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Magnesian collinsite from Milgun Station, Western Australia

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SUMMARY. An occurrence of magnesian collinsite has been found with other rare phosphates in a variscite deposit in semi-desert 15 km NW. of Milgun Station homestead (25° 6′ S., 118° 18′ E.), Western Australia. The collinsite occurs as tapering white 3-mm prisms, mammillated aggregates, and thin veinlets in cavities in mudstone. The crystals have two good cleavages, D2.93, subvitreous lustre, H4–5, white streak and are brittle. Optical properties α 1·632, β 1·642, γ 1·657, $2V\gamma \approx 80°$. The mineral is triclinic with a 5·734, b 6·780, c 5·441 Å, α 97·29°, β 108·56°, γ 107·28°. X-ray powder data given, the lines are similar to P.D.F. card 14–314 but new cell gives better indexing. Chemical analysis by F. R. W. Lindsey gave FeO 0·07, MgO 11·3, CaO 35·2, Na_2O 0·01, K_2O 0·02, P_2O_5 41·2, H_2O^+ 10·7, H_2O^- 0·15, F 0·02, SiO_2 (quartz impurity) 1·31, Al, Mn, Zn, SO_3 not detected, net sum 99·97, close to $Ca_2Mg(PO_4)_2.2H_2O$, after deduction of moisture and quartz impurity. Typical specimens are preserved at the Government Chemical Laboratories, Perth, Western Australia.

THE rare mineral collinsite has been discovered by P. J. Bridge in phosphatic mineral specimens he collected near Milgun Station (25° 6′ S., 118° 18′ E.), 966 km by road north of Perth, Western Australia, in 1972 and 1973. A Perth lapidary dealer, Mr. F. Soklich, also kindly donated to the Laboratories some fine collinsite from the same locality.

Collinsite containing significant ferrous oxide was originally described by Poitevin (1927) from an asphalt-impregnated apatite vein in andesite at François Lake, British Columbia. Zincian collinsite has been described from Reaphook Hill, South Australia, by Hill, Johnson, and Jones (1973). The Milgun material is the magnesian variety and the third world occurrence. Cassidyite, the nickel analogue of collinsite, was described by White *et al.* (1967) in the oxidized material of the Wolf Creek (Western Australia) meteorite.

Occurrence. The Milgun phosphate deposit is about 15 km north-west of the homestead on the west side of a range of hills on the bank of the Gascoyne River. The host rocks are interbedded mudstones and dolomites of the Irregully Formation of the Proterozoic Bangemall Group. The deposit has been mined for variscite, which occurs in veins near the surface.

A number of associated minerals including wardite, crandallite, natrojarosite, leucophosphite, hydroxyapatite, lehiite, montgomeryite, gordonite, turquoise, overite, alunite, and gypsum have already been determined, with several species yet to be identified. Possible mitridatite has also been identified in contact with the collinsite, similar to the mitridatite–fairfieldite association at Auzat described by Tollon, Gramont, and Monchoux (1968).

The area is semi-desert with mean minimum and maximum temperatures for January 23° and 38 °C, for July 6·7° and 19·6 °C respectively. At Milgun station the mean annual rainfall is 190 mm. The climate is similar to that of Fairfield, Utah, where a comparable mineral association occurs.

TABLE I. *X-ray powder data for collinsite; Guinier focusing camera, Cu-Kα_1 radiation, KCl internal standard, I visual*

hkl	*I*	d_{obs}	d_{calc}	*I*	d_{obs}	*I*	d_{obs}
010	2	6·29 Å	6·277	2	2·006 Å	< 1	1·480 Å
100	1	5·10	5·074	3	1·993	1	1·465
001	4	5·00	5·001	2	1·982	1	1·436
10$\bar{1}$	3	4·52	4·508	3	1·969	2	1·422
1$\bar{1}\bar{1}$	< 1	3·86	3·845	< 1	1·923	1	1·407
0$\bar{1}\bar{1}$	2	3·52	3·515	< 1	1·909	3	1·401
11$\bar{1}$	2	3·51	3·502	4	1·871	< 1	1·377
1$\bar{2}$0	5	3·24	3·239	3	1·837	4	1·369
1$\bar{1}$1			3·232	3	1·831	1	1·358
020	5	3·14	3·139	2	1·821	1	1·354
101	10	3·04	3·037	1	1·804	2	1·341
0$\bar{2}$1	5	3·02	3·011	1	1·796	2	1·315
2$\bar{1}\bar{1}$	1	2·757	2·752	2	1·778	2	1·308
1$\bar{2}$1	6	2·735	2·735	1	1·766	< 1	1·300
2$\bar{1}$0	8	2·713	2·715	3	1·759	< 1	1·276
20$\bar{1}$	3	2·707	2·710	1	1·753	1	1·267
12$\bar{1}$			2·704	< 1	1·738	< 1	1·253
10$\bar{2}$	9	2·682	2·677	3	1·698	< 1	1·246
0$\bar{1}$2	1	2·550	2·547	4	1·692	2	1·233
200	4	2·540	2·537	4	1·669	1	1·127
12$\bar{1}$	2	2·468	2·465	4	1·643	< 1	1·223
1$\bar{1}\bar{2}$	2	2·405	2·401	3	1·650	1	1·207
22$\bar{1}$	3	2·370	2·366	2	1·638	< 1	1·203
21$\bar{1}$	4	2·289	2·288	1	1·632	< 1	1·197
0$\bar{2}$2	4	2·241	2·241	2	1·617	1	1·185
2$\bar{1}\bar{2}$	3	2·192	2·191	1	1·593	< 1	1·166
0$\bar{1}\bar{2}$	1	2·153	2·149	1	1·573	< 1	1·159
2$\bar{1}$1	2	2·137	2·135	2	1·556	< 1	1·148
03$\bar{1}$	1	2·127	2·124	3	1·536	< 1	1·141
12$\bar{2}$	4	2·115	2·114	1	1·519	< 1	1·134
030	3	2·090	2·092	2	1·504	< 1	1·120
22$\bar{1}$	2	2·061	2·064	1	1·489		

Physical properties. In the most coarsely crystalline specimens, the collinsite has encrusted a solution cavity with white, tapering prisms 3 mm long with the appearance of sharks' teeth. Each collinsite prism is composed of multiple blades with complex faces. A fine-grained specimen displays mammillated structures of radiating crystal groups up to 1 cm diameter. Some flattened radiating fibrous aggregates up to 2 cm across also occur along the mudstone bedding.

The mineral has two good cleavages, D 2·93±0·01 (sink-float), D calc. 2·955, H4–5, a subvitreous lustre, white streak, and is brittle. Optical properties: α 1·632, β 1·642,

γ1·657, *n* calc. 1·65, $2V\gamma \approx 80°$ similar to collinsite properties reported by Poitevin (1927).

Chemistry. A sample with D 2·93±0·01 by sink-float method was prepared for analysis by handpicking and centrifuging with heavy liquid. The final sample, still containing a little inseparable fine quartz, was analysed by well-known methods.

Chemical analysis by F. R. W. Lindsey gave: FeO 0·07, MgO 11·3, CaO 35·2, Na_2O 0·01, K_2O 0·02, P_2O_5 41·2, H_2O^+ 10·7, H_2O^- 0·15, F 0·02, SiO_2 (quartz) 1·31, MnO, ZnO, Al_2O_3, SO_3 not detected, sum 99·98, less O ≡ F 0·01, net sum 99·97 %.

The unit cell contents, after deduction of moisture and 1·31 % quartz, with corrected D 2·936 and V 185·657 Å^3, are: Mg 0·93, Ca 2·09, P 1·94, H 3·96, O 9·85. The cell content is close to $Ca_2Mg(PO_4)_2.2H_2O$ with low Fe^{2+}, contrasting with the significant substitution of Fe^{2+} for Mg recorded by Poitevin (1927).

X-ray data. Unit-cell calibration was carried out on a single crystal by least-squares refinement of fifteen reflections centred in the counter of a four-circle diffractometer using Cu-$K\alpha$ radiation, $\lambda = 1{\cdot}5418$ Å. The calibration was done by Dr. A. H. White, Chemistry Department, University of Western Australia.

Milgun collinsite is triclinic with *a* 5·734(1), *b* 6·780(1), *c* 5·441(1) Å, α 97·29° (1), β 108·56° (1), γ 107·28° (1). *a*:*b*:*c* 0·8457:1:0·8025, V185·657 Å^3. The cell is close to that of Wolfe (1940: *a* 5·70, *b* 6·72, *c* 5·38 Å, α 96°48½′, β 107° 16½, γ 104° 32′, *a*:*b*:*c* 0·8479:1:0·8002, V184·46 Å^3).

The powder X-ray data, Table I, were measured from films taken with a Guinier-Hagg focusing camera with Cu–$K\alpha_1$ radiation, KCl internal standard, *I* visual. The powder data are very similar to P.D.F. card 14–314, Sabina and Traill (1960), and the new cell parameters completely index their partially indexed reflections.

The data have been collected for a crystal structure analysis. The intensities have been used to check that in Table I every strong peak is represented by a powder line.

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Note added in proof: M. E. Mrose (*U.S. G.S. Prof. Paper* **800-A**, 103 (1972)) has described the magnesian end-member, from the Tip Top mine, South Dakota. The Milgun material is thus the fourth occurrence.