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A FURTHER REPORT ON THE MINERALOGY OF BACTERIAL LEACH RESIDUES, DENISON MINES LTD., ELLIOT LAKE, ONTARIO

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M.R. HUGHSON AND S. KAIMAN

EXTRACTION METALLURGY DIVISION

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SUMMARY

Bacterial leach solutions have permeated only a short distance into minus 1 inch, plus 4 mesh ore from Denison Mines Ltd. after 19 weeks of treatment. This is shown by the effect of the leach solutions on grains of pyrite: only those grains within 3 or 4 millimetres of the surface of the ore chips are altered. The major proportion of the uranium extracted by the leaching appears to have come from the dissolution of crystals of uraninite in the outer parts of the chips. Brannerite-bearing grains appear to be only a minor source of uranium in this coarser fraction of ore. Other radioactive minerals appear to be unaffected by the leach solutions.

*Scientific Officer and **Head, Mineralogy Section, Extraction Metallurgy Division, Department of Mines and Technical Surveys, Mines Branch, Ottawa, Canada.

INTRODUCTION

A previous mineralogical investigation of bacterial leach residues of ore from Denison Mines Ltd. (Mines Branch Investigation Report IR 65-64) indicated that after 19 weeks the leach solutions had pervaded the conglomerate ore grains and had completely altered brannerite and uraninite in minus 4, plus 8 mesh material. At the request of Mr. V.F. Harrison a further study to compare the effect of bacterial leaching on uranium and sulphide minerals in a coarser fraction of ore was made on minus 1 inch, plus 4 mesh material leached for 19 weeks.

MINERALOGY

Preliminary microscopic examination of the minus 1 inch plus 4 mesh residue showed that it has a weathered appearance similar to that of the finer residue samples. The quartz-sericite matrix of the ore chips is covered in most places with a pale yellow, earthy material while the quartz pebbles are unaffected. Exposed grains of pyrite are scarce: where present they usually have a tarnished appearance.

Autoradiographs were prepared by contacting polished surfaces of the ore chips with alpha-sensitive plates for 212 hours. Radioactive grains were located by comparing the polished sections with the autoradiographs and were examined with an ore microscope. All mineral identifications were confirmed by X-ray diffraction methods.

Much of the radioactivity occurs in grains which consist of intergrowths of rutile, anatase and quartz (Figure 1). Small amounts of apparently unaltered brannerite are present in some of these grains (Figure 2). However, in one such grain in which brannerite is exposed at the surface of the ore chip (Figure 3) alteration of the brannerite appears to have been effected to a depth of approximately 60 microns. Present in smaller numbers are massive mottled grey grains of brannerite (Figure 4) and dense aggregates of lath-like brannerite crystals (Figure 5). These grains are usually rimmed by a zone of anatase which varies greatly in width: this is similar to what is observed in the original ore.

A few relict crystals of uraninite are present and most of these occur in small clusters near the centres of the ore chips (Figure 6). The rare crystal of uraninite near the edge of a chip shows considerable alteration (Figure 7). Rounded grains of monazite or brecciated fragments of such grains are common (Figures 6 and 8). A few dark grey subtranslucent grains of uranothorite are present (Figure 8). Small metallic inclusions believed to be pyrite commonly occur in grains of monazite and uranothorite (Figures 6 and 8) and in some grains of brannerite (Figure 4).

Alteration of the pyrite is greatest around those grains at or near the edges of the ore chips. Approximately three or four millimetres within the ore chip the pyrite grains are unaltered. Pyrite grains near the edges of the ore chips are commonly deeply serrated and are surrounded by an amorphous grey layer about 5 microns thick (Figure 9). Only a few grains of pyrrhotite, chalcopyrite, and galena were observed and these occur less than 1/2 mm from the edge of the ore chip. Pyrrhotite appears to show incipient alteration (Figure 10) but chalcopyrite and galena are unaltered.

PHOTOMICROGRAPHS

The conglomerate matrix of the ore chips consists chiefly of quartz and sericite and is labelled qtz-ser in the photomicrographs.

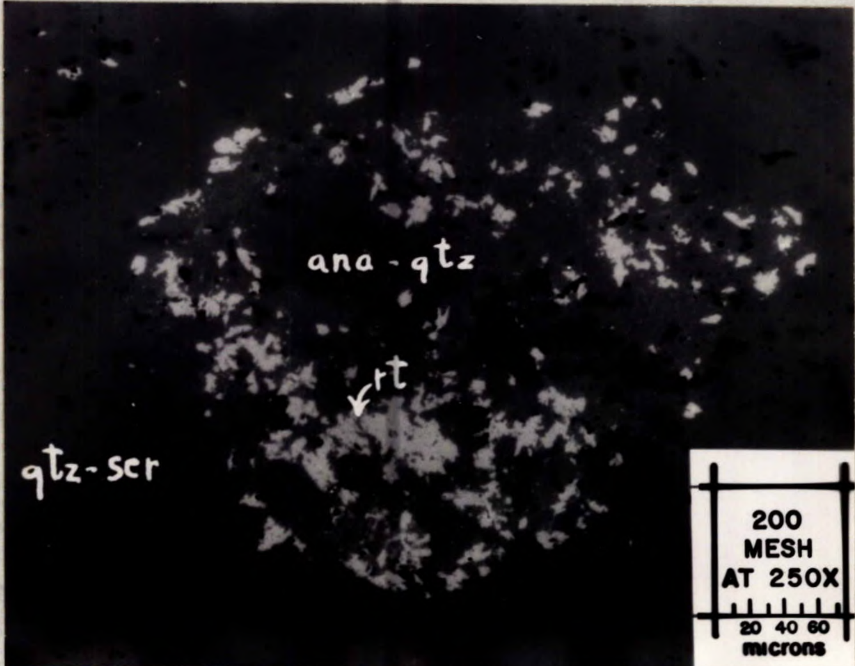

Figure 1. A uranium-bearing grain of rutile (rt), anatase and quartz (ana-qtz).

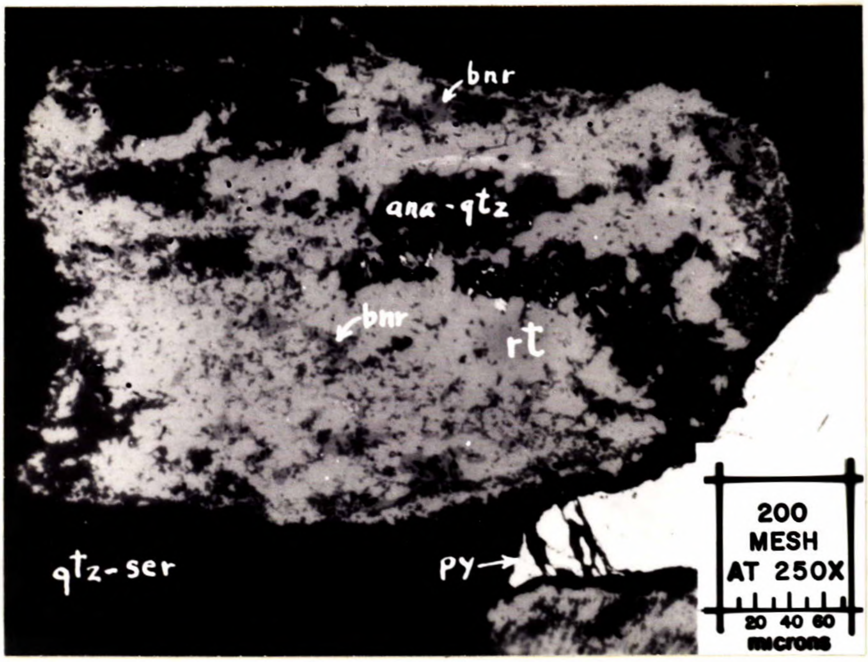

Figure 2. Brannerite (bnr) in a grain of rutile (rt), anatase and quartz (ana-qtz). Pyrite (py) is present.

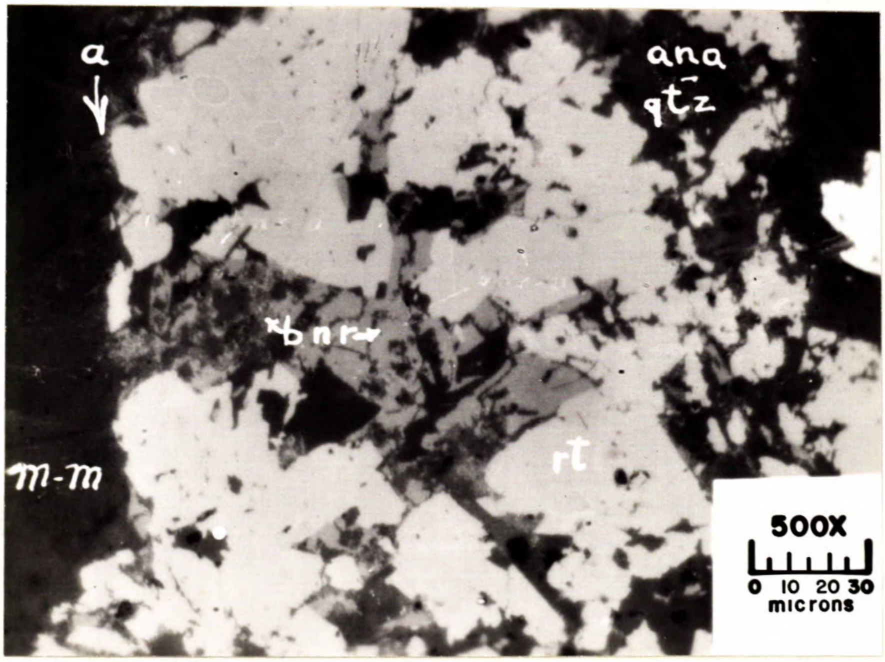

Figure 3. Brannerite (bnr) altered to a depth of approximately 60 microns from the edge (a) of a grain consisting of rutile (rt), anatase and quartz (ana-qtz). The mounting medium is marked m-m.

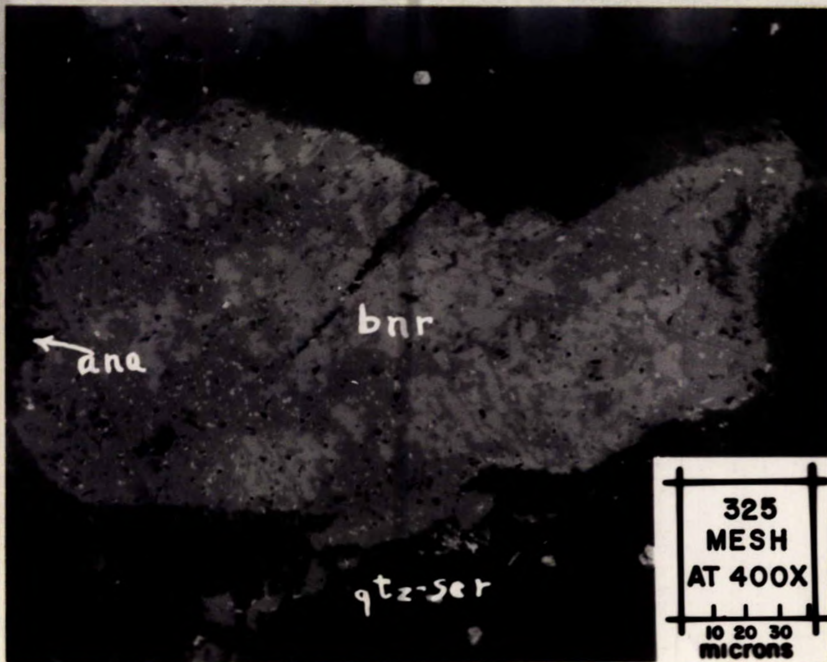

Figure 4. A massive, mottled grey grain of brannerite (bnr) rimmed by anatase (ana).

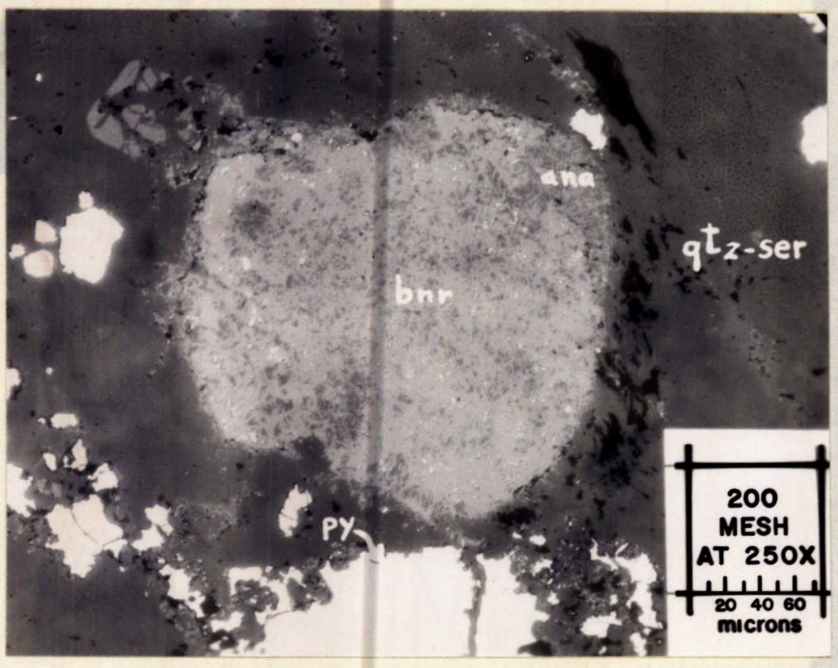

Figure 5. A dense aggregate of lath-like crystals of brannerite (bnr) with a rim of anatase (ana). Grains of pyrite (py).

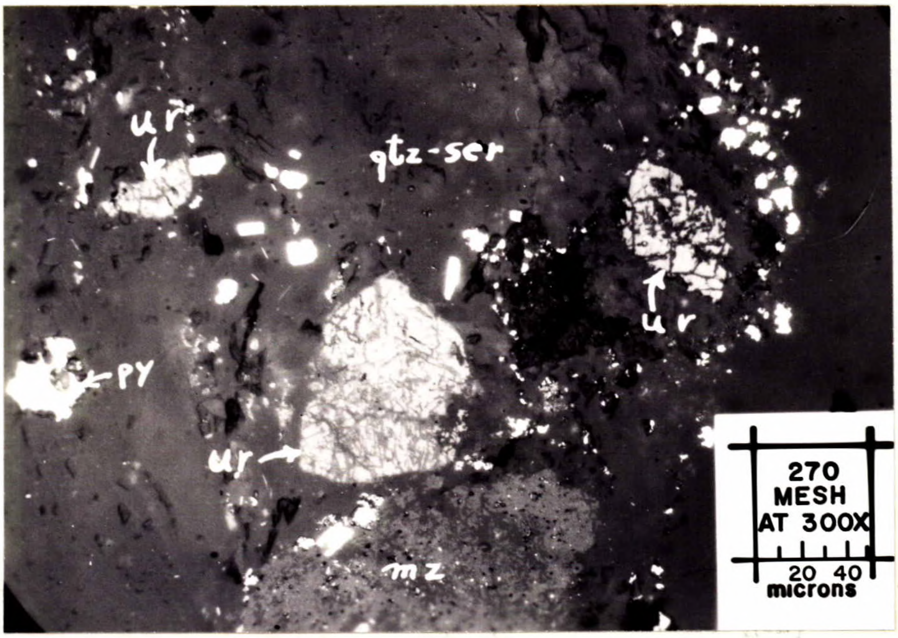

Figure 6. Relict crystals of uraninite (ur) near the centre of a chip. Monazite (mz) and pyrite (py) are also present.

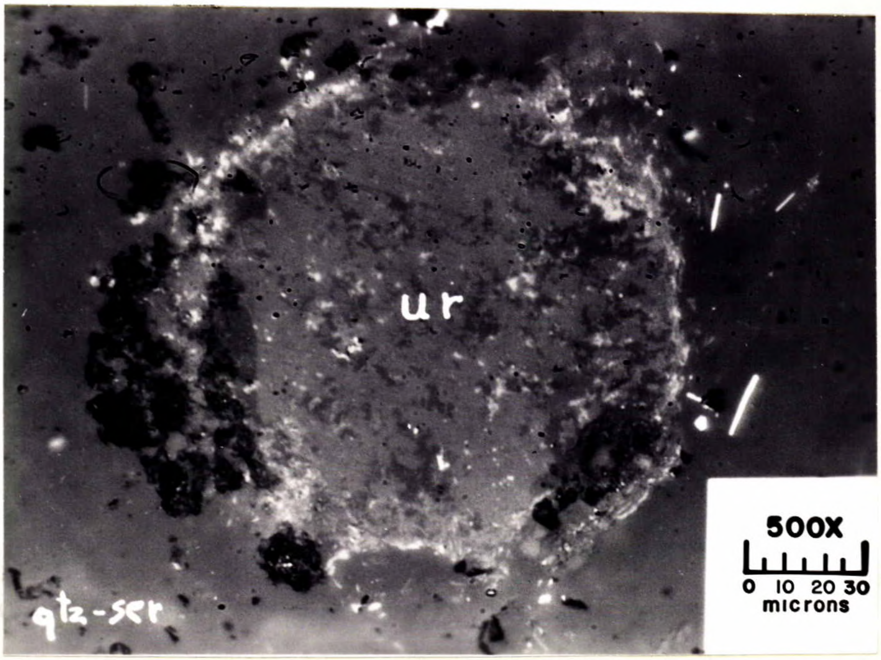

Figure 7. An altered crystal of uraninite (ur) near the edge of a chip.

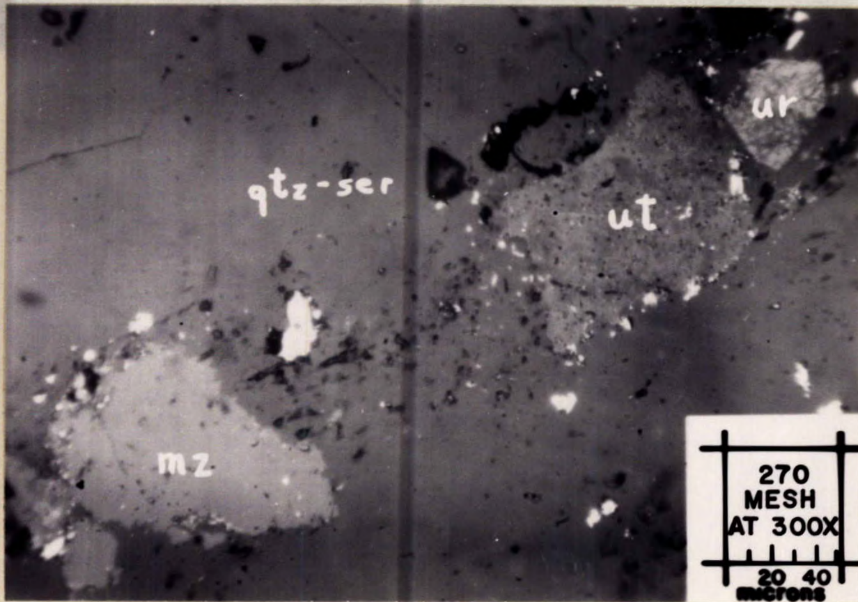

Figure 8. Radioactive grains include monazite (mz), uranothorite (ut), and uraninite (ur).

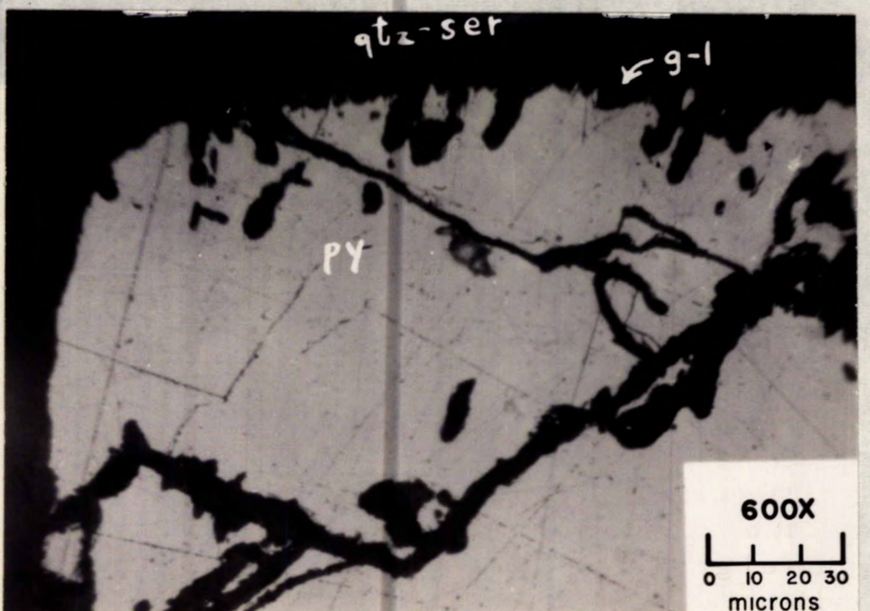

Figure 9. Pyrite (py) near the edge of a chip showing serrated edges and surrounded by an amorphous grey layer (g-1).

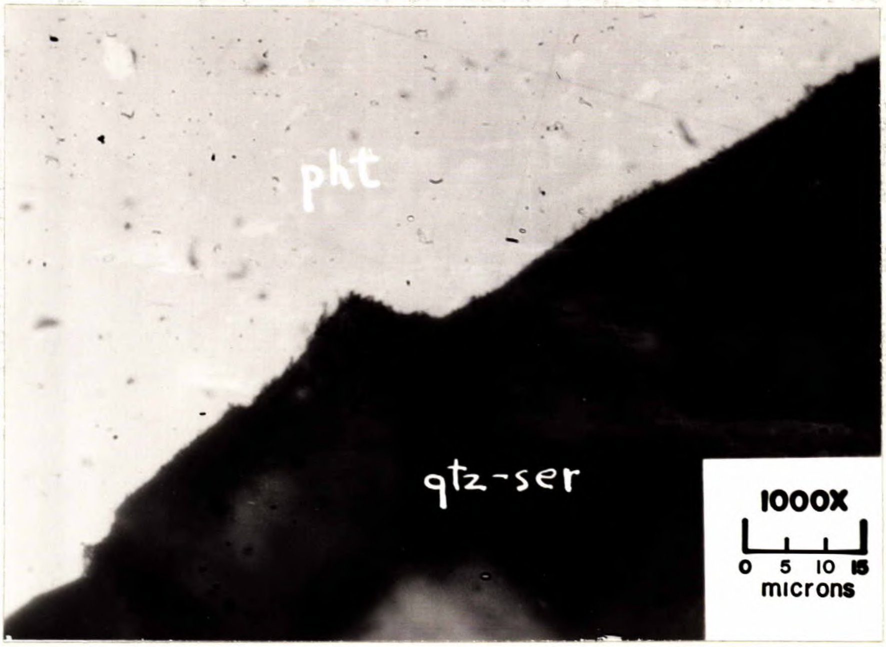

Figure 10. Edge of a grain of pyrrhotite (pht) showing incipient alteration.

DISCUSSION AND CONCLUSIONS

The uranium extraction effected by bacterial leaching of minus 1 inch plus 4 mesh ore after 19 weeks of treatment amounts to only 41.5 per cent as compared to 64.4 per cent from minus 4 mesh plus 8 mesh and 86.5 per cent from minus 8 plus 14 mesh ore. The present study shows that with the coarse material the uranium has come mainly from the outer few millimetres of the ore chips and chiefly from the dissolution of uraninite. That the leach solution has penetrated only a short distance into the ore chips is indicated by its effect on pyrite. Alteration is most pronounced in such grains at or near the edges of the chips and gradually decreases with depth: unaltered grains of pyrite are found at a depth of 3 or 4 millimetres. Further evidence of limited penetration by the leach solution is afforded by the presence of occasional clusters of uraninite crystals in the central parts of the ore chips whereas only rarely are uraninite grains observed near the edges of the ore chips and these grains are extensively altered. This also indicates that uraninite is a major source of the uranium extracted from the present sample.

The nature of occurrence of brannerite with anatase in the leach residue is similar to that observed in unleached ore. The presence of rims of anatase around grains of brannerite is therefore not unequivocal evidence of leaching of brannerite by the bacterial leach solution. Indeed, in one brannerite-bearing grain exposed on the edge of a leached ore chip, the alteration of the brannerite which has penetrated to a depth of about 60 microns was not necessarily caused by bacterial leaching. It may therefore be concluded that the bacterial leach solution has had at most only a minor effect on the brannerite grains and that brannerite has contributed only a small proportion of the uranium in solution after 19 weeks of leaching. Monazite and uranothorite show no evidence of alteration from the leaching. Of the sulphides other than pyrite, only pyrrhotite shows evidence of slight alteration.

MRH:SK:MN