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THE OCCURRENCE OF MONAZITE *in situ*  
AT BLATHERARM CREEK, NEAR DEEPWATER,  
NEW SOUTH WALES.

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The first reference to the occurrence of Monazite in New South Wales was made by Mr. W. A. Dixon, F.I.C., who in 1881 analysed a specimen from Vegetable Creek, Co. Gough.<sup>1</sup> No description of its mode of occurrence is given, but we may presume that it was found in alluvial drift. In 1898 Mr. J. C. H. Mingaye, F.I.C., F.C.S., Analyst and Assayer to the Department of Mines of New South Wales, contributed a note on an occurrence of Monazite in a gem sand from the Tooloom Alluvial Gold-fields.<sup>2</sup> More recently the same author detected it in the beach sands at Ballina, Richmond River.<sup>3</sup>

Towards the end of 1903 Mr. D. A. Porter, of Tamworth, a zealous collector of minerals in the northern districts of New South Wales, brought to the Museum for identification, some small fragments of a mineral found embedded in a decomposed felspathic rock near Deepwater, which he believed to contain some of the rare earths. This was identified as Monazite, and Mr. Porter having kindly presented a larger quantity, also specimens of the matrix and country-rock, it is now possible to supply some account of the occurrence *in situ* and mineral associates of this comparatively rare mineral in New South Wales.

The locality is given as Blatherarm Creek, about twenty-one miles N.W. of Deepwater, and twenty-five miles, approximately N.E. by N., from Emmaville. Of the mode of occurrence Mr. Porter says:—"It occurs in a mineral vein of six to eight inches wide, which exists in a small gap in a granite (?) or felsite (?) formation . . . and strikes about N. 20° E." The matrix consists of felspar (apparently orthoclase), much decomposed and kaolinised; quartz, slightly dark in colour, rarely shewing hexagonal outlines, but chiefly irregular and blebby; also wolfram which occurs in irregular masses. These are accompanied by a mineral consisting of small crumbling scales, bronzy in colour,

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<sup>1</sup> Dixon—Ann. Rept. Dept. Mines N.S. Wales for 1881 (1882), p. 26 ;  
Liversidge—Min. N.S. Wales, 1888, p. 114.

<sup>2</sup> Mingaye—Proc. Austr. Ass. Adv. Sci., vii., 1898, p. 333 ; Rec. Geol.  
Surv. N.S. Wales, vi., 1899, p. 118.

<sup>3</sup> Mingaye—Rec. Geol. Surv. N.S. Wales, vii., 1903, p. 222.

probably derived from the decomposition and oxidation of biotite. The monazite occurs in small crystals and irregular grains, embedded both in the quartz and in the felspar, hence we may conclude that it is at least not later in origin than these. The country-rock, from the specimens supplied by Mr. Porter, appears to be an ordinary biotite granite, rather coarsely crystalline in texture and much decomposed, the quartz bearing a general resemblance to that of the vein. I have not been able to detect monazite or wolfram in the country-rock itself.

With regard to the general mode of occurrence of monazite geologically, Mr. H. B. C. Nitze, says<sup>4</sup>:—"Monazite is an accessory constituent of the granitic eruptives and their derived gneisses." Prof. O. A. Derby makes the further statement<sup>5</sup>:—"There is thus a reasonable probability that zircon, and to a less degree monazite may prove to be guide minerals by which eruptives and their derivatives can be certainly identified no matter what degree of alteration they may have suffered." No doubt at Blatherarm Creek the mineral occurs in minute quantity in the granite of the district, and careful microscopic examination, or a "pan" test, may reveal its presence.<sup>6</sup> But from Mr. Porter's notes we learn that the larger masses of monazite are found in a "vein" enclosed in granite, which, as the result of erosion, now occupies a depression in the granite, and it is of importance to determine the relation of this vein to the enclosing rock. Either it is a segregation-vein, when it would probably be called pegmatite, or its contents have been leached out from the surrounding rock and redeposited in a fissure to form a mineral-vein in the ordinary sense of the term. I am of opinion that it is a pegmatitic vein, as quartz, felspar and mica (if the decomposed scales mentioned above represent mica), are normal constituents of pegmatite, and form an unusual association of veinstones. Careful examination of the ground is necessary to settle the question.

The mineral occurs in small crystals (too minute for accurate determination), in cleavage fragments, or in irregular grains. Its colour is reddish—or yellowish-brown, and the lustre is resinous. The specific gravity, determined by the pyknometer is 5.119 at 18° C. Under the microscope it is seen to be slightly pleochroic. By focussing a strong light from below on a cleavage fragment upon the stage of the microscope and replacing the eye-piece by a direct vision spectroscope, a broad absorption band appears in

<sup>4</sup> Nitze—16th Ann. Rep. U.S. Geol. Surv., iv., 1894-5, p. 682.

<sup>5</sup> Derby—Proc. Rochester Acad. Sci., i., 1891, p. 204.

<sup>6</sup> Derby—*loc. cit.*, pp. 198-206; Am. Jour. Sci., (3), xxxvii., 1889, p. 109; Min. Mag., xi., 1897, p. 304.

the yellow (didymium), and a faint dark line in the green (erbium ?)<sup>7</sup>

For analysis a collection of small crystalline fragments, which Mr. Porter obtained on his visit to the locality by panning the debris in a miner's dish, was utilised. The material was carefully selected under a lens and any shewing impurities rejected.

For the method of analysis the chief authorities followed are Baskerville,<sup>8</sup> Penfield<sup>9</sup> and Mingaye.<sup>10</sup>

For phosphoric acid the fine powder was fused with sodium and potassium carbonates, exhausted with water, filtered and washed. The filtrate was evaporated to dryness with nitric acid, and phosphoric acid precipitated with ammonium molybdate in the usual way. The mean of two closely agreeing results (28·17 and 28·24) gave 28·20 per cent. The residue was ignited in a platinum crucible, transferred to a porcelain basin, covered with concentrated sulphuric acid and heated for some time on a sand bath, the acid being renewed from time to time. The excess of acid was finally evaporated off, the residue dissolved in cold water and largely diluted. From the slightly acid solution, the rare earths were precipitated in the heat as oxalates by an excess of oxalic acid, warmed for some time, and allowed to stand. The precipitate was ignited and weighed, then redissolved with sulphuric acid as before, transferred to a small flask, excess of caustic potash added, and the whole submitted to a current of chlorine gas to saturation.<sup>11</sup> The flask was then corked and allowed to stand for twenty-four hours with frequent agitation. The undissolved oxides of cerium and thorium were filtered off, washed, dissolved in hydrochloric acid, and the treatment with potash and chlorine repeated. By this means the cerium and thorium (residue) were separated from the lanthanum and didymium (filtrate). The residue of cerium and thorium oxides was dissolved in hydrochloric acid, evaporated to expel excess of acid, and the earths precipitated as oxalates, ignited and weighed as sesquioxides, yielding 37·33 per cent. Thorium was determined by dissolving in sulphuric acid and adding sodium thiosulphate to the nearly neutral solution, warming for some time, igniting and weighing the precipitate as oxide (ThO<sub>2</sub>). The crude oxide was redissolved in sulphuric acid, the excess of acid removed, dissolved in water and ammonium acetate and ammonium oxalate

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<sup>7</sup> Scharizer—Zeits. für Kryst., xii., 1887, p. 264, quoted by Nitze, *loc. cit.*, p. 679.

<sup>8</sup> Baskerville—Quoted by Nitze, *loc. cit.*, p. 677.

<sup>9</sup> Penfield—Am. Jour. Sci., (3), xxiv., 1882, p. 253.

<sup>10</sup> Mingaye—Rec. Geol. Survey N.S. Wales, vii., 1903, pp. 224-225.

<sup>11</sup> Damour and St. Claire Deville—Compt. Rend., 1864, 59, p. 272.

added. As thorium oxalate is soluble in this menstruum while cerium oxalate is precipitated, by this treatment the thoria was freed from traces of ceria. The slight precipitate was filtered off and to the filtrate hydrochloric acid was added, reprecipitating thorium oxalate, which was washed, ignited and weighed. The result was 1.63 per cent.; therefore the percentage of cerium oxide is by difference 35.70.

Similarly lanthanum and didymium were precipitated as oxalates by ammonium oxalate, ignited, redissolved in sulphuric acid, and again precipitated by oxalic acid. They yielded 30.73 per cent. The weighed oxides were redissolved by sulphuric acid, diluted, and excess of tartaric acid and ammonia added. After standing for two days, a very slight precipitate came down, which is entered in the analysis as a trace of yttrium and erbium oxides.

As the quantity taken for the general analysis was rather small (.6687 grams) it was deemed advisable to make separate determinations of thoria and yttria on larger quantities. Accordingly, for yttria, a fresh portion was taken, weighing 1.3802 grams, decomposed by sulphuric acid, converted into oxalates, ignited and redissolved as sulphates. To the clear solution tartaric acid and ammonia were added. After standing for three days the precipitate was filtered off and weighed, yielding .12 per cent. Similarly for thoria .9577 grams were taken, decomposed, precipitated by oxalic acid, ignited, dissolved in sulphuric acid and evaporated to a nearly neutral aqueous solution. Thoria was precipitated by sodium thiosulphate and purified from traces of the cerium group as above. The result was 2.10 per cent.

Iron and alumina were estimated in the filtrate from the first precipitation by oxalic acid. The solution was evaporated to dryness, the oxalic acid decomposed by sulphuric acid and the oxides precipitated by ammonia.

Silica was determined by decomposing the finely powdered mineral with sulphuric acid as above, evaporating to dryness, adding water, filtering off the insoluble residue, which was ignited and weighed, then evaporated with hydrofluoric and sulphuric acids. Silica was estimated as the loss. Two determinations gave percentages of .59 and .35, yielding a mean result of .47 per cent.

I ought to state that I am far from regarding the results of the analysis as complete or altogether trustworthy. For example I have not looked specially for zirconium, which may be present in small amount. Again, manganese, lime, magnesia, and perhaps other elements may constitute fractional percentages. On the other hand, anyone who has attempted the

analysis of a mineral containing the elements of the cerium and yttrium groups must feel that the methods of separation are not ideally perfect.

Composition of Monazite (per cent.).

	I	II	III	IV	V
P <sub>2</sub> O <sub>5</sub> ... ..	29.92	29.32	26.86	25.09	28.20
Ce <sub>2</sub> O <sub>3</sub> ... ..	28.82	37.26	24.80	36.64	35.70
La <sub>2</sub> O <sub>3</sub> ... ..	} 40.79	} 31.60	} 26.41	} 30.21	} 30.73
Di <sub>2</sub> O <sub>3</sub> ... ..					
Y <sub>2</sub> O <sub>3</sub> + Er <sub>2</sub> O <sub>3</sub> ...	—	—	4.76	—	tr.
ThO <sub>2</sub> ... ..	—	1.48	12.60	1.23	1.63
SiO <sub>2</sub> ... ..	—	0.32	0.91	3.21	0.49
Al <sub>2</sub> O <sub>3</sub> ... ..	—	—	—	3.11	} 2.23
Fe <sub>2</sub> O <sub>3</sub> ... ..	—	—	1.07	—	
MnO ... ..	—	—	—	tr.	—
CaO ... ..	—	—	1.54	—	—
MgO ... ..	—	—	0.04	tr.	—
H <sub>2</sub> O ... ..	—	0.17	0.78	—	0.34
	99.53	100.15	99.77	99.49	99.32

I. Arendal, Rammelsberg—Mineral Chemie, Zweites Auflage, Ergänzungsheft, 1886, p. 169.

II. Alexander Co., N. Carolina, Penfield and Sperry—Am. Jour. Sci., (3), xxxvi., 1888, p. 322.

III. Ottawa Co., Quebec, Genth—Am. Jour. Sci., (3), xxxviii., 1889, p. 203.

IV. Vegetable Creek, Co. Gough N.S. Wales, Dixon—Ann. Rep. Dept. Mines N.S. Wales for 1881 (1882), p. 26.

V. Blatherarm Creek, N.S. Wales.

There is a general correspondence between analyses Nos. IV and V and considering that the two localities in question are roughly in the same area this may be taken to mean that the occurrences are also essentially similar geologically.

The most noticeable feature about the composition of the New South Wales monazite hitherto analysed is the low percentage of thoria, which is the constituent commercially valuable for the manufacture of incandescent mantles, but as the amount of thoria fluctuates considerably even in specimens from the same locality, it is possible that marketable monazite may yet be discovered in New South Wales.

Thus it may be worth while to look for it in the sands and gravels in the beds of rivers which flow through granite country.