

# AUSTRALIAN MUSEUM SCIENTIFIC PUBLICATIONS

Hodge-Smith, T., 1943. Mineralogical notes. No. VI. *Records of the Australian Museum* 21(4): 244–256. [22 December 1943].

doi:10.3853/j.0067-1975.21.1943.538

ISSN 0067-1975

Published by the Australian Museum, Sydney

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# MINERALOGICAL NOTES. No. VI.\*

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## Wolframite.

New South Wales.

(Figs. 1-10.)

Two contributions have been made to the classification of the minerals of the wolframite series in New South Wales. Mr. George Smith (1936, p. 132) makes the general statement that "it then appears that wolframite which contains a larger percentage of manganese than iron has only been identified as occurring in one part of the State [apparently Yalgogrin—T.H.S.] and the tungsten mineral so plentifully distributed should be classified as ferberite". He points to the difficulty in deciding when a mineral should be classed as wolframite or as ferberite and states that "it is difficult to draw a line of division between what are really variations of the one mineral".

Mr. E. J. Kenny (1928, p. 178) states that: "The principal ores of tungsten worked in New South Wales are: Wolfram, tungstate of iron and manganese. . . . Other less important ores are: Ferberite, tungstate of iron; Hubnerite, tungstate of manganese. . . . The ore from Torrington may be classified as 'Ferberite'."

It is obvious from these two statements that there is no agreement as to the classification of the wolframite series in New South Wales.

E. S. Dana (1892, p. 933) states that in wolframite, Fe:Mn chiefly 4:1 and 2:3, but varying from 9:1 to 2:3.

F. L. Hess (Hess and Schaller, 1914, p. 37) defines ferberite as "a monoclinic iron tungstate having when pure the composition  $\text{FeWO}_4$ . It may contain not more than twenty per cent. of the hubnerite molecule  $\text{MnWO}_4$ ", and hubnerite as  $\text{MnWO}_4$  containing not more than twenty per cent. of the ferberite molecule. While wolframite contains the hubnerite molecule in all proportions between twenty per cent. of  $\text{FeWO}_4$  and eighty per cent. of  $\text{MnWO}_4$ , and eighty per cent. of  $\text{FeWO}_4$  and twenty per cent. of  $\text{MnWO}_4$ .

A. K. Boldyrew and E. J. Liasky (1929, p. 242) divide the series into hubnerite containing up to five per cent. of  $\text{FeWO}_4$ ; ferrohübnerite from five to twenty-five per cent. of  $\text{FeWO}_4$ ; manganowolframite from twenty-five to forty per cent. of  $\text{FeWO}_4$ ; wolframite from forty to sixty per cent. of  $\text{FeWO}_4$ ; ferrowolframite from sixty to seventy-five per cent. of  $\text{FeWO}_4$ ; manganoferberite from seventy-five to ninety-five per cent. of  $\text{FeWO}_4$ ; and ferberite more than ninety-five per cent. of  $\text{FeWO}_4$ .

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\* For No. V, see RECORDS OF THE AUSTRALIAN MUSEUM, xix, No. 3, 1934, p. 165.

Both C. Doelter (1928, p. 846) and W. E. Ford (1932, p. 771) adopt the classification suggested by Hess and Schaller (1914, p. 37).

E. T. Wherry (1914, p. 501) bases his classification on the C.I.P.W. classification for igneous rocks, thus:

Permanganowolframite	.....	Mn:Fe 7:1.
Domanganowolframite	.....	Mn:Fe between 7:1 and 5:3.
Ferromanganowolframite	....	Mn:Fe between 5:3 and 3:5.
Doferrowolframite	.....	Mn:Fe between 3:5 and 1:7.
Perferrowolframite	.....	Mn:Fe 1:7.

He urges that none of these names, including the names of the end-members, should be used as mineral names for arbitrarily partitioned off portions. This leaves the names hubnerite for pure  $MnWO_4$ , ferberite for pure  $FeWO_4$ , and wolframite for the remaining members of the series.

From the above brief review of the various classifications it will be seen that there is considerable difference of opinion as to the proper division of this series of tungsten minerals. This is what might be expected, as any division must be necessarily arbitrary. If the majority opinion is taken from the above outline, then the classification of Hess and Schaller would be adopted, but, as Wherry very clearly points out, such a classification is mineralogically quite unsound.

Taking plagioclase as perhaps the best known example of an isomorphous series of two molecules, it is found that the names of the end members, albite and anorthite, are used as names for the molecules  $NaAl_2Si_2O_6$  and  $CaAl_2Si_2O_6$  respectively. The intermediate series are divided artificially into a number of members which are easily distinguishable without recourse to chemical analysis. These divisions play a very important part in the classification of rocks and are therefore useful. This well established division of the intermediate series of the plagioclases is mineralogically unsound, but can be defended on the grounds of utility and ease of determination.

Applying these principles to the wolframite series, the insistence of Wherry on the use of the names hubnerite and ferberite for the end members only is confirmed. Any division should apply only to the intermediate members of the series. The only method of determining any one of them is by careful chemical analysis. Schaller has shown the difficulty of interpreting the analysis and the same difficulty exists in regard to the New South Wales analyses.

The only locality in New South Wales where the mineral has been found well crystallized is in the Torrington district. No crystals have been found with sufficiently bright and smooth faces to give signals that would be of any use in tracing fundamental differences in crystal structure due to variations in the ratio of the two molecules. Even if such perfect crystals were obtainable it is doubtful whether the desired results could be established as the analyses show a varying content of tantalum and niobium.

A. K. Boldyrew and E. J. Liasky (1929, p. 242) have shown that the streak of the minerals changes from pale brown to almost black progressively from the hubnerite to the ferberite end of the series. They claim that the composition of the mineral can be determined by the colour of the streak to within fifteen per cent. of the molecular composition. The mineral from Rockvale near Torrington, New South Wales, containing eighty-five per cent. of  $FeWO_4$  cannot be distinguished by this method from that from Hogue's Creek, New South Wales, containing seventy-two per cent. of  $FeWO_4$ , and these two minerals would receive different names both under the Boldyrew and Liasky and the Hess and Schaller classifications. It is clear that this method is not accurate enough for purposes of classification.

Other ordinary physical tests are equally unsuitable.

It is obvious that, unlike the plagioclase series, the wolframite series cannot be divided into easily distinguishable members. Further, it cannot be claimed that any such division is of any great practical use.

A common method of indicating the composition of the feldspars is by the symbol  $Ab_nAn_m$ . Such a method can be easily applied to the wolframite series by using the symbol  $Fb_nHu_m$ . The classification would then be:

Ferberite:  $\text{FeWO}_4$  (Fb).

Wolframite:  $(\text{Fe}, \text{Mn})\text{WO}_4$  (Fb<sub>n</sub>Hu<sub>m</sub>).

Hubnerite:  $\text{MnWO}_4$  (Hu).

The majority of chemical analyses of New South Wales wolframites published have been carried out to determine only the amount of tungstic oxide present. In order to obtain somewhat better data the late Mr. H. P. White, formerly Chief Chemist, Department of Mines, kindly carried out four analyses on specially picked material, and Mr. R. O. Chalmers, Assistant Mineralogist, completed three such analyses. The result of this work together with some previously published analyses is given in Table I.

TABLE I.  
*Chemical Analysis of New South Wales Wolframite.*

Con-stituent.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\text{WO}_3$ ..	75.26	75.54	70.73	76.17	73.67	75.48	74.90	76.50	76.21	77.64	74.56	62.79	73.96	76.30	76.60
$\text{Nb}_2\text{O}_5^*$ ..	0.26	0.57	Abs.	Abs.	1.95	0.52	Abs.	0.36	0.31	..	1.10	Abs.	..	..	..
$\text{FeO}$ ..	20.15	20.40	18.13	17.68	18.85	20.07	20.44	16.88	16.53	18.76	18.64	5.39	15.84	23.70	..
$\text{MnO}$ ..	3.94	3.07	3.64	5.09	5.21	3.26	3.28	6.36	6.62	4.12	4.46	14.46	3.05	..	23.40
$\text{SiO}_2$ ..	0.30	..	..	..	0.39	0.29	..	0.17	..	..	0.75	..	2.84	..	..
$\text{CaO}$ ..	0.29	0.12	1.64	Abs.	..	0.50	0.48	Abs.	0.09	..	0.47	Abs.	2.48	..	..
$\text{MgO}$ ..	0.16	..	..	Abs.	..	0.09	Trace	Abs.	..	..	0.20	Abs.	0.31	..	..
$\text{H}_2\text{O}$ ..	..	..	..	Abs.	..	..	0.26	..	..	..	..	0.13	0.30	..	..
Gangue ..	..	..	5.55	1.34	..	..	0.52	..	..	..	..	17.09	..	..	..
$\text{Al}_2\text{O}_3$ ..	..	..	..	..	..	..	..	..	..	..	..	..	0.88	..	..
$\text{Bi}_2\text{O}_3$ ..	..	..	..	..	..	..	..	..	..	..	..	..	0.18	..	..
$\text{SnO}_2$ ..	..	..	..	Abs.	..	..	..	..	..	..	..	Abs.	Abs.	..	..
	100.36	99.70	99.69	100.28	100.07	100.21	99.88	100.27	99.76	100.52	100.18	99.86	99.84	100.00	100.00

\*Including  $\text{Ta}_2\text{O}_5$ .

1. Block 14, Torrington. Analyst H. P. White.
2. R. Smyth's Mine, Torrington. Analyst R. O. Chalmers.
3. Bismuth Mine, Torrington. Analyst H. P. White (Smith, 1926).
4. James Mine, Torrington. Analyst H. P. White (*Ann. Rpt. Mines*, 1920, 126).
5. Deepwater. Analyst H. P. White.
6. Rockvale Mine, Tungsten. Analyst H. P. White.
7. Rockvale Mine, Tungsten. Analyst H. P. White (*Ann. Rpt. Mines*, 1919, 186).
8. Hogue's Creek near Dundee. Analyst R. O. Chalmers.
9. Glen Eden near Glen Innes. Analyst R. O. Chalmers.
10. Inverell. Analyst A. Liversidge (Liversidge, 1882, 42).
11. Waukeroo, Yanco Glen, Barrier District. Analyst H. P. White.
12. Restdown Mine, Yalgogrin. Analyst H. P. White (*Ann. Rpt. Mines*, 1920, 126).
13. Pulletop. (*Ann. Rpt. Mines*, 1908, 183.)
14. Theoretical composition of ferberite.
15. Theoretical composition of hubnerite.

The presence of niobium and tantalum in all the later analyses carried out by White and Chalmers is of interest because in some of White's earlier analyses he records the absence of these elements. He considered that his later results are the more reliable, and that these elements are probably present in all New South Wales wolframite.

In 196 analyses given by Doelter (1929) only nine record the presence of niobium and/or tantalum. Of the 95 analyses quoted by Hess and Schaller (1914), fifteen record their presence. The greatest amount is that in the wolframite of Cave Creek, Arizona, which gives 2.20 per cent. of  $(\text{Ta}, \text{Nb})_2\text{O}_5$ .

It seems probable that the presence of tantalum and niobium in wolframite is much more general than the published analyses would indicate.

The comparatively high lime content is remarkable when it is considered that the crushed material was examined under the microscope before analysis. It is considerably

less than some of the older analyses, and may be a reflection of the degree of care taken in picking the sample.

The tungsten molecules calculated according to the method of Hess and Schaller from the analyses are shown in Table II. The symbols (*a*) are obtained by recalculating the ferberite and hubnerite molecules to 100 per cent. and taking the nearest whole numbers. Symbols (*b*) have been calculated by a simpler method, giving results which are sufficiently accurate for purposes of classification. Instead of utilizing all the CaO and MnO to form CaWO<sub>4</sub> and MnWO<sub>4</sub>, and then using the remaining WO<sub>3</sub> to form FeWO<sub>4</sub>, the MnO and FeO are taken to form the hubnerite and ferberite molecules. The values are recalculated to 100 per cent. and the nearest whole numbers taken for the symbol. Taking analysis No. 1, in which the percentage weights of MnO and FeO are 3.94 and 20.15 respectively, then:

	Recalculated to 100 per cent.
$\text{MnO} \times \frac{\text{WO}_3}{\text{MnO}} = \text{WO}_3 + \text{MnO} = \text{MnWO}_4$	
$3.94 \times 3.27 = 12.88 + 3.94 = 16.82$	MnWO <sub>4</sub> .. 16.62
Similarly for FeWO <sub>4</sub>	FeWO <sub>4</sub> .. 83.38
$20.15 \times 3.22 = 64.88 + 20.15 = 85.03$	100.00
101.85	

Thus the symbol (*b*) for this wolframite is Fb<sub>83</sub>Hu<sub>17</sub>.

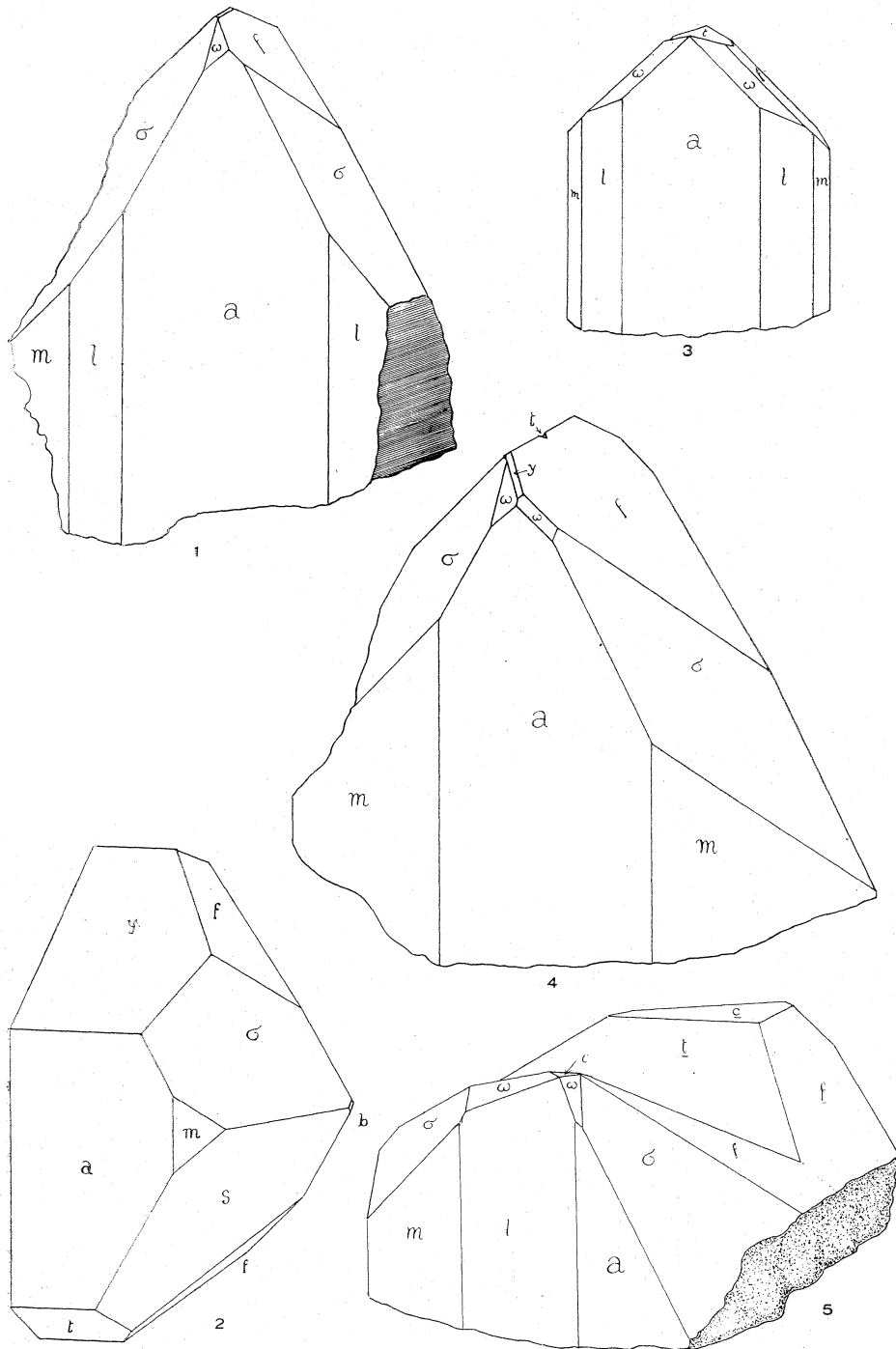
It is to be noted that, except in the case of the two analyses which include an appreciable amount of gangue, the agreement of the symbols calculated by the two methods is close and, further, is unaffected by the amount of CaWO<sub>4</sub> present. For purposes of classification the more simply calculated symbol (*b*) has been taken.

TABLE II.  
*Composition and Classification of New South Wales Wolframite.*

Analysis.	CaWO <sub>4</sub> .	MnWO <sub>4</sub> .	FeWO <sub>4</sub> .	Excess of FeO (f), or WO <sub>3</sub> (w).	Other Con- stituents.	Total.	Symbol ( <i>a</i> ).	Symbol ( <i>b</i> ).	Difference of Symbols in Units.
1	1.49	16.82	80.18	f 1.15	0.72	100.36	Fb <sub>83</sub> Hu <sub>17</sub>	Fb <sub>83</sub> Hu <sub>17</sub>	0
2	0.62	13.11	85.19	f 0.21	0.57	99.70	Fb <sub>83</sub> Hu <sub>17</sub>	Fb <sub>83</sub> Hu <sub>17</sub>	0
3	8.43	15.54	68.20	f 1.97	5.55	99.69	Fb <sub>81</sub> Hu <sub>19</sub>	Fb <sub>83</sub> Hu <sub>17</sub>	2
4	nil	21.72	74.61	w 2.61	1.34	100.28	Fb <sub>77</sub> Hu <sub>23</sub>	Fb <sub>77</sub> Hu <sub>23</sub>	0
5	nil	22.24	74.23	f 1.26	2.34	100.07	Fb <sub>78</sub> Hu <sub>22</sub>	Fb <sub>77</sub> Hu <sub>23</sub>	1
6	2.57	13.92	82.24	f 0.58	0.90	100.21	Fb <sub>86</sub> Hu <sub>14</sub>	Fb <sub>86</sub> Hu <sub>14</sub>	0
7	2.46	14.00	81.52	f 1.12	0.78	99.88	Fb <sub>85</sub> Hu <sub>15</sub>	Fb <sub>86</sub> Hu <sub>14</sub>	1
8	nil	27.16	71.23	w 1.35	0.53	100.27	Fb <sub>72</sub> Hu <sub>28</sub>	Fb <sub>72</sub> Hu <sub>28</sub>	0
9	0.46	28.27	69.76	w 0.96	0.31	99.76	Fb <sub>71</sub> Hu <sub>29</sub>	Fb <sub>71</sub> Hu <sub>29</sub>	0
10	nil	17.59	79.17	w 3.76	nil	100.52	Fb <sub>82</sub> Hu <sub>18</sub>	Fb <sub>82</sub> Hu <sub>18</sub>	0
11	2.42	19.04	76.05	f 0.62	2.05	100.18	Fb <sub>86</sub> Hu <sub>20</sub>	Fb <sub>81</sub> Hu <sub>19</sub>	1
12	nil	61.74	20.32	f 0.58	17.22	99.86	Fb <sub>25</sub> Hu <sub>75</sub>	Fb <sub>27</sub> Hu <sub>73</sub>	2
13	12.75	13.02	66.84	w 2.72	4.51	99.84	Fb <sub>84</sub> Hu <sub>16</sub>	Fb <sub>84</sub> Hu <sub>16</sub>	0

An examination of Table II shows that the composition of the New England wolframites varies from Fb<sub>86</sub>Hu<sub>14</sub> at Tungsten to Fb<sub>71</sub>Hu<sub>29</sub> at Glen Eden. The other New South Wales wolframites lie within these limits, except that from Yalgogrin which has a composition of Fb<sub>27</sub>Hu<sub>73</sub>, and all are definitely wolframite.

As previously stated, no crystals possess sufficiently bright faces for accurate measurement. Six crystals were measured on a two-circle goniometer and one, crystal ii, with a contact goniometer, and the readings can only be regarded as suitable for recognition of the forms present. The faces of the form  $\omega(111)$  nearly always gave good signals and those of the form  $f(011)$  sometimes gave bright signals, but generally they were multiple, probably due to twinning.

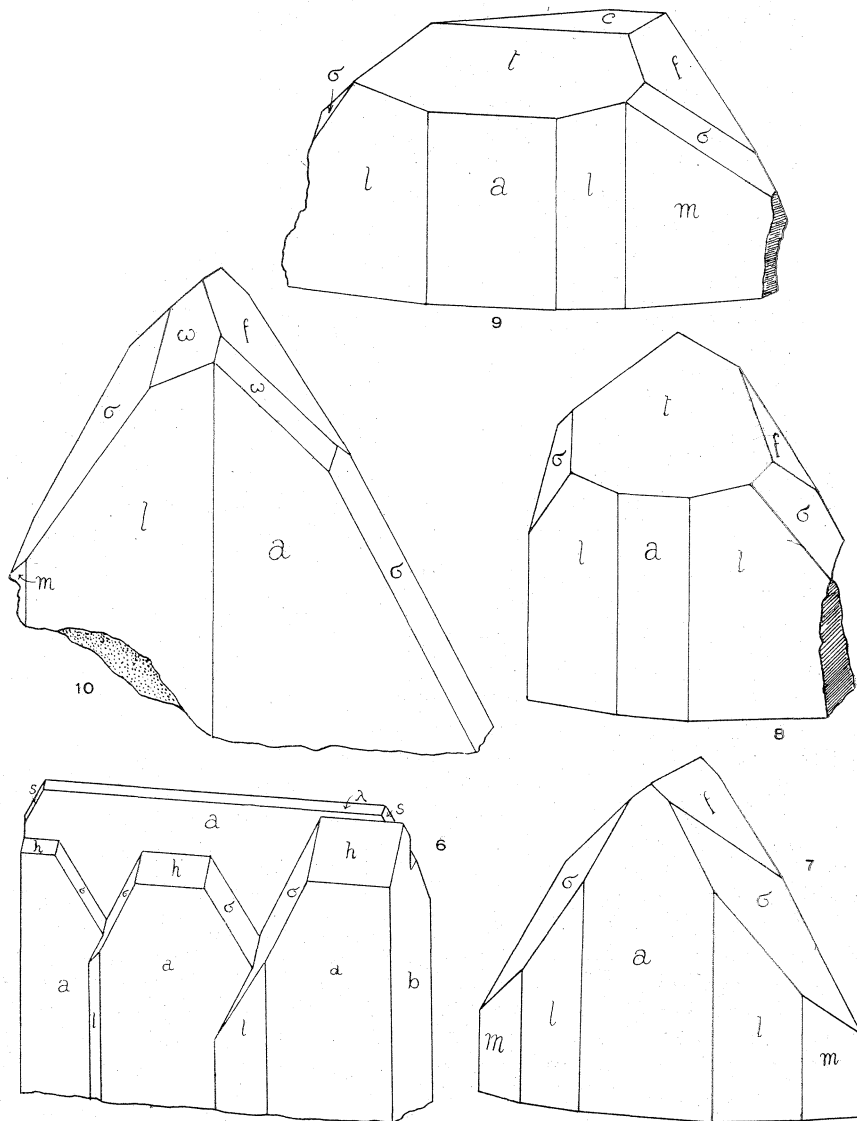


Figs. 1-5.—Wolframite from New South Wales. 1 and 5, R. Smyth's Mine, Tungsten. 2, Heffernan's Wolfram Mine, Torrington. 3, Torrington District. 4, Block 14 Mine, Bismuth. *Forms*:  $c(001)$ ,  $b(010)$ ,  $a(100)$ ,  $l(210)$ ,  $m(110)$ ,  $f(011)$ ,  $y(102)$ ,  $t(\bar{1}02)$ ,  $\omega(111)$ ,  $\sigma(121)$ ,  $s(\bar{1}21)$ .

Twinning is quite common with the  $c$  axis as the twin axis and the composition plane parallel to  $a(100)$ . None of the crystals examined showed twinning on  $K(023)$  as recorded by Rose (1845) for wolframite crystals from Zinnwald.

Crystal i (Fig. 1) from R. Smyth's Mine, Tungsten, is typical of the habit of the untwinned crystals. It measures 18 mm.  $\times$  15 mm.  $\times$  10 mm. and is about average size for this type of crystal. Australian Museum number D 27930.

Crystal ii (Fig. 2) from Heffernan's Wolfram Mine, four miles north-north-west of Torrington, is unique among the crystals in the collection. It resembles somewhat a crystal of wolframite from the Sheperd and Murphy Mine in the Mount Bell district, Tasmania (Hodge-Smith, 1930, p. 413). It measures approximately 6 cm.  $\times$  4 cm.  $\times$  5 cm.



Figs. 6-10.—Wolframite from New South Wales. 6, Glen Eden. 7-10, Wild Kate Mine, Torrington, after C. Anderson (Anderson, 1904 and 1920). Forms:  $c(001)$ ,  $b(010)$ ,  $a(100)$ ,  $l(210)$ ,  $m(110)$ ,  $f(011)$ ,  $t(\bar{1}02)$ ,  $\lambda(\bar{1}01)$ ,  $\omega(111)$ ,  $\sigma(121)$ ,  $s(\bar{1}21)$ .

It is not known whether it is part of a much larger crystal or whether it was attached by the large cleavage face present. Australian Museum number D 27939.

Crystal iii (Fig. 4) from Block 14 Mine, Bismuth, near Torrington, and crystal iv (Fig. 3) from the Torrington district, are typical of the twinned crystals. Australian Museum number D 22025. Crystal v (Fig. 5) from R. Smyth's Mine is also a fairly common type. Australian Museum number D 27929.

Crystal vi (Fig. 6) from Glen Eden consists of three individuals in parallel growth, all twinned in regard to the fourth individual. It is quite exceptional in habit. Australian Museum number D 22707.

Crystal vii is similar in habit to crystal iii and has not been drawn.

Crystals viii to xii (Figs. 7-10), after Anderson (1904 and 1920), are all from Wild Kate Mine, Torrington. In his descriptions he points out the impossibility of getting accurate readings.

TABLE III.  
*Combination of Forms in Crystals of Wolframite, New South Wales.*

Forms.	Crystals.											
	1	2	3	4	5	6	7	8	9	10	11	12
e(001) .. .. .	x				x						x	
b(010) .. .. .	c	x			c	c						
a(100) .. .. .	x	x	x	x	x	x	x	x	x	x	x	x
l(210) .. .. .	x			x	x	x	x	x	x	x	x	x
m(110) .. .. .	x	x	x	x	x		x	x	x		x	x
f(011) .. .. .	x	x		x	x				x		x	x
h(101) .. .. .						x						
y(102) .. .. .								x				
t(102) .. .. .	x		x	x	x		x	x		x	x	
λ(101) .. .. .						x						
ω(111) .. .. .	x		x	x	x		x			x	x	x
o(111) .. .. .					x					x	x	x
σ(121) .. .. .	x	x	x		x	x		x	x	x	x	x
s(121) .. .. .		x				x		x		x	x	x

c indicates that b(010) is present only as a cleavage plane.

### Apophyllite.

New South Wales.

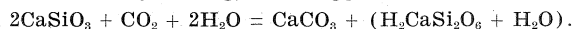
(Figs. 11-14.)

Some crystals of apophyllite were discovered by Mr. M. Mawby at the 1,702-foot-level of the Zinc Corporation Mine, Broken Hill. This is the first record of this mineral at Broken Hill.

Mr. Mawby states that the crystals were found in a watercourse in quartzitic ore carrying sphalerite. He suggests that the apophyllite has been derived by the zeolitization of the sericitic schists.

Associated with the apophyllite is calcite. Sometimes the apophyllite is directly on the quartz and at other times the calcite is. There does not appear to be any regular arrangement of the minerals that would indicate any regular periodic deposition. Some of the crystals of apophyllite exhibit definite zoning.

There is another possible origin differing from that offered by Mr. Mawby. The action of carbonated water on calcium silicate (wollastonite) in producing apophyllite at Auerbach has been noted by Streng, who suggests the following reaction:



The presence of wollastonite has been recorded from the 530-foot-level of the South Blocks Mine (Hodge-Smith, 1923), and it is possible that carbonated waters passing downwards along water channels have reacted on lime silicates such as wollastonite and deposited apophyllite and calcite at this comparatively great depth.



The crystals (Australian Museum number D 34888) vary in size from 2 mm. to 20 mm. measured along the vertical axis. They are pyramidal in habit (Fig. 11), the pyramid being  $p(111)$ . The small prism faces  $a(100)$  are invariably strongly striated parallel to the vertical axis. It does not appear that the basal plane is ever present. Those crystals in which the form appears have lost their apices by being knocked and cleaving along the perfect basal cleavage.

#### *Prospect.*

Although the dolerite intrusion at Prospect has been worked for many years by a number of quarries, and such minerals as analcite, prehnite, scapolite, stilbite, thomsonite, calcite and dolomite have been recorded, apophyllite has never been found until recently, when it was recognized by Mr. J. J. Johnston.

The mineral occurred in a large vesicle probably measuring a foot in diameter. The first mineral to form was prehnite, followed by pectolite and calcite, and finally apophyllite crystallized on the pectolite. Incidentally, although pectolite has been known for a number of years to occur at Prospect, its presence does not seem to have been recorded.

The colour of the apophyllite is an exceedingly pale pink forming a pleasing contrast with the pure white radiating fibrous pectolite which unfortunately does not retain its colour. In the course of a few months it becomes a dull brown on the surface.

While the crystals of apophyllite (Australian Museum number D 34921) appear to be bright, when examined on the goniometer they are found to be etched, giving poor signals making accurate measurement impossible. They are constant in habit (Fig. 13), consisting of short prisms  $a(100)$  terminated by the basal plane and the pyramid  $p(111)$ . In one crystal fragment the somewhat rare form  $h(221)$  was recognized (Fig. 14).

#### *General Occurrence in New South Wales.*

Very little apophyllite has been found in New South Wales. The first record was made in 1924 (Hodge-Smith, 1924) from Ardglen, and only one specimen (Fig. 12: Australian Museum number D 21405) was obtained. The next record is by Dr. Germaine A. Joplin (1935) from the Hartley district. Here it is abundant in the calcareous bed on the northern limb of the Moyne Anticline, and was also found in a boulder in the Bonnie Blink Creek. No macroscopic crystals have been found; the record has been made from the examination of microscopic slides only. Dr. Joplin discusses the origin of the mineral.

#### **Cassiterite Replacing Fossils.**

##### **Emmaville, New South Wales.**

The occurrence of these interesting objects has been known to the miners of the district for a number of years under the names shell or snail tin and screw tin. The former name is applied to cassiterite replacing small gastropods, and the latter to that replacing fragments of crinoid stems. Generally only one segment of the crinoid stem is preserved, though pieces showing several segments have been found.

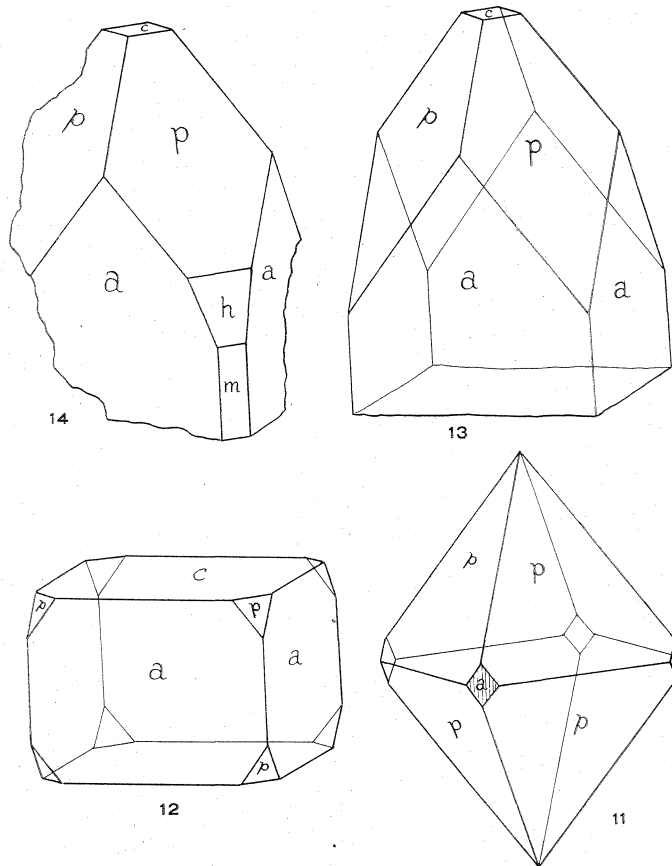
They are only known to occur in three small adjacent gullies about one mile north of the town of Emmaville, New South Wales. The two northerly gullies rise from the same shallow divide. That on the west is known locally as Steel's Gully, while the other apparently is unnamed. In these two gullies the screw tin is more abundant than the shell tin, while in the third gully, locally known as Charcoal Gully, the shell tin is the more common.

The gullies, mostly dry, have been worked long since for their alluvial cassiterite, and it is only after very heavy rain that it is regarded as at all worth while to recover cassiterite here.

In about a dozen "dishes" of dirt that I had washed from Steel's Gully, nine separate segments of crinoid stems were obtained from the concentrates which weighed about four pounds. The segments were very small, measuring only four millimetres in diameter. In two days' search I was unsuccessful in collecting any shell tin, though,

fortunately, I was able to secure a specimen. This measured 7 mm. by 6 mm. and has been identified as *Ptycomphalina* cf. *morrisiana* McCoy by Mr. H. O. Fletcher, Palaeontologist, Australian Museum.

The colour of both the shell tin and the screw tin varies from brownish-black to greyish-black. The cassiterite accompanying the fossils consists of a fairly even mixture of the ruby and black varieties with some resin tin. The size of the cassiterite grains varies considerably, but mostly they are about 2 mm. in diameter. One flat slug obtained in one of the dishes washed measured 25 mm. by 25 mm. by 6 mm., and was obviously part of a small vein from the country rock. A considerable number of small crystal fragments were obtained in the concentrates.



Figs. 11-14.—Apophyllite, New South Wales. 11, Broken Hill. 12, Ardglen. 13-14, Prospect.  
Forms:  $c(001)$ ,  $b(010)$ ,  $a(100)$ ,  $m(110)$ ,  $p(111)$ ,  $h(221)$ .

The bed rock on which the alluvium rests is locally known as "trap". It consists of sedimentary rocks of Permian (Lower Marine) age. They consist of slates and conglomerates. Diligent search failed to find any fossils in these rocks. They strike East  $20^\circ$  North and dip northerly at an angle of  $76^\circ$ . There does not appear to be any true lode of cassiterite from which the detrital cassiterite has been derived. Granite, portion of the New England batholith, underlies the sedimentaries at no great depth here. Tin-bearing solutions derived from this granite have invaded the overlying rocks forming a stockwork of innumerable veinlets of quartz, some of which are cassiterite-bearing. It was during this period of invasion that the fossil gastropods and crinoids were replaced by cassiterite. Some of the crinoid segments still have preserved

perfectly the minute hole left by the central canal of the stem, so that it is almost certain that these objects are pseudomorphs by substitution rather than by infiltration.

So far as I am able to find from the literature available, this constitutes the first record of cassiterite pseudomorphous after calcite and the first record of fossils composed of this mineral. It has been recorded as being pseudomorphous after quartz, orthoclase, and tourmaline from Cornwall; after feldspar from Tasmania; after hematite and magnetite from Mexico.

#### Phosphate Deposit.

Cathcart, New South Wales.

The deposit is situated in a small paddock on the eastern slope of Black Swamp, Portion 242, Parish Cathcart, County Wellesley, New South Wales. It came under the notice of the local residents by reason of the fact that crops would flourish in it when nothing would grow elsewhere. It was further noted that, on ploughing, white bone-like objects were turned over with the soil. Councillor H. Wiles, Shire President, became interested in the deposit, and Mr. R. Edwards secured some of the material and submitted it to the Museum for examination. Later Mr. Wiles took Mr. H. O. Fletcher, Palaeontologist, and myself to the deposit.

The soil is the typical basalt variety. About two chains towards the Black Swamp from the paddock a mica-hornblende-granite outcrops, while the hills above the deposit consist of olivine basalt of Tertiary age. In the south-western corner of the paddock a hole about eight feet deep had been made. The first three feet consisted of surface soil; underneath this is another three feet of thoroughly decomposed basalt which overlies a deposit of white phosphatic material in which fragments of fossil bone and wood were found. The contact of the decomposed basalt and the phosphatic material was quite irregular, and small veins of the latter passed irregularly up into the basalt. In part the altered rock is reticulated with thin veins of the white material.

Although actual contact of the phosphatic material and the underlying granite was not made, an examination of the occurrence clearly indicated that the granite was probably not more than two feet below the bottom of the hole.

The fossil wood is white and quite soft, having a hardness of not more than 2. In spite of its soft nature an excellent transverse section was obtained in a micro-slide.

#### *Analysis of Fossil Wood, Cathcart.*

SiO <sub>2</sub> .. ..	7.38		
P <sub>2</sub> O <sub>5</sub> .. ..	32.72		
Al <sub>2</sub> O <sub>3</sub> .. ..	29.21		
CaO .. ..	18.16	Approximate Mineral Composition.	
MgO .. ..	4.21	Tri-calcium phosphate .. ..	44
H <sub>2</sub> O .. ..	7.62	Hydrous aluminium phosphate ..	32
		Hydrous aluminium silicate ..	24
	99.30		100

The material is readily decomposed in acid with the separation of gelatinous silica. Iron, if present, can only be as a mere trace as there is not sufficient to impart the slightest colour to the ammonium precipitate. Fluorine is absent. The mineral composition given above can only be considered very approximate. The magnesia is considered as replacing lime in the tri-calcium phosphate.

The only other Australian record of phosphatized wood is by E. S. Simpson (1911) from Dandarragan, Western Australia. Here the replacing material is fluor-apatite (fluorophosphate of lime) and dufrenite (hydrous phosphate of iron), and the fossil wood is preserved in Mesozoic sandstones. This occurrence is similar to that found in certain Cretaceous sandstones of the Russian districts of Smolensk, Orel, etc., except that dufrenite has not been recorded from here.

The bone fragments are also white in colour, but the hardness is considerably greater than that of the fossil wood. Only fragments of what appear to be rib and limb bones of a fairly large animal comparable with the extinct kangaroo were found. Under the microscope only traces of bone structure can be distinguished. External structures

have been lost largely, in many cases entirely. Quite a few of the fragments could not be recognized as bone.

*Analysis of Fossil Bone, Cathcart.*

SiO <sub>2</sub>	.. ..	2.38		
CO <sub>2</sub>	.. ..	5.68		
P <sub>2</sub> O <sub>5</sub>	.. ..	36.66		
Al <sub>2</sub> O <sub>3</sub>	.. ..	0.76		
CaO	.. ..	46.66		
MgO	.. ..	3.86		
MnO	.. ..	trace		
Na <sub>2</sub> O	.. ..	1.32		
H <sub>2</sub> O	.. ..	3.59		
F	.. ..	absent		
		100.91		

Approximate Mineral Composition.				
Tri-calcium phosphate	.. ..	80		
Hydrous silicate	.. ..	9		
Magnesium carbonate	.. ..	8		
Calcium carbonate	.. ..	3		
				100
				---

Again the material is decomposed by acid with the formation of gelatinous silica. It effervesces slightly in cold acid and, after this ceases, effervescence is renewed on warming. In determining the approximate mineral composition, all the magnesia is used to form carbonate, and sufficient lime taken to satisfy the remaining carbon dioxide and all the phosphorus pentoxide. The remaining constituents formed a hydrous silicate somewhat resembling zeolitic material.

Although the material chosen for analysis was considered to show traces of bone structure, the result of the analysis does not support the view that it is fossil bone. According to F. W. Clarke (1916, p. 524), A. Carnot has shown that fossil bone shows an enrichment of calcium carbonate, iron oxide, and especially fluorine. In the above analysis it is to be noted that fluorine is absent, iron oxide is present as a mere trace and is included with alumina, while the carbonate is mainly magnesium carbonate. Further, concretions are characterized by an absence of fluorine.

In discussing the origin of this deposit it will be seen that these bones have been subjected to conditions not found in ordinary bone deposits. The phosphatized wood, bone, and cementing material in the Cretaceous sandstones of Russia have all practically the same composition. In this case all three are different. An analysis was not made of the cementing material, but it differs from both the fossil wood and bone in that it contains 15.26 per cent. of insoluble material. This indicates a considerable difference in the mode of formation of the two deposits.

*The Origin of the Phosphate Deposit.*

The origin of the phosphatic material may be sought either in the basalt or in the granite since it lies between them or in organic remains which have been covered by the basalt. The basalt is notably deficient in phosphorus. The granite is quite a normal type and may contain less than one-half per cent. of normative apatite. If either were responsible for the deposit it would be reasonable to expect phosphates to occur right along the contact and not in a restricted area.

It is therefore necessary to assume that the phosphates were derived from organic remains. The occurrence suggests a small marsh or water hole to which animals came for water and in which the bones of these animals accumulated until the area became covered by the Tertiary lava flows. The bones would be immediately attacked by the waters accompanying the lava. The smaller bones would suffer complete decomposition, and only fragments of the larger bones would remain. The resulting phosphate solutions, acting on the lava, would form aluminium phosphate and possibly magnesium phosphate. These solutions, coming into contact with the wood of the marsh, were responsible for the replacement of the woody material by phosphates of lime, magnesia, and alumina. Under these conditions it is probable that the leached fluorine was carried away in solution. It is surprising to find practically no iron oxide present, and possibly it has been leached out subsequently by ordinary ground waters.

**Microlite.**

Euriowie, New South Wales.

A single crystal fragment of microlite was obtained by Mr. M. Mawby from Euriowie, New South Wales. It measured approximately 13 mm.  $\times$  10 mm.  $\times$  10 mm. Four faces of the octahedron are shown, but they are quite rough. The colour is brownish-yellow and the specific gravity 5.43. This is the first record of microlite for the State.

**Scheelite.**

Hatcher's Creek, Northern Territory.

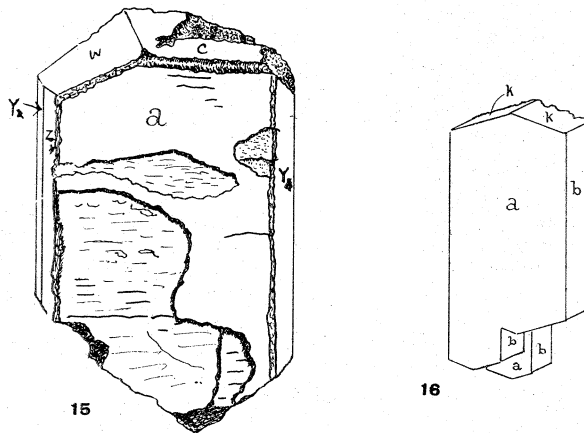
Mr. J. J. Johnston secured a crystal fragment of scheelite from Hatcher's Creek, Northern Territory. It measures 30 mm. along the intersection of two faces of the form  $e(011)$ , which is the only form represented.

**Tantalite.**

Finniss River, Northern Territory.

(Figs. 15-16.)

Mr. A. E. Williams presented to the Museum some crystals of tantalite from Porter's Claim, Finniss River, Northern Territory (Australian Museum number D 35552). Two of these are considered worthy of description. No. 1 crystal (Fig. 15) measures 56 mm. along the vertical axis and 22 mm. and 30 mm. along the horizontal axes. The habit is stout prismatic, somewhat flattened parallel to the macropinacoid, the faces of which are very rough. The edges between the macropinacoid and the basal pinacoid are very rounded, suggesting the development of a macrodome. In some of the other crystals the macropinacoid is strongly striated horizontally and one shows a steep macrodome lying between  $i(101)$  and  $a(100)$ , which may possibly be  $e(201)$ .



Figs. 15-16.—Tantalite, Finniss River, Northern Territory. *Forms*:  $c(001)$ ,  $b(010)$ ,  $a(100)$ ,  $y(160)$ ,  $z(150)$ ,  $k(011)$ ,  $w(164)$ .

Measurements were made by means of a contact goniometer and are therefore only approximate, but are sufficiently accurate and concordant for purposes of determination; in no case does the measured angle vary from the calculated angle by more than half a degree.

I can find no record of the large terminal face  $W(164)$ . It lies in the zone  $[610]$  and the measured angle between it and the basal pinacoid is  $30^\circ 30'$ , while the calculated angle is  $30^\circ 9'$ .

Crystal 2 (Fig. 16) is doubly terminated, though one termination is much stepped. One of the macropinacoids is missing and it would appear that it was the plane of attachment of the crystal. The crystal measured 9 mm. by 15 mm. by 33 mm. along the a, b, and c axes respectively. The macropinacoid, unlike those of crystal 1, is quite bright.

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