

Russellite: a second occurrence

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SUMMARY. Russellite $\text{Bi}_2\text{O}_3 \cdot \text{WO}_3$ occurs in a small pegmatite near Poona, Western Australia. The fine-grained yellow to pale green material is an inseparable mixture of russellite, bismite, koechlinite, and bismutite. X-ray powder diffraction, physical, and chemical data agree in general with the original description of the mineral from Cornwall, England. The original analyses made on micro quantities are now supplemented by analyses on macro quantities.

RUSSELLITE is an oxide of bismuth and tungsten described by Hey, Bannister, and Russell (1938) from the Castle-an-Dinas wolfram mine, Cornwall, England. The new locality represents the first recorded occurrence in Australia and the second reported occurrence in the world. The occurrence is in a small acid pegmatite vein outcropping on a granite hill approximately 6 miles east-north-east of the Emerald mine at Poona (latitude $27^\circ 10'$, longitude $117^\circ 25'$), in the Murchison Division, Western Australia. The area is approximately 40 miles north-west of Cue.

The region is a central part of the Western Australian Precambrian shield, which is characterized in this area by granites intruded by basic rocks. Small acid pegmatite veins are fairly common in the area.

The russellite was first noticed in a sample submitted by Mr. A. Sipos of Mt. Magnet, Western Australia, in September 1962. The sample on preliminary examination appeared to be bismutite, however simple tests showed that bismutite was only a minor component. A change in colour to orange-yellow in hydrochloric acid was noted. Subsequent powder diffraction X-ray and chemical analysis established that the main mineral present is russellite.

The pegmatite, which is almost vertical, is about 3 ft wide and traceable for about 200 ft along its strike (328° magnetic), with several small off-shoots. A section of about 100 ft has been opened up to about 5 ft deep by prospectors. The composition of the pegmatite is mainly quartz and muscovite with minor quantities of wolframite, beryl, secondary brochantite, and yellow earthy patches containing variable amounts of russellite, bismite, koechlinite, and bismutite. The bismutite also occurs separately. The colour of the russellite is variable in yellow with occasional areas of a greenish colour.

All attempts to separate the russellite, bismite, koechlinite, and bismutite failed as the mixture is too fine-grained; however, the russellite is in a few places relatively pure. This material was carefully selected, by numerous X-ray exposures using a small powder camera, for the work described in this paper. Since the specimen is too fine-grained for single crystal methods, the X-ray data were obtained from powder methods using a 114.6-mm Debye-Scherrer type Phillips camera with $\text{Cu-K}\alpha$.

The pattern is similar to that given by Hey, Bannister, and Russell (1938) with a few extra lines in the back reflection region and differences in intensities (see table I). The d 2.11 Å line is missing and a new line at d 2.48 Å is present. The slightly larger cell dimensions lead to differences in indexing, assuming the mineral is tetragonal. The lines of the pattern are broad suggesting the presence of two or more phases of the system $\text{Bi}_2\text{O}_3 \cdot \text{WO}_3$ as shown by Sillén and Lundborg (1943).

TABLE I. X-ray powder diffraction data for Poona russellite; a 5.48, c 11.5 Å

I	hkl	d_{obs}	d_{calc}	I	hkl	d_{obs}	d_{calc}	I	d_{obs}
100	103	3.12	3.14	45	413	1.25	1.26	25	0.922
80	200	2.71	2.74		109			20	0.911
	5	2.48	2.47	35	420	1.22	1.22	15	0.862
85	220	1.92	1.94	30	406	1.11	1.12	25	0.833
95	303	1.64	1.65		327			10	0.824
	312		1.66		30	503	1.05	1.05	
30	107	1.58	1.58	10	21.11	0.965	0.964		
15	400	1.37	1.37		440				0.968

A diffractometer trace was made by J. Graham of the Mineral Chemistry Division of C.S.I.R.O. and several patterns were made on a Guinier-Hägg focusing powder camera by D. J. M. Bevan and M. R. Thornber of the Chemistry Department, University of Western Australia, in attempts to improve the resolution. The spectra from both these methods showed no improvement in the resolution, leading to the conclusion that the russellite is very fine-grained and possibly poorly crystallized. The existence of two or more phases remains unproven.

The X-ray powder data was indexed by a programme, which allows manual selection, written by the author based on the methods of Henry, Lipson, and Wooster (1960). The indexing was confirmed by a least squares refinement programme written by A. W. Mann of the Chemistry Department, University of Western Australia. The programmes when applied to the powder pattern of the Cornish russellite (Hey *et al.*, 1938) gave identical indexing, except for the second last line 501, which would index better as 219.

Chemical analysis by M. B. Costello, using classical methods on approximately 5 g, gave: Bi_2O_3 64.99, WO_3 26.96, $(\text{Fe},\text{Al})_2\text{O}_3$ 1.10, CaO 0.48, MgO 0.07, SiO_2 3.09, MnO 0.04, K_2O 0.18, MoO_3 0.70, CO_2 0.10, H_2O^+ 1.69, H_2O^- 0.35, As_2O_3 and Na_2O nil, sum 99.75 %. Other analyses showed a higher CO_2 , and some fragments contained a trace of PbO . The specific gravity of the impure russellite, determined by the pycnometer method of Ellsworth (1928), was 7.44.

The total bismuth figure was adjusted by calculation, assuming CO_2 as bismutite and MoO_3 as koechlinite. Some doubt exists as to the truth of this assumption since there is an excess of CaO , which could account for some of the CO_2 . However, no calcite was detected and the presence of bismutite was established. Further the existence of koechlinite as a separate mineral in the mixture was not proved conclusively, due to the small amount present and the overlapping of the X-ray powder

patterns. The adjusted analysis, Bi_2O_3 69.50, WO_3 30.50, together with the cell dimensions and specific gravity, leads to a unit cell formula $\text{Bi}_{4.62}\text{W}_{2.04}\text{O}_{13.06}$. The substitution of molybdenum for tungsten cannot be discounted. The remaining excess bismuth is wholly or partially due to an indeterminate amount of bismite. Again bismite was not conclusively proved, and bismuth substitution in the tungsten positions could account for the larger cell parameters.

The remainder of the impurities are mainly quartz and muscovite. The analysed sample has an estimated composition of 92 % russellite (including up to 8 % bismite), 3 % koechlinite, 2 % quartz, 2 % muscovite, and 1 % bismutite. The water is assumed to be adsorbed. There is a multiplicity of 2.

The work on artificial compounds by Hey, Bannister, and Russell (1938), and Sillén and Lundborg (1943) was not repeated.

Acknowledgement. This work is published with the permission of the Director Western Australian Government Chemical Laboratories.

REFERENCES

- ELLSWORTH (H. V.), 1928. *Min. Mag.* **21**, 431.
HENRY (N. F. M.), LIPSON (H.), and WOOSTER (W. A.), 1960. *The Interpretation of X-ray Diffraction Photographs*, 2nd edn. London (Macmillan).
HEY (M. H.), BANNISTER (F. A.), and RUSSELL (A.), 1938. *Min. Mag.* **25**, 41.
SILLÉN (L. G.) and LUNDBORG (K.), 1943. *Arkiv Kemi, Min. Geol.* **17A**, 11 [M.A. 9-99].

[Manuscript received 5 August 1969]