MINERALOGICAL MAGAZINE, DECEMBER 1974, VOL. 39, PP. 847–9

Clinobisvanite, monoclinic $BiVO_4$, a new mineral from Yinnietharra, Western Australia

P. J. BRIDGE AND M. W. PRYCE

Government Chemical Laboratories, Perth, Western Australia

SUMMARY. Monoclinic $BiVO_4$, well known as a high-temperature compound, has been found as a mineral at Yinnietharra and subsequently in specimens from five further W.A. localities, Londonderry, Wodgina, Menzies, Westonia, and Corinthia. At the type locality, the mineral occurs on garnet in a beryl-bearing spessartine pegmatite associated with bismutite, bismutoferrite, and other pegmatite minerals.

Clinobisvanite occurs as yellow powder and orange aggregates and plates to 0·1 mm, is commonly intergrown with bismutite, and frequently associated with its polymorph pucherite. It has a yellow streak, earthy to subvitreous lustre, is very soft with perfect {010} cleavage, D calc. 6·95, transparent in very thin cleavage flakes, and shows multiple twinning with cross hatching, strong dispersion and *n* calc. 2·63.

Space group $I\,2/a$, *a* 5·186, *b* 11·708, *c* 5·100 Å, β 90° 26′ refined from powder data. An electron-probe analysis gave Bi_2O_3 69·88, V_2O_5 27·63, PbO 1·34 sum 98·85. Cell content $4[BiVO_4]$ with minor substitution of Pb for Bi. All measurable data agree with earlier work including a prior description of the mineral from Mozambique.

Type material is preserved in the government collections at the Government Chemical Laboratories, W.A.

IN November 1972 at the Western Australian Government Chemical Laboratories, P. J. Bridge detected by X-ray diffraction a mineral occurrence of the monoclinic form of bismuth vanadate previously known only as an artificial high-temperature compound (Roth and Waring, 1963; Swanson, Morris, Evans, and Ulmer, 1964). The mineral was present in specimens he collected in 1971 during a systematic sampling of pegmatites in the Yinnietharra district, W.A.

Later in 1972 at the Laboratories R. M. Clarke detected the X-ray pattern of the same mineral in material from Londonderry feldspar quarry 19 km south of Coolgardie (30° 57′ S., 121° 9′ E.). In this second occurrence the monoclinic bismuth vanadate was associated with pucherite, bismite, bismutite, and native bismuth on an albite–microcline–quartz pegmatite collected by P. J. Bridge in 1965.

Re-examination of likely pegmatite specimens in the Laboratory collections yielded three further localities for monoclinic bismuth vanadate: associated with pucherite from Wodgina (21° 10′ S., 118° 40′ E.) and Menzies (29° 41′ S., 121° 2′ E.), and without pucherite from the Champion Gold Mining Lease, Westonia (31° 18′ S., 118° 42′ E.).

A sixth occurrence was detected by E. W. Beng at the Laboratories on a specimen submitted in 1973 from a pegmatite 3 km north-west of Corinthia (31° 7′ S., 119° 12′ E.).

The name clinobisvanite from the crystal system and constituent elements with as much definitive data as could be obtained from the meagre Yinnietharra material were proposed as those of a new mineral in June 1973. The Commission on New Minerals and Mineral Names, I.M.A., accepted the proposal almost unanimously in September 1973.

Subsequently that year the authors were advised of the prior description of the same mineral, without a proposed name, by von Knorring, Sahama, Lehtinen, Rehtijärvi, and Siivola (1973). The prior work was part of a study of clinobisvanite and pucherite crystals collected by von Knorring in 1972 from the Mutala Pegmatite Area, Mozambique.

Occurrence. The W.A. holotype locality is 5 km south of Pyramid Hill (24° 42′ S., 115° 51′ E.) on Yinnietharra Station and 820 km north of Perth. The small pegmatite, originally mined for beryl, intrudes quartzite of the Lower Proterozoic Wyloogroup and was mainly composed of massive spessartine, yellow to pale green beryl, red feldspars, muscovite, and quartz. Also present are small amounts of bismutite, both massive and as fine green crystals, columbite, uvarovite, pyrite, leucophosphite, apatite, zircon, uraninite, bismutoferrite, triphylite, and several unidentified species, mainly associated with the garnet.

FIG. 1. Photomicrograph (crossed polars) of clinobisvanite cleavage flake showing lamellar twinning and cross hatching structure.

Physical properties. The clinobisvanite occurs as soft friable coatings, as globular aggregates, and rarely as small groups of reticulated plates up to 0·1 mm across, intergrown with bismutite on the garnet crystals. The colour of the clinobisvanite varies from Ridgway (1912) Raw Sienna 17i to Orange Rufous 11i to Mars Orange 9i with Cadmium Yellow 17 streak. The mineral has an earthy to subvitreous lustre, is very soft with a perfect {010} cleavage, D calc. 6·95. Clinobisvanite plates are Primuline Yellow 19′ to Orange Rufous 11i, *n* calc. 2·63 (Gladstone and Dale), transparent in very thin flakes; strong dispersion. Multiple twinning as described by von Knorring *et al.* (1973) with additional cross hatching was also observed in one cleavage flake.

Chemistry. Analyses by electronmicroprobe were done by R. B. W. Vigers on the M.A.C. instrument at the Commonwealth Scientific and Industrial Research Organization laboratory, Floreat Park, W.A. The data was computer-corrected for atomic number, fluorescence, and matrix effects by the MAGIC–4 program (Colby, 1968) to give Bi_2O_3 69·88, V_2O_5 27·63, PbO 1·34, total 98·85 % which calculates to a unit cell content of $4[BiVO_4]$ with about 1 % Pb replacing Bi.

X-ray data. Weissenberg films taken of numerous crystal fragments of clinobisvanite did not yield any useful data probably because of multiple twinning, cleavage dislocation, and mosaic structures. However, the powder diffraction pattern was recorded as very sharp lines with the high resolution of close pairs of lines typical of well-ordered material; it compares closely with those of Ross and Waring (1963), of Swanson *et al.* (1964), and of von Knorring *et al.* (1973), except that there is a marked difference between the intensities of 211 and $\bar{2}11$, and of 112 and $\bar{1}12$.

The unit cell was refined from the powder data by the CELFIT program described by Pryce (1970) employing a weighting scheme based on sin θ. The refined cell is $a = 5\cdot186\pm0\cdot005$, $b = 11\cdot708\pm0\cdot016$, $c = 5\cdot100\pm0\cdot005$ Å, $\beta = 90^\circ\ 26\pm2'$, $a{:}b{:}c{::}0\cdot4429{:}1{:}0\cdot4356$, $V = 309\cdot7$ Å^3, reasonably comparable with the three previously published unit cells. On the data of Knorring *et al.* (1973), CELFIT, with the sin θ weighting, gave $a = 5\cdot209\pm0\cdot004$, $b = 11\cdot719\pm0\cdot005$, $c = 5\cdot098\pm0\cdot01$ Å, $\beta = 90^\circ\ 26\pm5'$, in close agreement with their own refined cell values. They have also adequately discussed and compared the X-ray data of the natural and artificial bismuth vanadates.

Acknowledgements. The work was done and published with the permission of the Director, Western Australian Government Chemical Laboratories. The kind assistance of C.S.I.R.O. is gratefully acknowledged.

REFERENCES

COLBY (J.), 1968. *Advan. X-ray Anal.* **11,** 287–305.

KNORRING (O. von), SAHAMA (Th. G.), LEHTINEN (M.), REHTIJÄRVI (P.), and SIIVOLA (J.), 1973. *Contr. Min. Petr.* **41,** 325–31.

PRYCE (M. W.), 1970. *Journ. Phys. E.*, **5,** 1026. [M.A. 72–773.]

ROTH (R. S.) and WARING (J. L.), 1963. *Amer. Min.* **48,** 1348 [M.A. **16**-525].

SWANSON (H. E.), MORRIS (M. C.), EVANS (E. H.), and ULMER (L.), 1964. *Standard X-ray powder patterns, Nat. Bur. Standards Monograph,* **25,** section 3, 14–15.

[*Manuscript received 6 February 1974*]

Note added in proof: A further sample of clinobisvanite-bearing pegmatite was donated in November 1973 from a location ESE. of Try Again Bore (26° 21′ S., 119° 49′ E.) on Yandil Station, Western Australia.