MONAZITE FROM WEST PORTLAND TOWNSHIP QUEBEC

Hugh S. Spence[1] and O. B. Muench[2]

Part I. Hugh S. Spence

Introductory

In 1929, during a survey of feldspar mining operations, a small quarry on lot 2, range V of West Portland Township, in the Lièvre river section of Quebec—Lat. 45°45′30″N, 75°36′30″W (N side of river)—was visited. The property was idle, and the one small pit full of water; pegmatite was exposed only immediately around the pit and for about 75 feet up a low cliff-face rising abruptly from it. Examination of the cliff section, from which some rock had been scaled down during mining operations, disclosed nothing of interest in the way of unusual accessory minerals, the dyke-mass being the usual mixture of pink microcline (perthite) and massive white quartz, typical of the general run of Canadian pegmatites in both Quebec and Ontario. About 800 tons of feldspar were reported to have been shipped from the property.

On examining the waste-dump, however, some interesting minerals were found. A single large block of rock, lying on the top of the dump and evidently one of the last pieces raised from the pit, was found to contain considerable euxenite. In addition to the euxenite, and usually in close association with it, were found a number of crystals of the monazite described in this paper. The block was broken up, and about 5 pounds of clean monazite was recovered, in the form of rough crystals and cleavage pieces. The largest piece measured about $6'' \times 3'' \times 1''$ and weighed $\frac{3}{4}$ pound. Probably an equal amount of the mineral was secured as matrix specimens, mixed with euxenite, black tourmaline and feldspar. Further search in the dump, on this occasion and on several subsequent visits, was rewarded by the finding of more material, most of it as clean cleavage pieces up to $\frac{1}{2}$ pound in weight. The total collected was about 20 pounds.

The discovery was of interest, since monazite is not a common mineral in Canadian pegmatites and has been recorded from only

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a few dykes. This West Portland occurrence was briefly noted in a previous paper[3] by the writer. The only other recorded occurrence of the mineral up to the time that paper was written was at the old Villeneuve mine, in Villeneuve Township, Que., where a nodular mass of 12 pounds weight is stated[4] to have been found many years ago. In a later paper,[5] Ellsworth has described monazite from a pegmatite in Dickens Township, Nipissing District, Ont., and Walker mentions[6] its occurrence at the Huron claim, on the Winnipeg river, near Pointe du Bois, Man. The writer has observed it in small amount, but only as minute anhedral grains, in the beryl pegmatite on lots 23 and 30, concession XV of Lyndoch Township, Renfrew County, Ont., and also in the syenite pegmatite of Cardiff Township, Haliburton County, Ont.

Since a sufficient amount of the West Portland material was collected to serve research purposes, the writer sent a quantity of it to Dr. A. C. Lane, suggesting that it might be useful for age determination purposes, and also as a source of thorium-lead, in connection with the work of his Committee on the Measurement of Geologic Time. In this, Dr. Lane concurred, and a portion of the material was turned over to the second author for detailed chemical analysis, the results of which are given in Part II of this paper. Dr. Lane also sent a portion to Dr. Hecht, in Vienna, for microanalysis: the results of this are likewise appended.

Description of the Pegmatite

The West Portland pegmatite is a small dyke, not over 50 feet across at its widest surface exposure. This exposure occurs at the base of a low cliff-face in the north side of a small, open valley trending westward through the hills running north and south along the west side of the main Lièvre river valley. The single small pit opened on the dyke is situated at the foot of the cliff, and is about 20 feet square and 25 feet deep. Having sheer walls, and being half full of water, no examination of the opening was possible. The dyke follows an erratic, diagonal course up the cliff from the pit,

[3] Pegmatite Minerals of Ontario and Quebec, *Am. Mineral.*, vol. **15**, p. 448, 1930.

[4] *Geol. Surv. Can., Ann. Rep.*, vol. **2**, 1886, pp. 10–11T.

[5] Monazite Coloured by Carbon from Dickens Township, Nipissing District, Ontario: *Am. Mineral.*, vol. **17**, pp. 18–28, 1932.

[6] Rare Minerals in Pegmatite, Pointe du Bois, Manitoba, *University of Toronto Studies*, no. **30**, Contributions to Canadian Mineralogy, p. 12, 1931.

pinching out upwards until, at the top, it becomes a mere stringer. Beyond the pit, in the opposite direction, it is covered by waste and its further course is hidden beneath soil and drift cover. The country rock is biotite gneiss.

As stated above, the accessible portions in the cliff-face disclosed nothing of interest and no unusual minerals were noticed. It would appear that most, if not all, of the euxenite, monazite and other minerals noted below, which were found on the dump, came from the lower portion of the pit, since the material secured was mostly found in the upper layer of waste. The operator, also, stated that work had been discontinued on account of the increasing amounts of impurities encountered with depth.

Below are listed the various minerals found, in order of their relative abundance.

Minerals Present in the Pegmatite

Feldspar.—The rock of the dyke is predominantly a pale, pink perthite, intergrown with irregular zones of massive, white quartz.

In the zones carrying the monazite and euxenite, the feldspar is usually a grey or flesh-coloured albite, often showing the colour-play of peristerite. Sometimes, this albite shows the dark-reddish discoloration often noticed around radioactive minerals.

Quartz.—Only the normal massive, white type, common to pegmatites, occurs.

Tourmaline.—Black schorl is abundant, as fine needles penetrating feldspar, but more commonly as stout prisms, up to 2″ across and 12″ long. It is particularly abundant in the rock containing the euxenite and monazite. Having come from near the surface, most of the tourmaline is weathered and friable.

Euxenite.—Occurs as platy crystals up to 2″ across, but being firmly embedded in the rock, most of the material secured was fragmentary. The mineral is fresh and lustrous, and has, variously, a granular or a smooth, conchoidal fracture, the former being most common. On the edges, pieces show reddish-brown translucency. No analysis of the mineral was made.

Monazite.—Monazite and euxenite are present in about equal amount, and appear to be usually closely associated. Frequently, crystals of both occurred side by side, often accompanied by tourmaline. The monazite is uniformly of a dark-reddish colour. Much of the material found was more or less severely weathered, possessed little lustre and was of a dark, brick-red shade. A number of cleavage pieces were secured, however, which were relatively fresh. Under the binocular microscope, most of the mineral was found to show irregularly distributed zones or grains of a yellowish, resinous substance, which may be residues of fresh monazite that have escaped oxidation or, perhaps, altered fergusonite (see below). The same feature was observed on examining a thin section. In the feldspar enclosing the monazite, small anhedral grains of a similar yellow, resinous mineral are often present: whether these are monazite or fergusonite was not determined. Many of the more highly altered crystals also were found to contain numerous microscopic grains of feldspar and quartz, and often flakes of muscovite. Only the freshest monazite was selected for the purpose of the analysis given below.

Allanite (?).—A few specimens of a severely altered, greenish-black mineral that may originally have been allanite were found: the material was too highly weathered to be identified with certainty.

Titanite—Ilmenite: mixture.—A number of pieces, up to ½ pound in weight, of a heavy, greyish-black mineral, apparently having obscure crystal outline and showing indistinct cleavage, were collected. The material was nearly all severely altered (kaolinized) and much of it was of a clayey or earthy consistency, though the freshest specimens showed a matt, sub-metallic appearance, with a medium-granular texture. Alteration had proceeded too far to permit of a precise determination, but the original material was probably titanite. The ground-mass contains scattered grains of a heavy, black, magnetic mineral, which is probably secondary ilmenite. Some calcite, also, is present, and a little pyrite.[7] Analysis showed:

SiO_2	8.80
Al_2O_3	3.97
Fe_2O_3	55.83
TiO_2	22.00
CaO	8.80
	99.40

Fergusonite (?).—In the albite enclosing the monazite and euxenite, small amounts of a mineral having the macroscopic characteristics of fergusonite were observed. It occurs mostly in small,

[7] The writer is indebted to H. Berman for the mineral determinations given.

anhedral grains, seldom as much as 5 mm. across, but occasionally exhibits an approach to square prismatic form. When fresh, it is black and has vitreous lustre, but it evidently is readily altered, most of the larger pieces consisting of black cores surrounded by a brown zone which, in turn, is bordered externally by progressively lighter-coloured substance, the outer shell being pale yellow. Such altered material is translucent to transparent, possesses resinous lustre and exhibits conchoidal fracture similar to that of the fresh cores.

Cyrtolite.—Small crystals of pale grey cyrtolite are fairly frequent in the finer-textured pegmatite enclosing the monazite-euxenite association. Usually single individuals, they range from 3 mm. in diameter down.

Muscovite.—Very little mica is present in the pegmatite, all of it muscovite of a pale, yellow shade. This occurs as occasional small aggregates of flakes, seldom over ½″ across, and also as thin flakes coating tourmaline.

Tengerite.—On fractures (in part cleavage partings) in the albite enclosing the monazite, thin, radiated, dendritic crusts of a white secondary mineral with pearly lustre were noted. Specimens of this have been determined by Dr. Foshag as tengerite (yttrium carbonate). This is the first recorded occurrence of this mineral in Canada.

Specularite.—Small cavities in corroded feldspar are sometimes encrusted with minute crystals of specularite.

While none of the "accessory" minerals listed above were seen in place, the character of the rock enclosing them suggests that they are localized within a finer-grained, albite phase of the pegmatite, of pocket or "schlieren" type, and of limited extent. Just where this zone occurs in the dyke-mass could not be ascertained definitely, but there was some indication that it might be located in the east wall of the pit and near the contact of the pegmatite with the enclosing gneiss.

Part II.

The Analytical Determination of Thorium, Lead and Uranium in the West Portland Monazite

O. B. Muench

Thorium bearing minerals free from uranium and ordinary lead are of rare occurrence, especially in such quantities that an atomic weight determination can be made of the lead. A specimen of the monazite described in part I of this paper was sent to Dr. A. C. Lane, hoping that it might be nearly, if not quite free from uranium and at the same time high enough in lead and thorium to make it a practical source of these two elements.

An age determination of this mineral by the lead-uranium method was undertaken by the author so that the above information could be obtained and at the same time furnish some data on the age of the mineral and the pegmatite.

The sample as sent by the author of part I of this paper, was purified at Harvard University by treatment with heavy liquids. This sample (80 grams), as it reached the Laboratory of the University of Missouri, was ground in an agate mortar to pass an 80 mesh sieve. The sieve had no exposed solder on it to contaminate the mineral.

There was not enough of the sample available to do any extensive experimentation with different methods of analysis. Fenner[8] gives a detailed method for the analysis of monazite for thorium, lead and uranium, such as is used in age determinations.

Fenner's method was followed with but few modifications. The method consists essentially of a precipitation of the thorium together with the rare earths by means of oxalic acid, then thorough drying and conversion of the oxalates into nitrates by means of fuming nitric acid. This is followed by repeated precipitation with hydrogen peroxide (30%) in a slightly acid or neutral solution containing a strong electrolyte. This precipitate after conversion to the oxalate is ignited and weighed as ThO_2.

Instead of three precipitations with perhydrol, four were found necessary in order to get a thorium precipitate which, from its white color, showed no evidence of cerium.

The lead determination was made as carefully as possible on 30 gram samples, again following Fenner's method. Tested reagents and those known to be lead free were used throughout this analysis. The final precipitate was purified as suggested by Fenner. Care was taken not to heat this lead sulfate above 500°–600°C., for, according to Hillebrand and Lundell,[9] the decomposition of lead sulfate begins at 637°C. and becomes energetic at 705°C.

[8] Fenner, C. N., The Analytical Determination of Uranium, Thorium and Lead as a Basis for Age Calculations: *Am. J. Sci.*, p. 369, Nov. 1928.

[9] Hillebrand and Lundell, *Applied Inorganic Analyses*, p. 545.

The solutions from the lead determinations were taken for the determination of uranium, and although certain evidence of the presence of uranium was obtained, the results were not quantitative. Because of the comparatively small amount of mineral available, the quantitative results for the uranium were obtained by the emanation method on two gram samples.[10]

Experimental Results

Thorium

Analysis	Wt. of sample (grams)	Wt. of ThO_2 (grams)	Per cent Thorium
1	2.8045	0.1082	3.39
2	2.7029	0.1040	3.38
3	2.5007	0.1010	3.55
			Average = 3.44

Lead

Analysis	Wt. of sample (grams)	Wt. of $PbSO_4$ (grams)	Per cent Lead
1	30.0000	0.0317	0.072
2	30.0000	0.0285	0.065
			Average = 0.068

Uranium

By the emanation method.

Average of two determinations 0.054%

Loss at 110°C. for three hours 0.012%

Loss on ignition 0.07%

If we assume the absence of ordinary lead and use the conversion factor 0.36 for thorium, the lead-uranium ratio is:

$$\frac{.068}{.054+3.44\times .36}=0.053.$$

The approximate[11] age of the mineral is:

$$\frac{.053\times 1.15}{1.57\times 10^{-4}}\text{million years} = 388 \text{ million years.}$$

The age corresponding to a lead-uranium ratio of 0.053, reading from Holmes[12] graph is 391 million years.

[10] The determinations by the emanation method were made with the assistance of Mr. Charles M. Burton.

[11] Kirsch, G., Geologie und Radioaktivität, **1928**, p. 128. The value 1.57 as given by Kirsch on p. 134, was used in the above formula, instead of 1.5.

Using the formula[13]:
Age in million years = 15140 log(1+1.155Pb/(U+.36Th)) we get $t = 391$ million years.
This would be the age of Taconic intrusions such as the Bedford cyrtolite.

The experimental result of this work is that the lead-uranium ratio of the Portland monazite is 0.053, and that the percentage of lead present in the mineral is small.

This research was greatly helped by a grant from the Elizabeth Thompson Science Fund and the writer expresses his grateful appreciation. The Laboratory of the University of Missouri and other privileges were made available to the author through the kindness of Dr. H. Schlundt.

Note by A. C. Lane

Originally two pounds and twelve ounces were sent by Spence, November 16, 1933. Eighty grams were specially purified by E. S. Larsen for O. B. Muench, of which 3 grams were sent to F. Hecht who made the pilot micro-analysis given below.

It will be noted that the lead is much less than Muench found. The difficulty of getting strictly reliable results on the lead in microanalysis, when it exists only in fractions of a per cent is shown by the lack of close agreement with Muench's figures. Yet it has value in that it confirms Muench's surprisingly low results. The thorium checks reasonably. It was hoped and expected that the mineral would have a ratio characteristic of the pre-Cambrian. It does not and there seems to be hardly enough lead for atomic weight determination. The question whether there can have been a loss of half the lead in the few years exposure in the dump, or whether there was some mineral rearrangement of this pegmatite at the time of the Taconic uplift requires further investigation. Looking at the material it is hard to believe a lead extraction. It seems fresh and the map shows not far away an igneous intrusion and it is conceivable that lead may have been driven off at the time of this intrusion.

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[12] Holmes, Arthur, on pages 208–9 of The Age of the Earth, Bulletin No. **80,** *National Research Council*, June, 1931.

[13] *Report Com. on Measurement Geol. Time*, 1934.

MICROANALYSIS OF THE WEST PORTLAND MONAZITES (F. HECHT)[14]

Employed for analysis:	23.65 mg.	
SiO_2 (impure)	3.21%	
(SiO_2 pure)		(2.35)
PbO		
Pb		(.032 to .05)[1]
Rare earths[3]	62.09	
ThO_2	4.25	
(Th)		(3.72) or (3.18)[1]
U		(.094)[2]
Fe_2O_3	2.10	
Al_2O_3	0.69	
CaO	0.99	
MgO	0.56	
P_2O_5	27.39	
Loss on ignition (1000°)	0.60	
S	none	
Sum	101.88%	

[1] From later letters, the last letter (Apr. 7, 1935) reported that testing a larger quantity for Pb he has not been able to get more than 0.05 Pb, but that the Th checks better with Muench.

[2] 1.0035 grams was taken for this determination.

[3] The excess is due to the rare earths being weighed and reported as RO_2 which in the mineral are R_2O_3.

[14] Methods and analysis reported by F. Hecht and E. Kroupa: *Zeit. für An. Chemie*, vol. **102**, pp. 81–90.