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Julgoldite, new data and occurrences; a second recording

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SUMMARY. Two new occurrences, in quartz dolerite, are reported for julgoldite. Physical and chemical data is presented together with indexed powder data for fifty-five reflections, fifteen of them additional to those previously reported. The julgoldite infra-red spectrum possesses the same configuration as that of an epidote or clinozoisite but with large peak shifts due to the high iron content.

JULGOLDITE, $Ca_2Fe^{2+}(Fe,Al)_2(SiO_4)(Si_2O_7)(OH)_2.H_2O$, was first briefly reported from Långban, Sweden, as a new mineral by Moore (1967) though not fully characterized by him until 1971. The Långban julgoldite was found filling cavities and embedded in apophyllite and baryte, which constitute fissure-filling in granular hematite–magnetite ore.

Heddle (1901) regarded small, black crystals occurring in pectolite from a Ratho quarry (O.S. sheet 62, 128 708) near Edinburgh as ænigmatite and X-ray examination of the original Heddle specimen (register number 343·2) revealed the 'ænigmatite' to be julgoldite. Other pectolite specimens from the same quarry occasionally carry very small black grains of julgoldite or, very rarely, a julgoldite–pectolite excrescence on pectolite. Another Heddle specimen (register number 435.27) labelled 'apophyllite associated with goethite, pectolite', from Auchinstarry quarry (O.S. sheet 61, 720 767) Kilsyth, contains several black, highly lustrous, plumose clusters up to 2 mm long of julgoldite. The 'goethite' of this latter sample was mistakenly identified and is julgoldite. At both localities the julgoldite-bearing pectolite forms very rare pockets in quartz-dolerite. Between the pectolite and fresh dolerite a pale-greenish, bleached area of deuterically (?) altered dolerite occurs, which also contains minor microscopic julgoldite.

Physical properties. Morphologically, the Scottish julgoldite resembles the Långban material with rudimentary terminations comparable with those depicted by Moore (1971). The only cleavage, {100} good, detected by Moore, combined with the bladed morphology, inhibited a full optical study. In the Scottish julgoldite more than one cleavage was suspected. The first three lines (see Table I) on the julgoldite X-ray powder photograph display preferred orientation effects and index as 002, 100, and $10\bar{2}$. From a study of crushed grains the {001} and {100} cleavages are perfect although it is difficult by this means to substantiate the $\{10\bar{2}\}$ cleavage direction.

A density of 3·602 g/cm^3 was reported by Moore, whereas Allmann and Donnay (1973), after redetermination of the cell parameters on the Långban julgoldite, gave a

calculated value of 3·56 g/cm³. Suspension of hand-picked pure Ratho julgoldite in diluted Clerici solution and subsequent determination of the liquid density gave a value of 3·58, using minute grains; larger, pure grains gave approximately 3·4 g/cm³. The calculated density for the Auchinstarry julgoldite is 3·56 g/cm³.

TABLE I. *X-ray powder pattern of julgoldite;* Co-*Kα radiation,* Fe *filter*

d	I*	hkl	d	I*	hkl	d	I*	hkl
9.71 Å	20	002	2.574 Å	80	024, 31$\bar{3}$, 311	1.742 Å	30	415, 42$\bar{4}$, 135
8.85	20	100	2.591	60	220, 11$\bar{7}$, 215	1.721	10	3.0.10, 40$\bar{6}$
7.07	10	10$\bar{2}$	2.473	10	222, 206, 124	1.696	10	51$\bar{3}$, 1.1.11
6.16	10	102	2.382	40	222	1.674	10	331
4.817	70	004	2.323	10	306, 31$\bar{5}$	1.627	80	0.2.10, 424
4.479	30	10$\bar{4}$	2.294	<5	22$\bar{4}$, 21$\bar{7}$	1.607	20	0.0.$\underline{12}$
4.232	5	20$\bar{2}$	2.247	40	208, 108	1.588	30	2.2.$\underline{10}$
4.068	5	104, 11$\bar{3}$	2.213	20	400, 026, 40$\bar{2}$	1.536	10	408
3.859	70	202	2.159	40	224	1.519	80	040, 42$\bar{8}$
3.588	5	21$\bar{1}$	2.125	20	404, 320	1.476	10	2.2.10
3.494	20	20$\bar{4}$	2.102	10	126, 32$\bar{2}$, 41$\bar{1}$, etc.	1.428	5	602, 1.2.$\underline{12}$
3.305	5	213?	2.039	10	317, 306	1.415	<5	0.2.$\underline{12}$, 242, 60$\bar{6}$
3.158	5	106, 11$\bar{5}$	1.952	20	131, 406	1.392	10	4.0.$\underline{12}$
3.068	10	204	1.911	20	226	1.366	5	42$\bar{8}$, 43$\bar{7}$, etc.
2.958	100	300, 115, 30$\bar{2}$	1.888	40	028, 12$\bar{8}$	1.335	10	622, 24$\bar{6}$, etc.
2.881	10	120, 10$\bar{6}$	1.844	<5	32$\bar{6}$	1.321	5	62$\bar{4}$
2.780	80	206, 122	1.793	<5	420	1.283	5	626, 43$\bar{9}$, etc.
2.724	20	122, 30$\bar{2}$	1.766	<5	41$\bar{7}$	1.269	10	2.0.14, 1.1.$\underline{15}$
2.675	40	304, 31$\bar{1}$	* Intensities estimated using calibrated strips.					

X-ray powder data. Within the region *d* 9·71 to 1·269 fifteen reflections additional to those noted by Moore have been observed. Fifty-five reflections in Table I are indexed by analogy with the calculated powder data of Allmann and Donnay (1973) using cell dimensions of *a* 8·922, *b* 6·081, *c* 19·432 Å, and *β* 97·60°. Five observed lines *d* 3·305, 3·158, 2·294, 1·844, and 1·766 Å are additional to those listed by Allmann and Donnay although the last four are quoted in the julgoldite data of the National Bureau of Standards, Monograph 25 (1972). The line at *d* 3·305 indexes with difficulty and is too low for quartz impurity, nor is it a main line of the associated apophyllite or pectolite.

Chemical composition. An electron-probe microanalysis of the Auchinstarry julgoldite was undertaken and gave: SiO_2 32·04, Al_2O_3 0·68, FeO 9·5, Fe_2O_3 30·28, CaO 19·93, MgO 0·23, H_2O (by difference) 7·34 %; the FeO was determined from a Mössbauer ferric/ferrous ratio. Calculation to thirty-two cations gives: Si 12·03, Al 0·30, Fe^{3+} 8·55, Fe^{2+} 3·00, Mg 0·13, Ca 8·01, O 48·47, H_2O 9·18, Σ(Al, Fe^{3+}, Fe^{2+}, Mg) 11·98. The cation ratios are in excellent agreement with the theoretical, but the high O figure suggests that FeO was underestimated by about 3 %, and that the Auchinstarry julgoldite is very close to the $Fe^{2+}Fe^{3+}$ end-member of the series. For the ideal water content of 8 mol. per unit cell, the calculated percentage is 6·39; this agrees reasonably well with the figure of 7·34, obtained by difference.

Infra-red analysis. The julgoldite infra-red absorption spectrum (fig. 1) exhibits the same configuration as epidote and clinozoisite spectra (Strens, 1964) although with large peak shifts towards lower energies. For the analysed epidotes Strens suspected a slight peak shift with iron content. The large shift noted for julgoldite due to the high

iron content affords a sensitive method for infra-red analysis in the julgoldite–pumpellyite series, comparable with that utilized by Burns and Huggins (1972) in the forsterite–fayalite series.

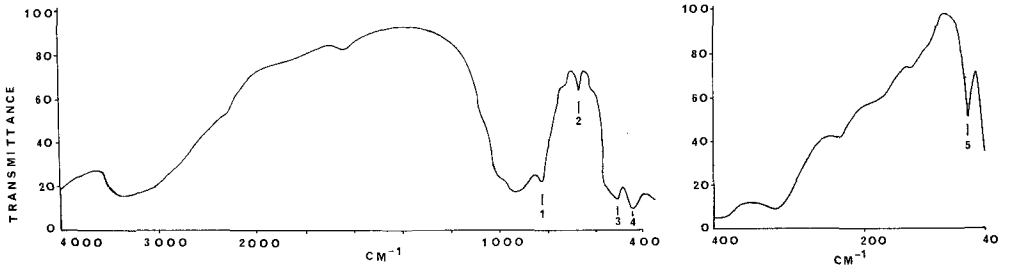

FIG. 1. Infra-red absorption spectrum of julgoldite, 4000 to 40 cm^{-1}. The numbers correspond to the 825, 680, 525, 450, and 70 cm^{-1} peaks.

Paragenesis. The marked chemical disparity between julgoldite and the associated minerals suggests that it results from the highly localized late-stage alteration processes that affected the quartz dolerite. A replacement-type occurrence in the radiating pectolite contrasts with the simultaneous crystallization of julgoldite and pectolite in the julgoldite–pectolite excrescences.

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