ferrian-alluaudites
Norrö 1	Hagendorf	
	Hagendorfite 2	Buranga 10
	Varulites	
	Skrumpetorp 3	Black Hills 11
	Varuträsk 4, 5	Hühnerkobel
	Lemnäs 6	Hühnerkobelite* 12
	Varuträsk 7	
	Chanteloube 8	
	Sukula 9	

* Hühnerobelite could be designated as a calcian ferrian-alluaudite when it is important to be precise.

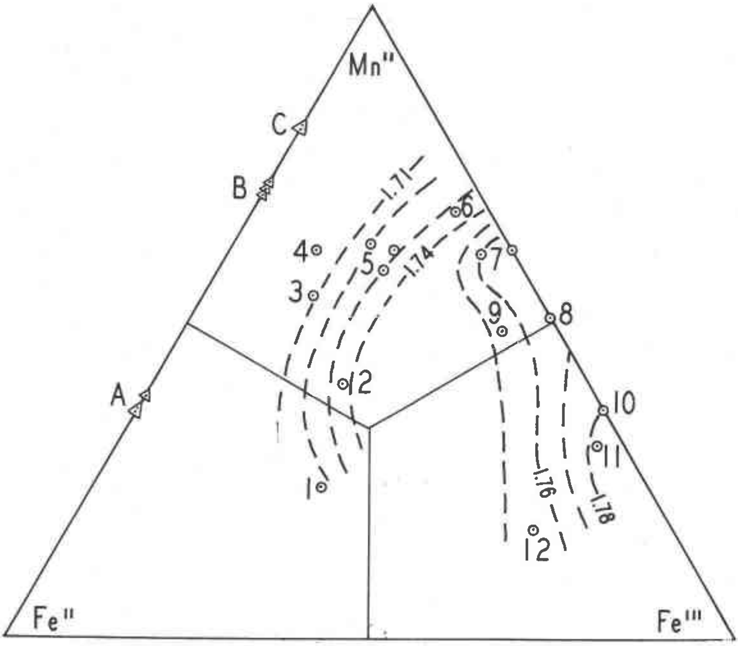

FIG. 1. Alluaudites and varulites plotted according to weight percentages of the three cations (numbered points in circles; see the table). The points in triangles represent ferro-dickinsonites (A), mangano-dickinsonites (B), and fillowite (C). The isopleths show index of refraction (α) values.

turn may alter to alluaudite. "One thin section shows lithiophilite in contact with yellow-brown alluaudite, the latter mineral containing small grains of green varulite." Mason notes that the green varulite "is structurally similar to alluaudite (judging from *x*-ray powder photographs, measurements of which he gives), but is distinct in its . . . physical properties and in the presence of most of the iron in the bivalent state." The last phrase of Mason's statement that "the alteration of varulite to alluaudite involved the oxidation of the iron from the ferrous to the ferric state, with the concomitant removal of some sodium ions from the lattice to maintain electrical neutrality" is not borne out by the analyses presented, unless one assumes atomic sodium is present in alluaudite. The fact that dickinsonite is readily oxidized to alluaudite on heating in air for a day at about 500° also belies this concept.

If the investigators of the Varuträsk pegmatite have made no mistakes in their thin-section identification of the phosphate minerals, it is not readily apparent why varulite and alluaudite (their terminology) appear as separate physical entities if they are actually members of an isotypous series. Nevertheless it is not inconceivable that oxidation of the varulite would not go ahead uniformly through the specimen, but it might proceed by "leaps and bounds"; i.e., at certain places the material be more susceptible to oxidation than at others.

The remarks in this note are preliminary; detailed optical, chemical, thermal, and *x*-ray studies are in progress on all these minerals.

Appendix. In working out the unit cell of hagendorfite, I found that both it and alluaudite could be described using space group 15—C^6_{2h} in the orientation $I\,2_1/a$ with a β-angle of $97\frac{3}{4}°$. This has advantages over the orientation $C\,2/c$ of this same space group with β of 114°22′ used in my 1955*b* paper. This was noted on p. 1101 of this paper (where the transformation formula appears) but it was stated that the less-oblique orientation resulted in "systematic absent spectra which do not fit space group criteria." This statement is erroneous. Fig. 2 on p. 1104 in the preferred $I\,2_1/a$ orientation should be labelled "sketch of (001) cleavage flake of alluaudite" and the face-trace on the right is 100 (instead of $\bar{1}00$); the indices of the face-traces on the top and bottom and on the left are correct if all signs are reversed. In short this change in orientation merely involves a change in the choice of the *a*-axis direction.

REFERENCES

All needed references are in vol. 2 of Dana's *System* (1951, pp. 669, 674 and 717) except as follows:

Fisher, D. J. (1954), Arrojadite is a ferro-dickinsonite: *Am. Mineral.*, **39,** 676–680.

———, (1955*a*), Soda Fe-Mn pegmatite phosphates, *Science*, **121,** 312.

———, (1955*b*), Alluaudite. *Am. Mineral.*, **40,** 1100–1109.

———, (1956), Hagendorfite unit cell: *Bull. Geol. Soc. Amer.*, **67**, 1694–1695 (abstract).

Quensel, P. (1956), The paragenesis of the Varuträsk pegmatite: *Arkiv för Mineralogi och Geologi*, **2**, no. 2, 125 pp.

Strunz, H. (1954), Hagendorfit, ein neues Mineral der Varulith-Hühnerkobelit-Reihe: *Neues Jahrb. Mineral.*, Monatshefte, 252–255.

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LATTICE CONSTANTS FROM WEISSENBERG PATTERNS

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In a recent article Christ (1956) has called attention to the possibility of correcting for film shrinkage and related errors in the measurements from Weissenberg patterns by recording the powder pattern of a standard substance on the same film. This provides a scale of standard angular distances on the film. Christ discussed the procedures for calibration at length and claimed "that a precision of about 2 to 4 parts in 10,000 may be easily obtained." To record the powder pattern over but a limited strip of the film a "slotted brass cylinder" was added to the usual rotation shield. Judging from the appearance of the powder pattern shown at the left of Christ's Fig. 1, the width of the slot must have been just over one centimeter. Christ (p. 571) stated that "whenever possible spots measured on the Weissenberg part of the film were taken close to the calibration pattern."

A few years ago the writer (Pabst, 1951, footnote on p. 557) mentioned the use of a *c*-axis zero layer for calibration. Since then it has been regular practice in single crystal work in the Geology Department at Berkeley to use zero-layer strips of quartz *c*-axis rotation patterns recorded at each edge of the zero-layer Weissenberg patterns for calibration. Figure 1 shows a Weissenberg pattern calibrated in this manner. The calibration strips are recorded at each edge by insertion of the Weissenberg screen, whose slot width is 0.2 cm., and proper placing of the cassette. Ordinarily an exposure of one hour for each strip will suffice with copper radiation. The general procedure to be followed is that described by Christ and it yields about the precision that he claims.

For the method here reported one must have a suitable reference crystal perfectly oriented on the goniometer head before being placed on the Weissenberg apparatus so that no *x*-ray adjustment is needed. The writer has used very slim needles of quartz. That used for the pattern shown in Fig. 1 was just under 0.04 mm. in thickness and had been oriented on a Stoe two-circle goniometer fitted with adapter to accommodate the goniom