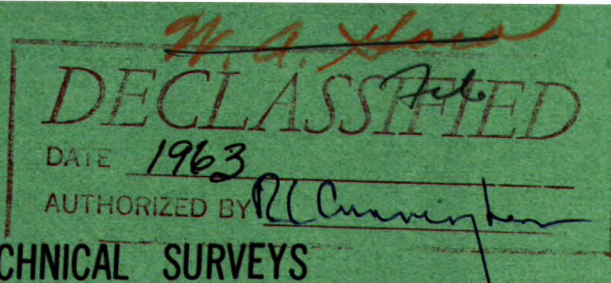


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CANADA



DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 60-19

MINERALOGICAL COMPOSITION OF CONGLOMERATE ORE AND
OF ASSOCIATED ACID-CONSUMING ROCKS FROM MILLIKEN
LAKE URANIUM MINES LIMITED, ELLIOT LAKE, ONTARIO

by

S. KAIMAN

EXTRACTION METALLURGY DIVISION

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MINERALOGICAL COMPOSITION OF CONGLOMERATE ORE
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SUMMARY OF RESULTS

Mineralogical examinations were made of a sample of quartz pebble conglomerate, of two lamprophyre dyke samples, and a sample of sericite schist (basement rock) from Milliken Lake Uranium Mines Limited in order to determine which mineral constituents are responsible for the high acid consumption and the filtering difficulties occasionally encountered in the mill treatment. Biotite, serpentine and carbonate minerals are present in the dyke samples and chlorite in the basement rock. These minerals along with pyrrhotite, iron oxides, brannerite and uraninite, present in the ore conglomerate, probably account for most of the acid consumed. Silica and alumina residues resulting from the decomposition of silicates in the acid circuit may impede settling and filtering of the pulp.

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INTRODUCTION

At the June 18/59 meeting of the Canadian Uranium Producers' Metallurgical Committee it was suggested that mineralogical and leaching investigations be carried out to learn the cause of increased acid consumption, and poor filtering and settling conditions which occur in some of the Elliot Lake mills when the feed contains basement rock or diabase dyke rock. It was decided that samples of the refractory ore types from Can-Met Explorations Ltd., and Milliken Lake Uranium Mines Ltd., would be investigated by the Extraction Metallurgy Division of the Mines Branch.

Accordingly, the following rock samples were received from Milliken Lake Uranium Mines Ltd., and were assigned the reference number 9/59-9.

TABLE 1
Submitted Samples

Sample	Sender's Label	Type of Sample	Approx. Wt. lb
A	Diabase-centre of dyke	lump	40
B	Chilled diabase-small dyke	lump	40
C	Greenstone	lump	40
D	Conglomerate-good ore	minus 3/4 in.	90

The purpose of the present investigation was to determine the mineralogical composition of the four samples and, more particularly, to attempt to identify the acid-consuming minerals, and those minerals in the non-ore types of rock which are responsible for filtering and settling difficulties. This report gives the results of the mineralogical examinations carried out on specimens taken at random from each of the submitted samples.

Chemical analyses of representative head samples gave the results shown in Table 2.

TABLE 2
Chemical Analyses

Sample	Analysis No.	U ₃ O ₈ %	Fe %	Al %	Ti %	CO ₂ %	
						Combustion	Evolution
A	R 4137	0.002	6.20	4.57	0.84	4.67	4.49
B	R 4138	0.013	5.38	4.30	0.70	7.91	7.86
C	R 4139	0.001	7.59	14.21	1.88	0.28	0.11
D	R 4171	0.099	4.19	3.93	0.15	0.51	0.16

ROCK COMPOSITION

Sample A. Diabase - centre of dyke

Microscopic study of thin sections of the dark greenish-grey "diabase dyke" rock shows that it is a fine grained altered lamprophyre. It consists mainly of biotite mica, augite, olivine, carbonate minerals and serpentine (Figure 1). The flakes of biotite are occasionally bleached in the interior. Augite occurs as prismatic crystals which, to varying degrees, are altered to serpentine and carbonate mineral. Olivine occurs as euhedral crystals, and often as phenocrysts, and is usually partially or completely replaced by pseudomorphs of serpentine and carbonate. Calcite is the main carbonate mineral in the rock but a small amount of dolomite is also present. Some calcite appears, in thin sections, as cloudy elongated areas which probably result from the alteration of original plagioclase feldspar. Calcite also occurs in narrow veins, often with fibrous serpentine. Accessory minerals in the rock include apatite, sphene, pyrite and a fine-grained opaque mineral believed to be magnetite.

Sample B. Chilled diabase - small dyke

Microscopic study of this sample shows that it consists mainly of dark grey lamprophyre rock which is similar in mineralogical composition to that of the previous rock examined (Sample A). In addition, a small proportion of conglomerate rock and quartzite is included in the sample, attached to the lamprophyre.



Figure 1. Thin section of lamprophyre dyke rock, to show occurrence of olivine (ov), biotite (bi), augite (aug) and calcite-serpentine intergrowth (calc-serp). A 200-mesh screen opening is outlined.

As compared to the previous lamprophyre rock, described above, the small dyke rock is finer grained and contains a higher proportion of carbonate mineral (mainly calcite). The proportions of the other major mineral constituents are about the same in the two varieties of lamprophyre.

Dolomite occurs in narrow borders of very fine grained chilled rock in the lamprophyre which form a sharp contact adjacent to conglomerate or quartzite. Against conglomerate this border is dull

white in colour and against quartzite, dark grey. The conglomerate rock is light yellow due to sericite and the quartzite rock is pink due to the presence of fine hematite. Both rocks consist essentially of quartz and a small amount of feldspar cemented by sericite. A small proportion of pyrite is present in the conglomerate and a trace amount in the quartzite. Occasional veins of dark green fibrous serpentine cut the quartzite.

Microscopic examination of polished sections of the attached conglomerate in this sample shows that it contains brannerite and a smaller amount of uraninite. Pyrite is the main sulphide mineral in the conglomerate and it is occasionally altered to hematite. Small amounts of marcasite and chalcopyrite are intergrown with the pyrite.

Sample C. Greenstone

This sample consists of a very fine grained rock composed mainly of sericite and chlorite. The rock is perhaps better referred to as sericite schist. Abundant fine grains, of ilmenite and of anatase, which are usually 10-20 microns in size, are also present in the rock.

Sample D. Conglomerate - good ore

Quartz pebble conglomerate rock constitutes most of Sample D. The conglomerate consists mainly of quartz grains, and a minor proportion of microcline feldspar, in a matrix of smaller grains of these minerals and sericite. Sulphide minerals and radioactive

minerals as well as trace amounts of zircon and magnetite are also present in the matrix.

The quartz grains are usually colourless but some are grey to black. Cherty grey or black pebbles consist of a mosaic of fine quartz. Feldspar grains in the matrix often have corroded edges. Where the sericite content is high the rock has a yellowish colour.

Sulphide minerals are concentrated in certain areas of the conglomerate and are absent or rare in other areas. Generally those areas which contain higher proportions of sulphides also have higher contents of radioactive minerals. On the surface of specimens of the conglomerate, thin rusty friable coatings are often present on or near grains of sulphide mineral. These coatings, which probably result from the oxidation of iron sulphide, are readily soluble in strong sulphuric acid.

Microscopic examination of polished sections shows that pyrite is the most abundant sulphide mineral in the conglomerate. A small amount of pyrrhotite occurs as discrete irregular grains or intergrown with pyrite (Figure 2). The pyrite:pyrrhotite ratio as determined by traversing six sections is approximately 23:1. Thus pyrrhotite constitutes about 4% by weight of the sulphides in the conglomerate. Other sulphides are present in trace amounts only and include chalcopyrite, galena, marcasite and, possibly, cobaltite.

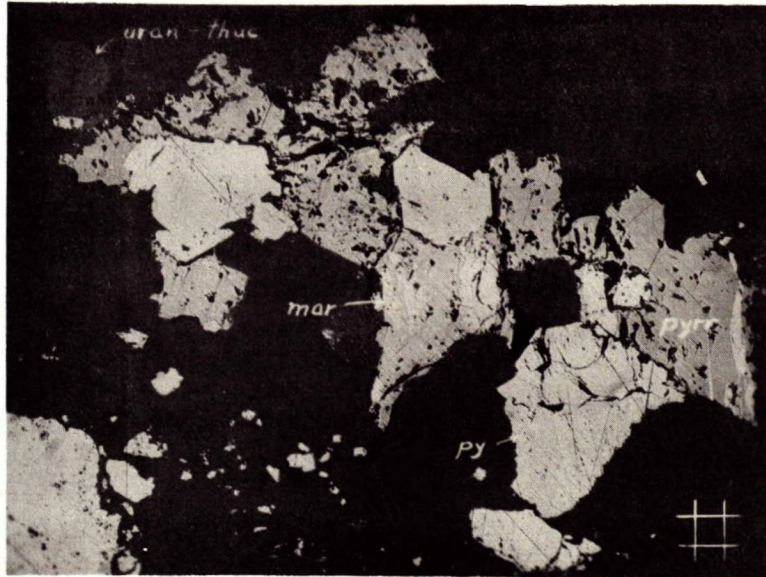


Figure 2. Intergrowth of sulphide minerals containing pyrite (py), pyrrhotite (pyrr) and marcasite (mar). A grain consisting of uraninite intergrowth with thucholite (uran-thuc) is also present. A 200-mesh screen opening is outlined.

Alpha-track autoradiographs of polished sections show that most of the radioactivity in the ore is due to brannerite and uraninite. The relative abundance of these minerals varies from specimen to specimen. A small amount of monazite is also present.

Brannerite occurs in irregularly-shaped to rounded grains (see Figures 5, 6) and, to a lesser extent, as disseminations in the matrix. Some grains are compact masses but most are aggregates of brannerite with varying proportions of rutile, anatase, gangue

mineral and sulphides. The brannerite in these aggregates at times appears as fine, prismatic crystals. Most of the brannerite grains observed are in the size range 65-150 mesh, and the coarsest grains present are about 48 mesh in size. In addition to the discrete grains some brannerite occurs as short streaks and films in gangue mineral, often with fine inclusions of sulphide minerals (Figure 3). Some weakly radioactive areas consist of fine grained quartz-sericite rock which contains extremely fine disseminated radioactive grains which are possibly brannerite-anatase intergrowths. A concentration of such grains is shown in Figure 4.

Photomicrographs

Figures 3-8 are photomicrographs of polished sections to show the occurrence of the radioactive mineral constituents in the conglomerate. A 200-mesh opening is outlined on each photomicrograph.

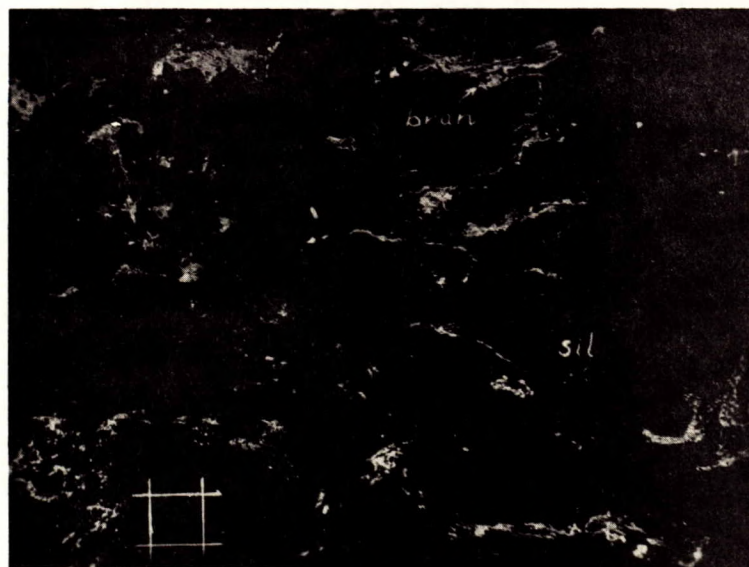


Figure 3. Streaks of brannerite (bran) in siliceous gangue (sil).

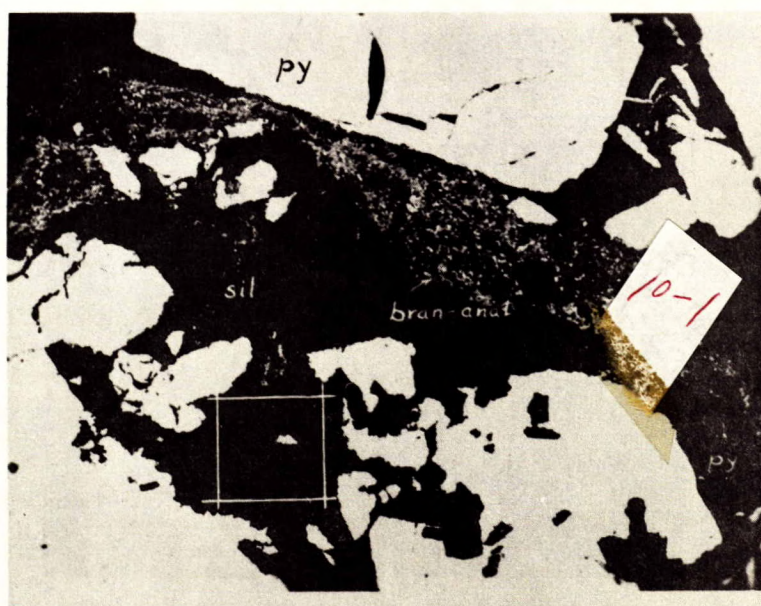


Figure 4. Disseminated intergrowth of brannerite-anatase (bran-anat) in siliceous gangue (sil) adjacent to grains of pyrite (py).

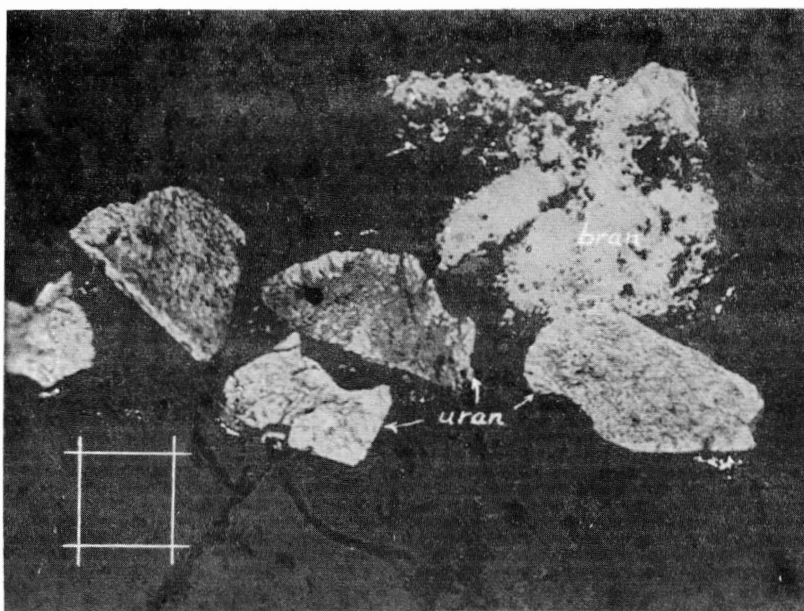


Figure 5. Subhedral grains of uraninite (uran) and an irregular area of brannerite (bran).

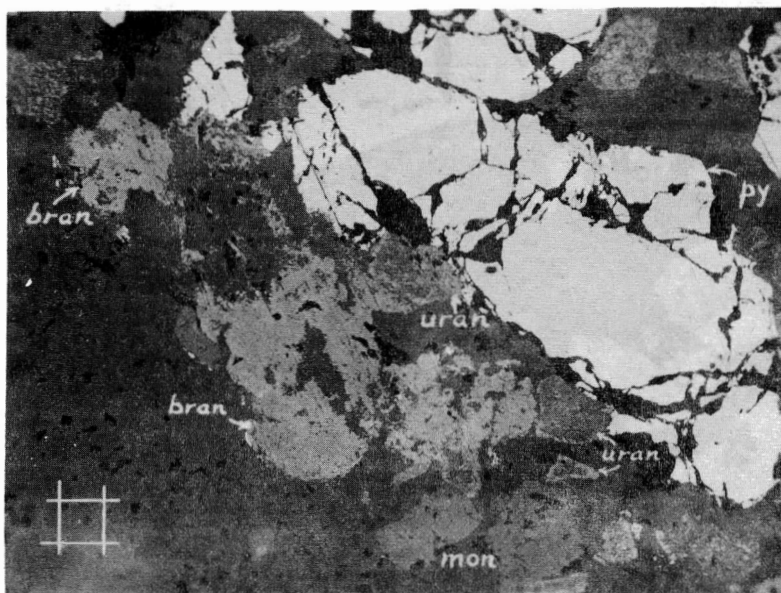


Figure 6. Concentration of radioactive grains, uraninite (uran), brannerite (bran) and monazite (mon) adjacent to pyrite (py).

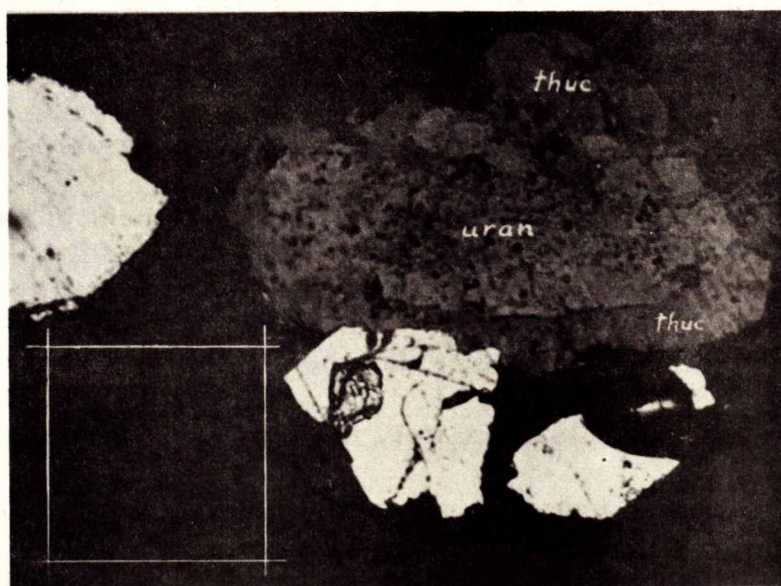


Figure 7. Thucholite (thuc) replacing uraninite (uran).

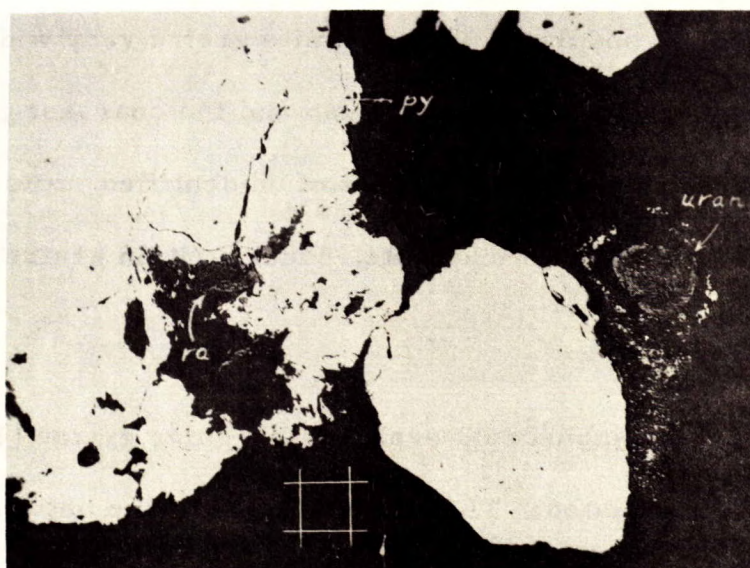


Figure 8. Radioactive mineral (ra) within grain of pyrite (py), and an altered grain of uraninite (uran).

Uraninite occurs both as isolated subhedral to anhedral grains and as clusters (Figure 5). The grains of uraninite often occur near grains of brannerite and monazite (Figure 6). The uraninite is frequently intensely fractured and altered and commonly only a rim of unaltered mineral remains (Figures 5, 6, 8). Replacement of part or most of the uraninite grain by hydrocarbon (usually referred to as "thucholite") is common: in some grains the thucholite is attached (Figure 7), and in others it is intimately intergrown with the uraninite (Figure 2). Fractures in uraninite are often rich in galena. The radioactivity of the uraninite grains varies considerably depending on the extent of alteration and replacement - unaltered grains are the most strongly radioactive. Thucholite appears to be only feebly radioactive and grains in which uraninite has been largely replaced by thucholite tend to be nodular. The uraninite grains vary widely in size but most are in the range 150-325 mesh and the coarsest grain is about 65 mesh in size. A small amount of unidentified radioactive mineral, believed to be altered uraninite, occurs within grains of pyrite (Figure 8).

Monazite occurs as subhedral, oval, or irregular grains (Figure 6) which at times are brecciated. The grains range in size between 65 and 200 mesh and appear to contain little or no radioactivity.

Also in Sample D, in addition to the quartz pebble conglomerate, minor amounts of two other types of rock were observed. Only one

specimen of a dark green fine grained rock was noted. It is similar in composition to the lamprophyre rock of Sample B, and is highly altered to talc and carbonate and is veined by carbonate. Also present in Sample D is a small amount of friable, black, magnetic material which occurs in flakes, usually with good parting and showing rusty surfaces. It consists of an intergrowth of iron oxide minerals, mainly goethite and magnetite (or maghemite). This magnetic material may occur as a selvage in fractures in the rock, but none was observed, in the submitted material, attached to specimens of conglomerate.

DISCUSSION AND CONCLUSIONS

Sample A and Sample B consist of lamprophyre rock which is rich in ferromagnesian minerals, biotite, augite, olivine, and in secondary minerals, serpentine and carbonate, produced by the alteration of augite, olivine and possibly plagioclase feldspar. If subjected to sulphuric acid treatment it is probable that biotite, serpentine and carbonate would be affected: carbonate would dissolve and biotite and serpentine would be decomposed. Olivine, too, might react with sulphuric acid. The basement rock Sample C, consists of sericite schist which contains a high proportion of chlorite. Chlorite is known to react with sulphuric acid. Thus the presence of higher-than-average amounts of lamprophyre dyke rock or chloritic

basement rock in the mill feed would account for excessive consumption of acid. Also, subsequent settling and filtering difficulties in the mill treatment of such ores may be due to the residues of silica, and possibly alumina, left by the decomposition of the silicates.

In clean quartz pebble conglomerate ore the main acid-consuming minerals are probably pyrrhotite, iron oxide minerals formed by the oxidation of sulphides, and the radioactive minerals, brannerite and uraninite. The inclusion of lamprophyre rock, as was observed in Sample D, would probably affect acid consumption in proportion to the extent of dilution of the conglomerate. Iron oxide material, such as the magnetic flakes noted in Sample D, might have the same effect.

Some of the refractory uranium remaining in leach tailings is probably due to the presence of fine grains of radioactive minerals locked in siliceous gangue, in pyrite, and in anatase or rutile.