AUSTRALIAN NUCLEAR SCIENCE
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A REPORT TO LAGOON CREEK RESOURCES

on

THE EXTRACTION OF URANIUM FROM THE WESTMORELAND DEPOSITS

by

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EXECUTIVE SUMMARY

ANSTO has previously carried out extensive leaching testwork and mineralogy on ore samples from several deposits in the Westmoreland area in 1992-1995. Solvent extraction (SX) and ion exchange (IX) were briefly tested and column leach testing was undertaken to assess the amenability of the ore to heap leaching. More recently, Lagoon Creek Resources has acquired the major interest in the Westmoreland tenements and ANSTO Minerals was requested to undertake a metallurgical test program on the extraction of uranium from four composite lens samples (Junnagunna, Redtree Upper, Redtree Lower and Jack) of the Westmorland deposit.

The overall aim of this work was to obtain data on process options for the recovery of uranium. A conceptual design flowsheet, which comprises conventional acid leaching followed by IX or SX and uranium product recovery, was examined in this test program.

The major findings from the testwork program are as follows:

Sample Characterisation

- Samples were obtained from HQ drill core from Laramide's 2008 drilling program which focused on the Redtree and Junnagunna deposits, in particular the Upper and Lower Garee lens and Jack Lens of the Redtree deposit and the steeply dipping structurally controlled lenses at Junnagunna. ANSTO was advised that the samples obtained were chosen to be geologically and mineralogically representative of drill intervals that intersected these lenses, which have been modelled as distinct domains within the resource model.
- Composite ore samples of Junnagunna, Garee lower lens, Garee upper lens and Garee (Redtree) composite contained uranium grades of (1370 ppm, 1860 ppm, 1380 ppm and 1700 ppm U_3O_8, respectively. The Jack lens composite sample had a lower grade of 929 ppm U_3O_8. The grades of the Junnagunna and Garee samples are greater than the average quoted for the deposit of 900-1000 ppm U_3O_8. Major gangue elements in the 4 composite ores decreased similarly in the order of Si > Al > Fe > K > Sr > Ca = Mg > Ti. All samples were low in sulphides (≤ 0.04%) and total carbon (≤ 0.06%);
- Given the competent nature of the ore, which produced few fines during crushing, the plan to examine scrubbing as an option was not tested as it was not expected to be successful, in terms of liberation and further breakdown;
- The size by size analysis of each composite sample of crushed rock over the range 1-19 mm indicated that uranium was uniformly distributed in each size fraction, in proportion to the sample mass distribution, with a slight enrichment in the < 1 mm fraction. Therefore, upgrading of ore could not be achieved by a size based separation;
- The uranium in the Junnagunna and Redtree composites ground to a P_{80} of 250 μm was concentrated in the fines, with uranium concentrations in the < 38 μm fines of 2580 and 3150 ppm U_3O_8 for Junnagunna and Redtree, respectively. The < 106 μm fractions of both ores represented about 40% of the total mass, but contained 65 and 57% of the uranium;

- Quantitative XRD indicated that quartz was the dominant gangue mineral in all ore samples. Its relative concentrations varied from 88 to 92 wt%. The minor constituents (less than 5% each) were illite, hematite, jarosite, chamosite and hydroxylapatite. Chamosite (Fe rich chlorite), an acid consuming mineral, was found in four ores, whereas hydroxylapatite was detected only in Junnagunna ore. The uranium-bearing minerals were not abundant enough to be detectable by XRD;
- SEM analysis on leach residues showed other gangue minerals such as rutile/anatase (TiO_2), zircon ($ZrSiO_4$), monazite ($(Ce,La,Nd,Th)PO_4$), florencite ($(Ce,La)Al_3(PO_4)_2(OH)_6$), pyrite ($FeS_2$), galena (PbS), iron copper sulphide, copper sulphide and barite ($BaSO_4$) were also present in the samples.

Leaching Studies

The Garee lower and upper lens samples were blended to form a Garee (Redtree) composite for leaching. The compositions of the three samples leached are compared in the table below (in wt%).

Sample name	U_3O_8 (ppm)	Sulphide S	Total Carbon	Al	Ca	Fe	K	Mg	Si
Junnagunna	1370	0.04	0.04	1.53	0.104	1.10	0.61	0.14	43.6
Garee (Redtree) Composite	1700	0.02	0.04	1.38	0.041	1.52	0.55	0.073	42.6
Jack Lens	929	0.02	0.01	1.05	0.033	0.75	0.44	0.018	43.6

Dilute leaching tests on pulverised ore under ideal leach conditions designed to determine the limit for extraction showed that the uranium mineralisation was very amenable to leaching, with extractions of 98.6-99% achieved for the Junnagunna and Redtree samples. Extraction from the lower grade Jack ore was 97.6%. Compared to other ores tested by ANSTO Minerals, the concentrations of ions dissolved were low, decreasing in the order Si>Al≈Ca>K>Mg. Gangue dissolution was greatest for Garee Lower lens, and lowest for Jack Lens, noting that Fe dissolution cannot be estimated because iron was added to the leach solution.

The Junnagunna and Redtree samples were readily leached under conventional leaching conditions (55 wt% solids, 40 °C, pH 1.5, P_{80} of 250 µm and ORP of 500 mV), achieving uranium extractions of 96.5-97.5% after 24 h. As very little uranium dissolution occurred between 12 and 24 h, a 12 h leaching time would be sufficient. The rate of leaching of uranium also responded to ORP, and an ORP of 550 mV is recommended. For these conditions uranium extraction was 97% for both ores, with acid additions of only 18 and 14 kg/t for Junnagunna and Redtree, respectively. Predicted pyrolusite requirements were also low at 3.0-3.1 kg/t for both ores.

Under base conditions, the extraction of uranium from the Jack ore sample was 87%, considerably less than the dilute leach result of 97%. Addition of 0.5 g/L Fe to the leach increased extraction to 91-91.5% after 24 h. Further work is recommended to identify conditions that could further increase extraction from the Jack ore. Reagent requirements for Jack ore were very low, less than half those for the Redtree composite.

The optimisation tests on the Junnagunna and Redtree samples showed that:

- Varying the P_{80} grind sizes in the range 350 - 75 μm had negligible impact on uranium extraction and acid addition. Finer grinding resulted in faster initial uranium leaching kinetics, but a similar effect can was achieved by increasing the ORP. Grinding to a P_{80} of 350 μm significantly reduced the rate of uranium extraction up to about 12 h. On this basis a P_{80} of 250 μm would probably be selected to target a 12 h leach time.
- Leach pH over the range 1.3 – 1.7 had little impact on uranium recovery for Junnagunna ore. At pH 2, extraction was reduced by 1% to ~ 96%. For the Redtree sample, the 24 h extraction increased from 92% to 98% when the leaching pH was decreased from pH 2.0 to pH 1.3. The pH also had an impact on the initial leaching rate. The optimum pH for both ores was 1.5, or perhaps slightly lower for Redtree;
- Acid addition was low for both ores, ranging from 10-25 kg/t and 10-20 kg/t for Junnagunna and Redtree, respectively, for all conditions examined;
- The pyrolusite requirement for both ores was ~3.0 kg/t for optimum leach conditions. Note, the use of potassium permanganate and pyrolusite as oxidants produced equivalent results;
- The uranium leaching rate increased with increasing temperatures from 30°C to 50 °C. For both ores, leaching at 30 °C significantly decreased the extraction rate, and to a lesser extent, the final extraction of uranium. The initial rate of leaching was reduced at 40 °C, but extractions were quite similar to those at 50°C after 12 h. Although temperature has a significant effect on the initial extraction rate, there was also a significant relative increase in the acid addition. The optimum temperature appeared to be ~ 40 °C;
- For both samples, similar final (24 h) uranium extraction results were achieved for leaching at ORP levels of 500-550 mV. Uranium extraction decreased significantly when leaching at 450 mV. Addition of 0.5 g/L ferric ion at 500 mV had a slight impact on the rate of extraction, but there was little difference after 12 h. A similar result was achieved by leaching at 550 mV, and this approach would be preferred to adding iron. For both samples, there was a significant increase in demand for oxidant to increase the ORP from 450 to 500 mV, but only a further small addition was required to achieve 550 mV. The oxidant demand for both samples was very similar for both samples. The optimum ORP is considered to be 550 mV;
- For both the Junnagunna and Redtree ores, sizing of leach residues from base case conditions showed that high uranium extractions were obtained for all size fractions, with extraction decreasing slightly in the three coarsest fractions (> 150 μm). Residue grades were greatest, marginally, for the three finest fractions (< 53 μm).

The limited tests carried out on the Jack ore sample showed that:

- Under base conditions, the extraction of uranium from the Jack ore sample was 87%, considerably less than the dilute leach result of 97%, and significantly less than the 96-97% extraction from the other two samples under base case conditions. This result could be due to the very low ferric ion concentration (0.2 g/L) in the Jack leach liquor;

- Addition of 0.5 g/L Fe, leaching at pH 1.2, and leaching at a finer grind of P_{80}=150 µm at pH 1.5 with addition of Fe, all increased the extraction from 87% for base case conditions to 91-91.5%, after 24 h;
- Optimum conditions for the Jack sample would either be leaching at pH 1.2, with other conditions at base case, or leaching at pH 1.5, with addition of 1.0 g/L Fe. Note that the latter conditions may occur if Jack ore was blended with either Junnagunna or Redtree because of the amount of iron dissolved from these ores;
- Further work is recommended to identify conditions that could increase extraction from the Jack ore;
- Reagent requirements for Jack ore were very low, less than half those for the Redtree composite.

Leach Liquor Composition

- For the Junnagunna and Redtree ores, iron was the dominant ion in solution. For the Junnagunna ore the concentrations of elements in solutions generally decreased in the order:

$$Fe>Al>Si>Ca>Mg\approx K>P>As$$

- The Redtree ore contained about 6 times the level of arsenic than the Junnagunna ore, hence the much higher arsenic levels in solutution. For the Redtree ore the concentrations of elements in solution generally decreased in the order:

$$Fe>Al>Si>Ca\approx As\approx K\approx Mg>P$$

The following general impacts of leach variables were evident:

- The concentrations of all elements, except K, increased with decreasing pH;
- The concentrations of all elements, except Ca and P, increased with increasing temperature;
- Grind size had little impact on the concentrations of gangue elements in solution;
- The concentrations of all elements increased with increased leaching time;
- The concentrations of all elements were marginally greater in the Junnagunna liquor compared to Redtree (expect for As), which was reflected in the acid requirement;
- None of the major gangue element concentrations in solutions would be expected to result in downstream processing problems. The Si concentrations were typical of many of the acid uranium leach liquors that are currently being processed, but noting that it is the form of the silica, rather than the total concentration, that results in silica problems;
- Ferric concentrations were reasonably high for Junnagunna and Redtree, which is a positive for leaching, but will result in some degree of iron loading if IX is used for uranium recovery. Iron concentrations were quite low for Jack Lens;

- The concentrations of all ions, except for P and Ca, were considerably less in the Jack liquors, as reflected by the very low acid requirement;
- The concentrations of the minor elements that could report to final product as penalty elements, eg Mo, V, Zr, were low. Arsenic was present at 40-180 mg/L for Redtree ore and may warrant additional attention in regards to waste water treatment. However, the arsenic levels in solution when the Redtree was combined with Junnagunna and Jack was lower at ~100 mg/L. It is likely that the vast majority of arsenic will precipitate as ferric arsenate during a neutralisation process. However, this still has to be proven.

Settling Tests

Preliminary settling tests on Junnagunna and Redtree leach slurries at a grind of P_{80} = 250 µm showed that the ores had similar settling properties. The preliminary flocculant and thickener requirements indicate that solid/liquid separation by settling would be applicable. Further optimisation was carried out in the bulk leach test work phase.

Unleached Uranium

The residual uranium minerals in the leach residues from Junnagunna, Redtree and Jack ores consisted of coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$), uranium phosphate, probably phosphuranylite ($KCa(H_3O)3(UO_2)_7(PO_4)_4O_4{\cdot}8(H_2O)$), and uraniferous zircon, where coffinite was the most common uranium mineral. The uranium minerals were almost always enclosed in quartz particles. Various amounts of arsenic were detected in most uranium minerals.

The major findings from the SEM examination were:

- Coffinite and a uranium phosphate similar in composition to phosphuranylite were found in all residues. Uraninite/pitchblende, uraniferous zircon and a uranium phosphate similar in composition to autunite were detected only in the residues of the Redtree and Jack samples;
- The uranium bearing minerals in the residues of Junnagunna and Redtree were enclosed within quartz, with the one exception of coffinite intimately intergrown with zircon in Redtree. They did not appear altered by leaching. It is likely that the acid solution could not penetrate the enclosing quartz, since no liberated or partially exposed uranium minerals were found. The coffinite intimately intergrown with zircon appeared to be refractory to the leaching conditions employed;
- The uranium phosphates in the residue of Jack ore were only partially dissolved, when they were exposed to the leach liquor. Their solubility was limited under the test conditions. The other uranium minerals in this residue appeared to be soluble under the test conditions, since they were detected only as inclusions in quartz. Moreover, a uraninite/pitchblende grain and a uraniferous zircon grain, which were enclosed in quartz, were partially dissolved. Their dissolution was limited by the reduced permeability of the quartz particles.

Sizing of head and leach residue for Junnagunna and Redtree ores showed that high extractions were obtained for all size fractions, with extraction decreasing slightly in the three

coarsest fractions. Residue grades were greatest, marginally, for the three finest fractions. Even though extractions were lowest for the coarsest fractions for both ores, finer grinding is not recommended as these lower extractions were a function of the reduced head grades in these fractions.

Bulk Leach

The bulk leach was conducted according to conditions selected from the optimisation studies. These parameters were:

Temperature:	40 ^{o}C
pH:	1.5
Grind size:	P_{80} 250 μm
Duration:	12 h
Oxidant:	pyrolusite
ORP:	550 mV

Approximately 60 kg of solids were used in the bulk leach. The solids were a composite of the three ores tested in the leaching studies.

The uranium extraction was 96.2%, which was higher than the expected extraction of ~95.6% (calculated from the extractions from similar tests conducted on the individual ore types). It is likely that the uranium extraction from the Jack component of the composite was higher than for the tests conducted on Jack ore due to the elevated ORP and ferric ion concentration. The uranium extraction was complete in 8 hours.

The acid and oxidant consumptions were higher than expected in the bulk leach. The acid addition, at 23.7 kg/t, was higher than in any of the previous tests with the exception of test LC4 A, which was a test on Redtree ore at pH 1.3. The oxidant addition was also higher at 6.4 kg/t. The likely reasons for the higher consumptions were due to the high ORP, and that the material for the bulk leach was ground by Metcon in a mild steel mill with mild steel balls. It is likely that some of the steel reported to the ground material and leached, consuming both oxidant and acid. The bulk leach had the highest iron level in solution of any test.

Ion Exchange Testwork

Ambersep 920 and Amberjet 4400 were used to recover uranium from the bulk leach liquor. The Ambersep represented a large bead 'resin-in-pulp' resin, which would be used for recovery directly from leach slurry, and Amberjet was used to recover uranium from clarified leach liquor after a CCD operation.

The Ambersep 920 and Amberjet 4400 resins successfully removed uranium and demonstrated uranium loadings of 45 and 78 g/L wsr, respectively, in a column loading experiment.

Both resins also demonstrated satisfactory loading and elution kinetics and were able to be completely eluted by ≤ 15 BV of eluant in a column strip experiment. In elution, iron (III) and phosphorous impurities were eluted along with uranium.

In precipitates produced by direct precipitation of uranyl peroxide from the partially neutralised eluate (from which gypsum and iron hydroxide had been removed), both iron and phosphorous were close to specification impurity limits.

Solvent Extraction Testwork

A McCabe-Thiele diagram indicated that a two stage extraction process operating at 85% efficiency, with an A/O = 4.3 was sufficient to extract 99% of the uranium from a feed of 970 mg/L U resulting in a raffinate with <10 mg/L U.

The time to achieve full phase disengagement was the same for both organic and aqueous continuous at <1 minute, though aqueous continuous was slightly faster in the first 30 seconds.

The McCabe-Thiele diagram suggests that 94% stripping can be achieved in a two stage process at an O/A = 5.4, leaving approximately 200 mg/L U in the organic phase. In practice up to three stripping stages would be used, with gradual pH control from pH 3.5 – 5.

ADU precipitation produced a product meeting most of the strict Converdyn specifications except for chloride which could be removed by better washing of the final uranium precipitate. However, under counter current solvent extraction conditions, the chloride would not load to the same extent as for the batch loading tests, which would decrease the chloride in the strip liquor and UOC product.

Conclusions

The following conclusions can be made:

Leaching

- Optimum conditions yielded 96-97% uranium extraction for Junnagunna and Garee Redtree and 91 to 91.5% uranium extraction for Jack. It is likely that further optimisation work would improve the extraction of uranium from Jack.
- The reagent consumptions were relatively low for Junnagunna and Garee Redtree, at 10-25 kg/t acid and ~ 3 kg/t pyrolusite. The reagent consumptions for Jack were less than half required for the other two ores.
- None of the gangue elements that leached, with the possible exception of As, are likely to result in difficulties in downstream processing. The Si concentrations were typical of many uranium acid leach liquors that are currently being processed.

Ion-Exchange

- Uranium can be recovered effectively using Ambersep 920 and Amberjet 4400; resin loadings of 45 and 78 g/L wsr U_3O_8, respectively, were achieved.
- Precipitation of uranyl peroxide from eluates yielded a precipitation product that compared favourably with a Cameco, Comurhex and Converdyn (upper limit) purity specifications.

Solvent Extraction

- Uranium loading of up to 4.7 g/L were achieved using a mixture of 5 vol.% Alamine 336, 2 vol.% Isodecanol in Shellsol 2046.
- The impurity load on the solvent was low and stripping with ammonia/ammonium sulphate worked well.
- ADU precipitation yielded a product meeting most of the strict Converdyn specifications.

Recommendations

- Conduct leach tests using solution either from site or a synthetic solution to simulate expected leach make-up solution;
- Conduct optimisation tests on the expected composite feed;
- Conduct downstream neutralisation testwork, on liquors generated from Redtree ore and a composite of all three ores, to ensure that the arsenic can be effectively immobilised into an iron precipitate;
- Conduct a continuous pilot operation on the expected feed composite to confirm data generated in batch tests, and to generate slurry/solution for continuous downstream piloting;
- Conduct filtration, settling and rheology test work on the product slurry from the continuous test work;
- Conduct downstream continuous test work, i.e. ion-exchange and/or solvent extraction;
- Consider tailings neutralisation treatment and recycle of liquor.

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APPENDICES

1. INTRODUCTION

The Westmoreland deposit is near the Gulf of Carpentaria located in north western Queensland, 400 km north-west of Mount Isa.

During 1992-95, ANSTO carried out an extensive mineralogical assessment and leaching testwork on samples from several deposits in the Westmoreland area. SX and IX were briefly tested and column leach testing was undertaken to assess the amenability of the ore to heap leaching.

More recently, Laramide/Lagoon Creek Resources acquired the deposit. ANSTO Minerals was requested to provide a proposal for testwork to cover the hydrometallurgical aspects of the extraction process, including testing of a large bead resin for IX, which would be used in a resin-in-pulp (RIP) process option.

Samples of ore representing four lenses from the Redtree and Junnagunna deposits, which were received in August 2008, were available for the testwork. The aim of the proposed program was to determine the primary metallurgical parameters for two composites representing these two deposits, followed by testing of down stream process options for liquors generated from one (or both) of these samples.

2. OBJECTIVES AND SCOPE

The overall aim of this work was to undertake preliminary testwork to provide data on process options for the recovery of uranium.

The following process options were assessed:

1. The possibility of rejecting a uranium depleted coarse fraction either with or without an ore scrubbing step;
2. Acid leaching of ground ore;
3. Solid/liquid separation by settling or filtration;
4. Recovery of uranium from clarified leach liquor by ion exchange and solvent extraction;
5. Recovery of uranium from leached pulp by RIP;
6. Precipitation of a final uranium oxide concentrate (UOC) from IX eluate and SX strip liquor.

The specific tasks were as follows:

- Crush all interval samples to <25 mm, and combine to produce a composite for each of the four lens samples;
- Split the four crushed composite lens samples to provide sub-samples. One sub sample for each lens was used to determine size versus uranium distribution and to conduct scrubbing tests. A second sub-sample was crushed to <2 mm to provide samples for assay and leach testwork. The remaining sub-samples were retained;

- Undertake quantitative XRD on the four lens samples to identify the proportions of major/minor gangue minerals. Four selected leach residues were similarly assessed;
- Undertake dilute leach tests on samples from each lens to determine the limit for uranium extraction under typical and more severe leach conditions;
- Develop laboratory grind calibration curves for the Redtree and Junnagunna composites;
- Undertake a series of tests to determine optimum leaching conditions for the Redtree and Junnagunna composites;
- Carry out 2-3 slurry leach tests on a sample of Jack lens composite;
- SEM examination of 4 selected leach residues to assist in identifying any factors limiting uranium extraction during leaching;
- Prepare a "bulk" composite for leaching and for the generation of pregnant liquor for use in uranium recovery work;
- Undertake batch laboratory ion exchange equilibrium, loading and elution tests;
- Undertake batch laboratory solvent extraction equilibrium and stripping tests;
- Produce uranium oxide concentrates from the IX and SX routes;
- Prepare a report which presents all results and findings;
- Dispose of analytical samples and return excess bulk sample to the client.

3. SAMPLE PREPARATION

3.1 Ore Samples

Details and composition of the available samples are shown in **Appendix A**, and are summarized in **Table 3.1**. The samples were chosen to be representative intervals of specific recognizable lenses, which account for the majority of the resource base. It was proposed to combine all the samples from the two Garee lenses to form a Redtree Composite and samples from the Jack lens were not included. The samples from Junnagunna were combined to form a Junnagunna composite. In the current study, only limited leaching work was done on the Jack lens composite, because it is considered to be surface, oxidized, ore.

TABLE 3.1
Ore Samples

	Hole ID	From (m)	To (m)	U_3O_8 (ppm)	wt (kg)	Total (kg)
Junnagunna "Steep"	JDD08-023	45	65	2250	70	
Mineralisation	JDD08-023	80	90	2910	34	
	JDD08-026	20	70	850	179	283
Garee Upper Lens	WDD08-009	30	50	540	69	
(Redtree)	WDD08-012	35	55	540	68	
	WDD08-037	12	36	610	86	
	WDD08-040	16	36	5270	74	297
Garee Lower Lens	WDD08-011	62	82	2580	73	
(Redtree)	WDD08-012	60	80	510	68	
	WDD08-040	88	103	3210	74	215
Jack Lens	WDD08-054	1.5 ?	20	90	35	
Mineralisation (Redtree)	WDD08-055	0	25	1040	69	104

In previous ANSTO work, the ore types examined, which contained predominantly uraninite, coffinite and primary and secondary phosphate uranium minerals, were from Redtree, Junnagunna, Huarabagoo, Outcamp and Black Hills. The mineralogical and elemental compositions of these ores are reported in **Appendix B,** which shows that elemental compositions of the samples tested in the nineties are similar to the compositions of the current ores (see **Appendix A**).

The previous testwork on leaching performance of the old ore samples is also compared in **Appendix B**. The leaching work, although extensive, focussed more on the impact of ore variability than a detailed optimisation of leaching conditions. That said, uranium extraction was typically >92% for leaching at pH 1.5 and 500 mV for 24 h at a nominal P_{80} grind of 150 µm. Grind size, in particular, was not optimised, but there were indications that a coarser grind could be used. Acid addition was typically 10-20 kg/t, but ore samples containing high Fe concentrations required additions up to ~55 kg/t. Where low uranium extractions were obtained, a higher proportion of the uranium was present as phosphate minerals, particularly ningyoite.

3.2 Composite Samples - Preparation and Head Analyses

A list of half core samples prepared into 4 composite samples for the current testwork program is given in **Table 3.2**. Each bag of sample was checked against a list provided by the client and the weights, to within the nearest kilogram, confirmed.

TABLE 3.2
Half Core Sample Details

Sample Description	ANSTO Sample	Mass (kg)	200L Drum No.	Assigned Composite ID
WDD08-12 Core Samples				
35-40m	WM070808-1	`21	1	GUL
40-45m	WM070808-2	`14	1	GUL
45-50m	WM070808-3	`16	1	GUL
50-55m	WM070808-4	`17	1	GUL
60-65m	WM070808-5	`17	1	GLL
65-70m	WM070808-6	`17	1	GLL
70-75m	WM070808-7	`17	1	GLL
75-80m	WM070808-8	`17	1	GLL
JDD08-026 Core Samples				
20-25m	WM070808-9	~18	2	JUN
25-30m	WM070808-10	~19	2	JUN
30-35m	WM070808-11	~18	2	JUN
35-40m	WM070808-12	~19	2	JUN
40-45m	WM070808-13	~17	2	JUN
45-50m	WM070808-14	~18	2	JUN
50-55m	WM070808-15	~18	2	JUN
55-60m	WM070808-16	~18	2	JUN
60-65m	WM070808-17	~17	2	JUN
65-70m	WM070808-18	~18	2	JUN
JDD08-023 Core Samples				
80-85m	WM070808-19	~17	3	JUN
85-90m	WM070808-20	~17	3	JUN
45-50m	WM070808-21	~17	3	JUN
50-55m	WM070808-22	~17	3	JUN
55-60m	WM070808-23	~18	3	JUN
60-65m	WM070808-24	~18	3	JUN
WDD08-040 Core Samples				
21-26m	WM070808-25	~18	4	GUL
26-31m	WM070808-26	~19	4	GUL
31-36m	WM070808-27	~18	4	GUL
98-103m	WM070808-28	~18	4	GLL
WDD08-9 Core Samples				
30-35m	WM070808-29	~21	5	GUL
35-40m	WM070808-30	~17	5	GUL
40-45m	WM070808-31	~14	5	GUL
45-50m	WM070808-32	~17	5	GUL
WDD08-11 Core Samples				
62-67m	WM070808-33	~18	5	GLL
67-72m	WM070808-34	~17	5	GLL
72-77m	WM070808-35	~19	5	GLL
77-82m	WM070808-36	~19	5	GLL
WDD08-040 Core Samples				
16-21m	WM070808-37	~19	6	GUL
88-93m	WM070808-38	~18	6	GLL
93-98m	WM070808-39	~19	6	GLL
WDD08-054				
15-20m	WM070808-40	~17	7	Jack
20-25m	WM070808-41	~18	7	Jack
WDD08-055				
0-5m	WM070808-42	~16	7	Jack
5-10m	WM070808-43	~18	7	Jack
10-15m	WM070808-44	~18	7	Jack
15-20m	WM070808-45	~17	7	Jack
WDD08-37				
12-17m	WM070808-46	~19	8	GUL
17-22m	WM070808-47	~18	8	GUL
22-27m	WM070808-48	~18	8	GUL
27-32m	WM070808-49	~17	8	GUL
32-36m	WM070808-50	~14	8	GUL

The bags were sorted into the nominated composites as below, and processed according to the sample preparation plan shown in **Figure 3.1**.

Garee Upper lens	GUL	17 bags
Garee Lower lens	GLL	11 bags
Junnagunna	JUN	16 bags
Jack Lens	Jack	6 bags

The scrubbing test was omitted, as it was not expected to be successful, in terms of liberation and further breakdown, given the competent nature of the ore, which produced few fines during crushing. It was observed during preparation of the composites that, although the ore material appeared partially pitted, it was quite competent and produced very little fines during crushing. This was also confirmed on random pieces of rock, which were immersed in water for 4 hours with no visual signs of any fretting or clay liberation/breakdown.

A representative portion of each sample, crushed to <25 mm, was further crushed to a top size of about 2 mm. These crushed samples was then split and riffled into 1 kg portions and stored in individual sealed plastic bags until required. Samples from the Garee lenses were combined to form a Redtree composite.

A 1 kg portion of each crushed lens sample was split into two fractions. One half was retained for mineralogical examination. The other half was pulverised to produce samples for assay, and 40 g samples for dilute leach tests. Samples were analysed for uranium by DNA and by XRF for Al, As, Ba, Bi, Ca, Co, Cr, Cu, Fe, Mg, Mn, Mo, Ni, P, Pb, S, Si, Th, Ti, U, V, Zn and Zr. In addition the total carbon, inorganic carbon and sulphide concentrations were measured by Leco.

The ore sample compositions determined by ANSTO (using XRF, DNA[1] and Leco analytical methods) are given in **Tables 3.3** and **3.4**.

TABLE 3.3
Head Samples – Uranium and Leco Assays

Sample name	U_3O_8 (ppm)	LECO assay (%)					
		Sulphate SO_4^{2-}	Sulphide S	Total S	Total Inorganic C	Total Organic C	Total Carbon
Junnagunna	1370	0.01	0.04	0.05	0.03	<0.02	0.04
Garee Lower Lens	1380	<0.01	0.01	0.01	0.04	0.02	0.06
Garee Upper Lens	1860	0.01	0.02	0.03	<0.02	0.02	0.02
Garee (Redtree) Composite	1700	0.01	0.02	0.03	0.03	<0.02	0.04
Jack Lens	929	0.02	0.02	0.04	<0.02	<0.02	0.01

***** by DNA

Samples of Junnagunna, Garee lower lens, Garee upper lens and Garee (Redtree) composite contained a significantly higher uranium grade (1370-1860 ppm U_3O_8) than the Jack lens composite sample (929 ppm U_3O_8).

[1] DNA delayed neutron assay for uranium using ANSTO's OPAL reactor.

Ore samples - four ore types as half core?

Junnagunna	283 kg
Gareev (Redtree) Upper	297 kg
Garee (Redtree) Lower	196 kg
Jacks	104 kg

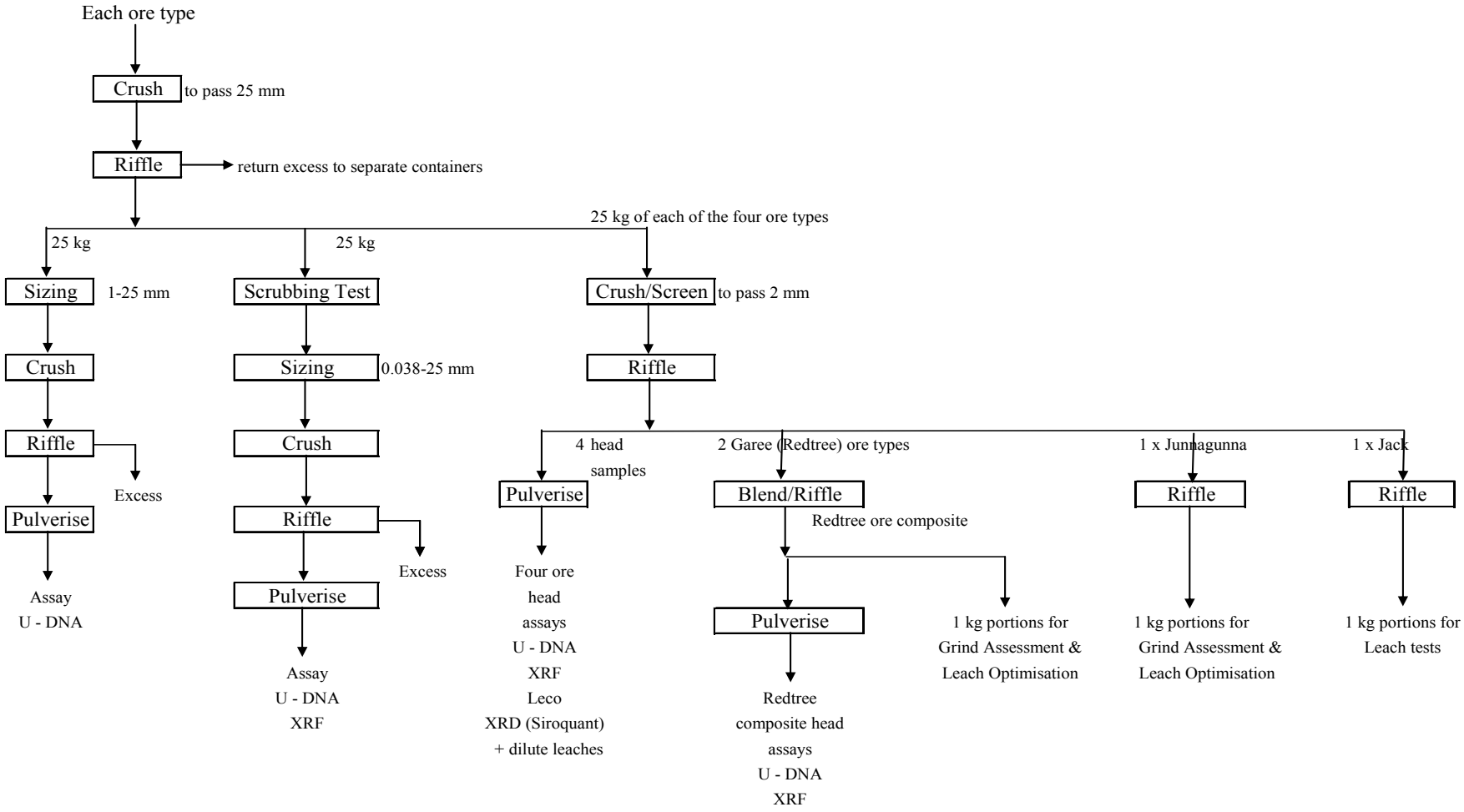


FIGURE 3.1 Sample Preparation Plan

TABLE 3.4
Head Samples – XRF Assay (%)

	Al	As	Ba	Ca	Ce	Co	Cr	Cu	Fe	K	Mg	Mn	Ni
Junnagunna	1.53	0.004	0.012	0.104	0.018	<0.001	0.048	0.004	1.10	0.611	0.135	0.001	0.003
Garee Lower Lens	1.65	0.015	0.012	0.049	0.015	<0.001	0.040	0.004	1.59	0.652	0.104	0.001	0.003
Garee Upper Lens	1.11	0.030	0.007	0.030	0.015	<0.001	0.041	0.001	1.43	0.457	0.037	<0.001	0.001
Garee (Redtree) Composite	1.38	0.024	0.009	0.041	0.016	<0.001	0.042	0.003	1.52	0.550	0.073	<0.001	0.004
Jack Lens	1.05	0.006	0.009	0.033	0.014	<0.001	0.061	0.012	0.75	0.440	0.018	<0.001	0.016

	P	Pb	S	Si	Sr	Th	Ti	V	Y	Zn	Zr	Mo	Bi
Junnagunna	0.027	0.013	0.042	43.63	0.140	0.011	0.050	0.033	0.007	<0.001	0.038	0.015	<0.01
Garee Lower Lens	0.014	0.009	0.035	41.90	0.129	0.009	0.053	0.022	0.008	<0.001	0.030	0.009	<0.01
Garee Upper Lens	0.011	0.013	0.015	42.99	0.150	0.010	0.038	0.021	0.006	<0.001	0.027	0.009	<0.01
Garee (Redtree) Composite	0.013	0.012	0.027	42.63	0.135	0.010	0.045	0.021	0.007	<0.001	0.031	0.011	<0.01
Jack Lens	0.021	0.007	0.037	43.56	0.152	0.009	0.036	0.037	0.007	<0.001	0.032	0.009	<0.01

* XRF UniQuant results

The XRF assay results showed that major gangue elements in the composites decreased similarly in the order of Si > Al > Fe > K > Sr > Ca = Mg, with only the first four elements greater than 0.5%.

3.3 Gangue Mineralogy

Samples of ore were also submitted for quantitative XRD using SiroQuant software to determine the distribution of the major gangue minerals. Results are summarised in **Table 3.5**.

Quartz (SiO_2) was the dominant gangue mineral in all samples. Its relative concentrations varied from 88 to 92.3 wt%. The minor constituents (less than 5% each) were illite, hematite jarosite, chamosite and hydroxylapatite. Illite, hematite and palygorskite were present in all ores. Chamosite (Fe rich chlorite) was found in four ores, whereas hydroxylapatite was detected only in Junnagunna ore. The uranium-bearing minerals were not abundant enough to be detectable by XRD.

The lowest Fe content of the Jack Lens measured by XRF is consistent with the absence of chlorite reported in **Table 3.5**. In terms of acid requirement, chlorite is a known acid consumer and will undergo substantial dissolution under mild acid leaching conditions.

TABLE 3.5
Concentration of Major Gangue Minerals (wt%)

XRD Ref		Junnagunna XP00041	Garee Upper XP00042	Garee Lower XP00043	Garee Composite XP00044	Jack XP00045
Chlorite	Fe – rich*	1.8	0.5	2.8	1.7	
Hematite	Fe_2O_3	0.5	1.4	0.8	1.1	0.8
Jarosite	$((K,H_3O)Fe_3(SO_4)_2(OH)_6)$	0.9	0.8	0.7	0.9	0.6
Hydroxylapatite	$Ca_5(PO_4)_3(OH)$	0.8				
Illite	$(K,H_3O)Al_2Si_3AlO_{10}(OH)_2$	8.0	6.6	6.8	6.6	6.4
Quartz	SiO_2	88.0	90.6	88.8	89.7	92.3

*$(Mg_{5.036}Fe_{4.964})Al_{2.724}(Si_{5.70}Al_{2.30}O_{20})(OH)_{16}$

3.4 Uranium Size by Size Deportment

A portion of each composite sample crushed to pass 25 mm was screened on standard screen sizes from 1 to 24 mm. A total of 8 fractions were collected, crushed, and pulverised and portions assayed using DNA to determine the size by size uranium deportment to see if a coarse fraction could be rejected on the basis of size alone and thereby increase the ore head grade to the leach circuit.

The distributions of uranium (DNA result) in the size fractions for each composite sample are given in **Tables 3.6-3.9** and **Figures 3.2-3.5**. The uranium concentration was typically greatest in the finest fraction (< 1 mm). However, the uranium contents of the coarser fractions were also quite similar, and too high to contemplate rejection.

TABLE 3.6
Distribution of Uranium in Size Fractions (Junnagunna)

Size Fractions	Weight		Uranium (DNA)	
(mm)	(kg)	%	ppm	Dist'n
19	5.03	25.5	1223	25.1
16	2.61	13.2	1246	13.3
12.5	2.41	12.2	1277	12.6
9.4	2.43	12.3	1159	11.5
4.7	1.88	9.5	1330	10.2
2.0	1.50	7.6	1170	7.2
1.0	0.79	4.0	1099	3.5
< 1.0	3.09	15.7	1321	16.7
Calculated Head	19.7	100.0	1241	100.0
Assay Head			1138	

TABLE 3.7
Distribution of Uranium in Size Fractions (Garee Lower Lens)

Size Fractions	Weight		Uranium (DNA)	
(mm)	(kg)	%	ppm	Dist'n
19	4.78	24.3	1139	21.8
16	2.78	14.1	1013	11.3
12.5	2.72	13.8	1390	15.2
9.4	2.50	12.7	1505	15.1
4.7	2.00	10.2	1347	10.8
2.0	1.53	7.8	1294	7.9
1.0	0.78	4.0	1121	3.5
< 1.0	2.56	13.0	1399	14.4
Calculated Head	19.7	100.0	1269	100.0
Assay Head			1170	

TABLE 3.8
Distribution of Uranium in Size Fractions (Garee Upper Lens)

Size Fractions	Weight		Uranium (DNA)	
(mm)	(kg)	%	ppm	Dist'n
19	4.31	21.9	1967	28.0
16	2.46	12.5	864	7.0
12.5	2.60	13.2	1467	12.6
9.4	2.36	12.0	1103	8.6
4.7	1.89	9.6	1353	8.4
2.0	1.67	8.5	1195	6.6
1.0	1.11	5.6	1299	4.8
< 1.0	3.25	16.5	2246	24.1
Calculated Head	19.7	100.0	1543	100.0
Assay Head			1579	

TABLE 3.9
Distribution of Uranium in Size Fractions (Jack Lens)

Size Fractions	Weight		Uranium (DNA)	
(mm)	(kg)	%	ppm	Dist'n
19	4.73	23.7	616	18.0
16	2.97	14.9	674	12.4
12.5	2.46	12.3	902	13.7
9.4	2.45	12.3	872	13.2
4.7	2.00	10.0	737	9.1
2.0	1.57	7.9	868	8.4
1.0	1.03	5.2	739	4.7
< 1.0	2.76	13.8	1209	20.6
Calculated Head	20.0	100.0	812	100.0
Assay Head			737	

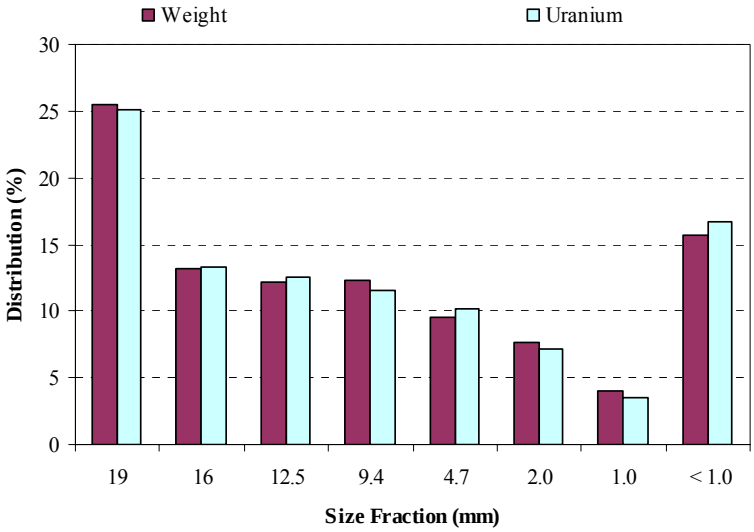


FIGURE 3.2 Weight and Uranium Distributions in Size Fractions for Junnagunna Lens

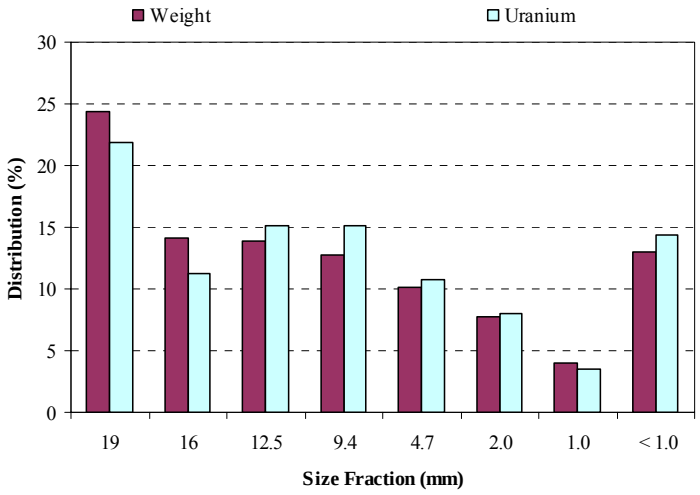


FIGURE 3.3 Weight and Uranium Distributions in Size Fractions for Garee Lower

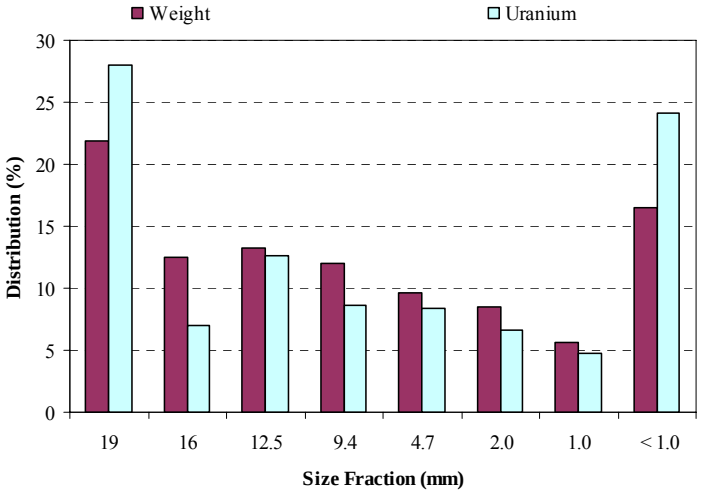


FIGURE 3.4 Weight and Uranium Distributions in Size Fractions for Garee Upper

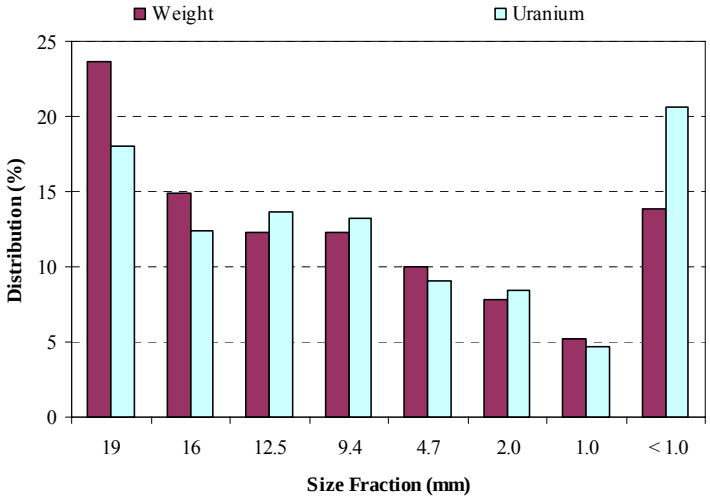


FIGURE 3.5 Weight and Uranium Distributions in Size Fractions for Jack Lens

The size by size analysis of each composite sample indicated that uranium was uniformly distributed in each size fraction, in proportion to the sample mass distribution with a slight tendency for uranium minerals to report to the finest fraction. Therefore, the ore could not be upgraded based on size separation.

3.5 Grind Calibration Curve

Grinding assessment tests were carried out on the composites from the Redtree and Junnagunna deposits in a batch rod mill on 1 kg samples with 10 rods to produce grind response curves that will allow the time required to produce a target P_{80} grind size for the crushed ore materials.

All grinding tests were carried out in Sydney tap water. Grind size distributions were determined by wet screening at 38 µm and dry screening the oversize at 600 to 45 µm. A wide spread of grind sizes was targeted, as follows:

P_{80} = 350 µm

P_{80} = 250 µm

P_{80} = 150 µm

P_{80} = 75 µm

The size fractions from the coarsest grinds of the Redtree and Junnagunna composites were analysed for U by DNA and by XRF for the same suite of elements as described in **Section 3.2**. Ore samples were milled in Sydney tap water in preparation for leaching to achieve a specified P_{80} grind size. The trial grinding tests results are summarised in **Tables 3.10** and **3.11**. Particle size distribution (PSD) curves from the grinding assessment testwork are shown in **Figures 3.6** and **3.7**.

TABLE 3.10
Summary of Trial Grinding Results - Junnagunna Lens

	Cumulative wt% Passing				
Size (µm)	3 mins	10 mins	14 mins	20 mins	60 mins
600	93.8	100.0	100.0	100.0	100.0
425	75.1	99.9	100.0	100.0	100.0
300	53.8	94.0	99.2	100.0	100.0
212	38.5	70.7	86.0	97.3	100.0
150	30.0	54.1	67.2	82.3	100.0
106	22.4	40.0	49.8	61.8	99.1
75	17.6	30.5	37.2	45.5	89.5
53	13.9	23.3	28.0	33.5	68.3
45	12.2	20.5	24.6	29.3	60.0
38	10.9	17.9	21.2	25.1	51.8

TABLE 3.11
Summary of Trial Grinding Results – Garee Redtree Composite

Size (µm)	Cumulative wt% Passing				
	3 mins	10 mins	14 mins	20 mins	60 mins
600	85.6	100.0	100.0	100.0	100.0
425	64.9	99.4	100.0	100.0	100.0
300	45.7	89.1	98.5	100.0	100.0
212	32.5	64.9	82.4	97.1	100.0
150	25.1	49.8	62.8	81.7	100.0
106	18.7	36.9	46.6	61.9	99.2
75	14.7	28.2	35.0	46.2	91.4
53	11.8	22.1	26.5	34.7	71.2
45	10.5	19.5	23.4	30.7	62.7
38	9.4	17.1	20.2	26.6	54.5

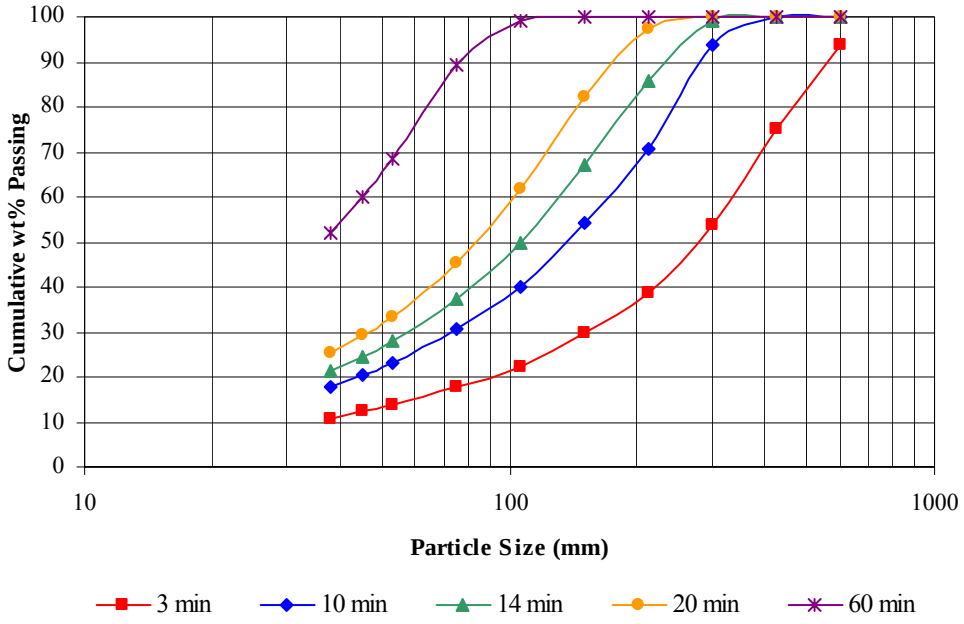


FIGURE 3.6 PSD Curves from the Junnagunna Trial Grinding Tests

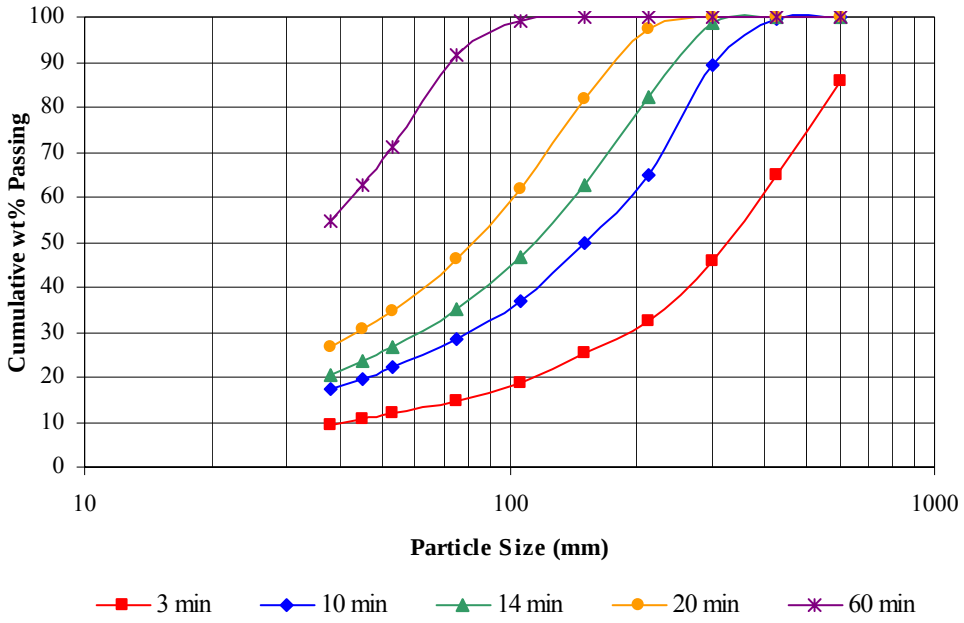


FIGURE 3.7 PSD Curves from the Garee Redtree Trial Grinding Tests

From **Figures 3.6** and **3.7**, the required grind time to achieve the specified P_{80} grind sizes for leaching of the two composite samples are plotted in **Figure 3.8**.

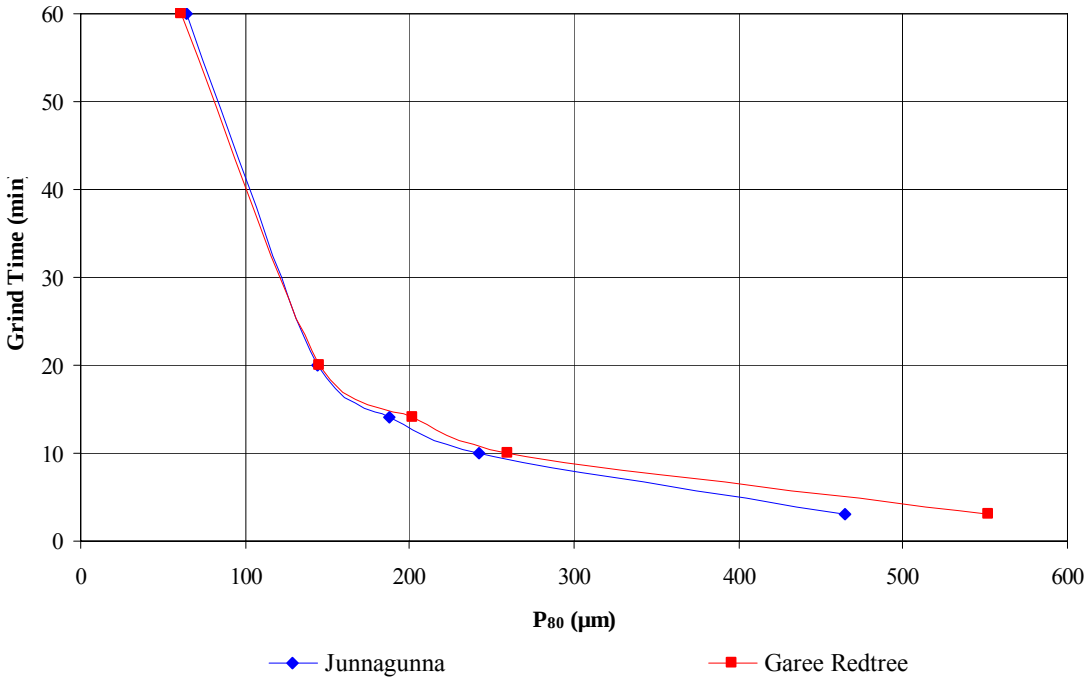


FIGURE 3.8 Grind Time versus P_{80} Size for Junnagunna and Garee Redtree

From the **Figure 3.8**, a grind time of 19 minutes was indicated for grinding each composite sample in the laboratory rod mill to achieve a P_{80} size of ~150 µm. Ore samples were then milled in Sydney tap water in preparation for leaching at the specified grind time interpolated from **Figure 3.8** for the other specific P_{80} grind sizes.

The uranium distribution in the Junnagunna and Redtree samples ground to a P_{80} of 250 µm were also determined. **Figure 3.9** shows that for both ores the uranium grade increased from 400-500 ppm in the coarsest fraction to 2500-3000 ppm U_3O_8 in the less then 38 µm fines. The detailed data is given in **Appendix C**.

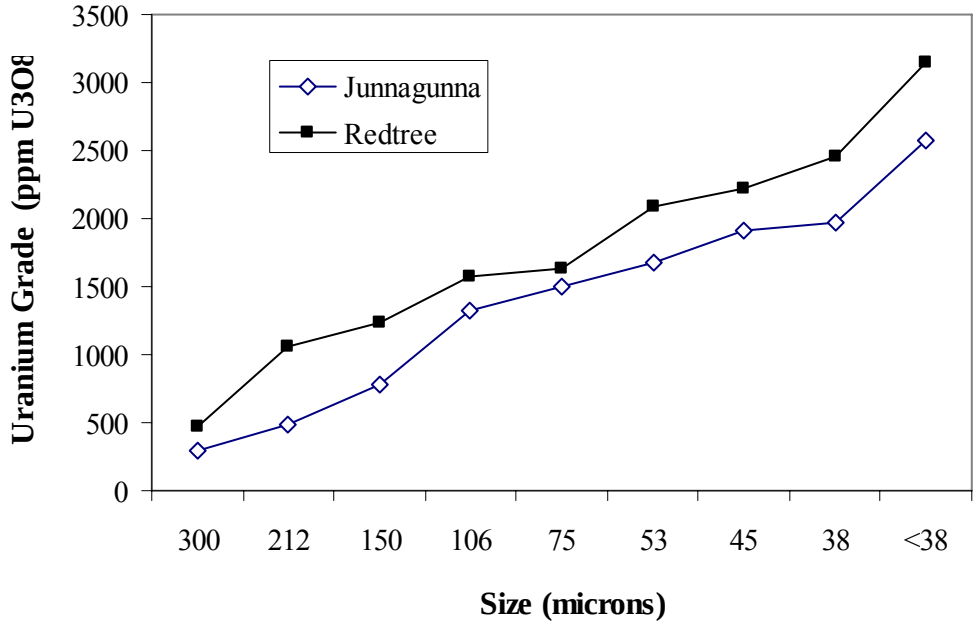


FIGURE 3.9 Uranium Grade of Size Fractions for Base Case Grind

4. LEACHING TESTS AND RESULTS

4.1 Dilute Leach Tests

Eight dilute batch leaches, two on each sample, were carried out under specified conditions on pulverised ore. The leach procedure and sampling/assay schedules are described in **Appendix D**. Dilute tests were used to determine the ultimate uranium extraction and provide an estimate of the propensity for gangue dissolution.

Two conditions were examined:

A	Temperature	:	40 °C
	pH	:	1.5
	ORP	:	500 mV (with addition of 1.5 g/L of Fe)
B	Temperature	:	60 °C
	pH	:	1.0
	ORP	:	550 mV (with addition of 1.5 g/L of Fe)

Condition A was used to determine the maximum extraction under expected plant conditions, while condition B was designed to determine the maximum extraction under more severe, but still realistic conditions. The dilute leaching results are summarised in **Table 4.1**. Detailed experimental data are attached in **Appendix E**.

TABLE 4.1
Dilute Acid Leaching Test Results Summary

Test ID	Composite	Conditions	Uranium (ppm U_3O_8)		
			Head grade	Leach residue grade	Extraction (%)
LC1 A	Junnagunna	Base case	1370	14	99.0
LC1 B	Garee Lower lens	Base case	1380	19	98.6
LC1 C	Garee Upper lens	Base case	1862	21	98.9
LC1 D	Jack Lens	Base case	929	22	97.6
LC2 A	Junnagunna	Extreme case	1370	9	99.3
LC2 B	Garee Lower lens	Extreme case	1380	12	99.1
LC2 C	Garee Upper lens	Extreme case	1862	14	99.2
LC2 D	Jack Lens	Extreme case	929	14	98.5

Dilute leach test results on the ores were encouraging. The uranium was readily leached with a similar high recovery of ~99% under either base case or extreme conditions. The relative dissolution of gangue can be assesses by comparing the concentrations of ions in the final dilute leach liquors, which are shown in **Table 4.2.** For the dilute base case conditions, the concentrations are relatively low, decreasing in the order Ca>Si>Al>K>Mg. gangue dissolution was greatest for Garee Lower lens, and lowest for Jack Lens, noting that Fe dissolution cannot be estimated because of iron was added to the leach solution.

For the more extreme conditions, the concentrations of Al, K and Si increased significantly, whereas Mg was slightly higher, and Ca appeared to decrease. For both conditions, the rate of uranium extraction, from liquor assays, was very fast, appearing to be complete after 8 h.

TABLE 4.2
Composition of 24 h Dilute Leach Liquors (mg/L)

Composite	Conditions	Al	Ca	K	Mg	P	Si
Junnagunna	Base case	21	28	15	13	2	35
Garee Lower lens	Base case	33	70	16	13	< 1	43
Garee Upper lens	Base case	10	25	11	6	< 1	21
Jack Lens	Base case	6	23	<10	4	< 1	13
Junnagunna	Extreme case	56	34	44	18	10	80
Garee Lower lens	Extreme case	72	23	33	17	3	95
Garee Upper lens	Extreme case	34	19	30	6	2	52
Jack Lens	Extreme case	24	20	31	5	3	35

4.2 Conventional Leach Tests

4.2.1 Leach Procedures

The leach procedure used for the preliminary leach tests and the optimisation leach series is described below. All tests were carried out using 1 kg of ore. After grinding, the ore slurry was allowed to settle, and water decanted to produce the target slurry density.

In all tests, pH was controlled for the duration of leaching by automatic addition of concentrated sulphuric acid. ORP was controlled by automatic addition of sodium permanganate[2] for 12 h. Acid and oxidant consumption was monitored and recorded for the period of leaching. All tests were carried out at set agitation speed using the same leach tank size and impellor diameter, type and position.

The rate of leaching was determined by taking 30 mL slurry samples at 2, 4 and 8, and 12 and 24 h. The samples were centrifuged and the residues washed with dilute sulphuric acid solution (at leach pH), water washed and finally dried at 105°C. Uranium residue grades were determined by assaying the dried solids using the DNA technique. The 24 h leach residue solids were analysed by XRF for the suite of elements listed in **Section 3.2**. Selected intermediate solids were analysed by XRF, depending on results.

For selected tests, a final washed bulk leach residue of about 500 g was collected and retained for possible mineralogical examination. This required washing of the final bulk leach residue, which was analysed for uranium to confirm the assay of the leach residue thief sample.

Filtrate from the thief slurry filtration was refiltered through a 0.45 μm filter, immediately diluted 1/10 in 3% nitric acid and subsequently analysed for U, P, Fe, Si, Mg, Al, S, K, Ca, Mn, As, Mo, V by ICP/OES. Ferrous ion and free acidity was determined in all leach liquor samples by titration methods. The final leach liquor was analysed for U by ICP/MS.

For all tests, a leach spreadsheet was produced that reports accountabilities for uranium. For selected leach conditions, the final leach slurry was used for settling tests conducted by ANSTO Minerals' personnel.

4.2.2 Preliminary Leaching

Base case acid leaching conditions similar to those identified in previous ANSTO studies on Westmoreland ores were used in the preliminary leach tests on the Redtree and Junnagunna composites to gain an understanding of likely leaching conditions. Sydney tap water was used in all the leach tests. Site water was not available, and, moreover, the quality is likely to be at least of a reasonable standard.

The base case leach conditions are as shown below.

Parameter	Base Case
Solids concentration	55 wt%
Temperature	40°C*
Duration	24 hour
Acidity – controlled 24 h	pH 1.5
ORP – controlled 12 h	500 mV[3]

* Equivalent to ambient conditions at Westmoreland for a low acid addition

[2] This oxidant would not be used in practice, but is used in laboratory tests for convenience and ease of control. Other work by ANSTO Minerals has shown that this oxidant will yield the same extraction of uranium as other commonly used commercial oxidants, eg pyrolusite, sodium chlorate.

[3] In previous work an ORP of 475 mV was maintained relative to a saturated calomel electrode. Against the current reference system of Ag/AgCl (filled with 3 M KCl), this is about 500 mV.

The base case leaching results are summarised in **Table 4.3** at a grind of P_{80} = 250 µm. Detailed experimental data are given in **Appendix F**.

TABLE 4.3
Summary of Base Case Leach Results

Composite	Leach ID	Acid Addition (kg/t)	Oxidant Addition (kg/t)	Head Grade (ppm U_3O_8)	Residue Grade (ppm U_3O_8)	Uranium Extraction (%)
Junnagunna	LC3 A	20.6	1.6	1370	34	97.5
Garee Redtree	LC3 B	17.1	1.6	1700	59	96.5

For both composite ore samples, the base case conventional leaches at the coarse grind (P_{80} of 250 µm) indicated a uranium recovery of 96-97%, which is close to the 98% achieved under the ideal dilute leach conditions. The majority of uranium extraction was achieved in the first 12 h of leaching with a significant decrease of residue grade as shown in **Figure 4.1**, although uranium was still dissolving slowly from the Redtree composite between 12-24 h. The high extractions of uranium were achieved with moderate addition of acid as shown in **Figure 4.2**.

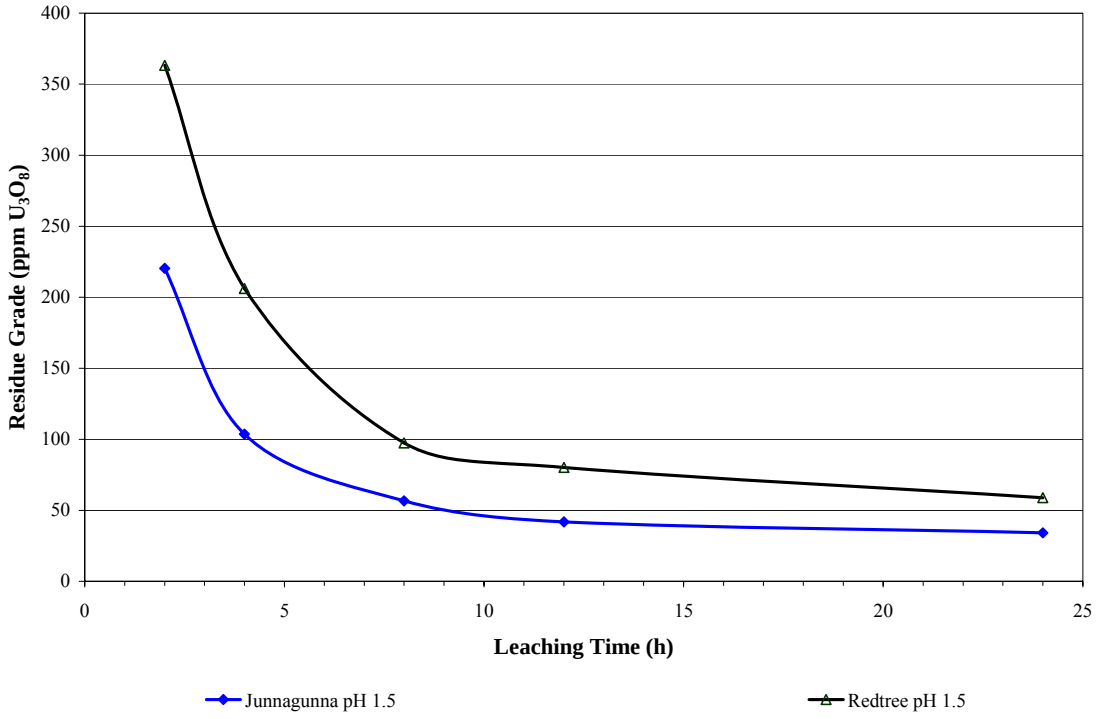


FIGURE 4.1 Residue Profiles for Base Case Conventional Leaches

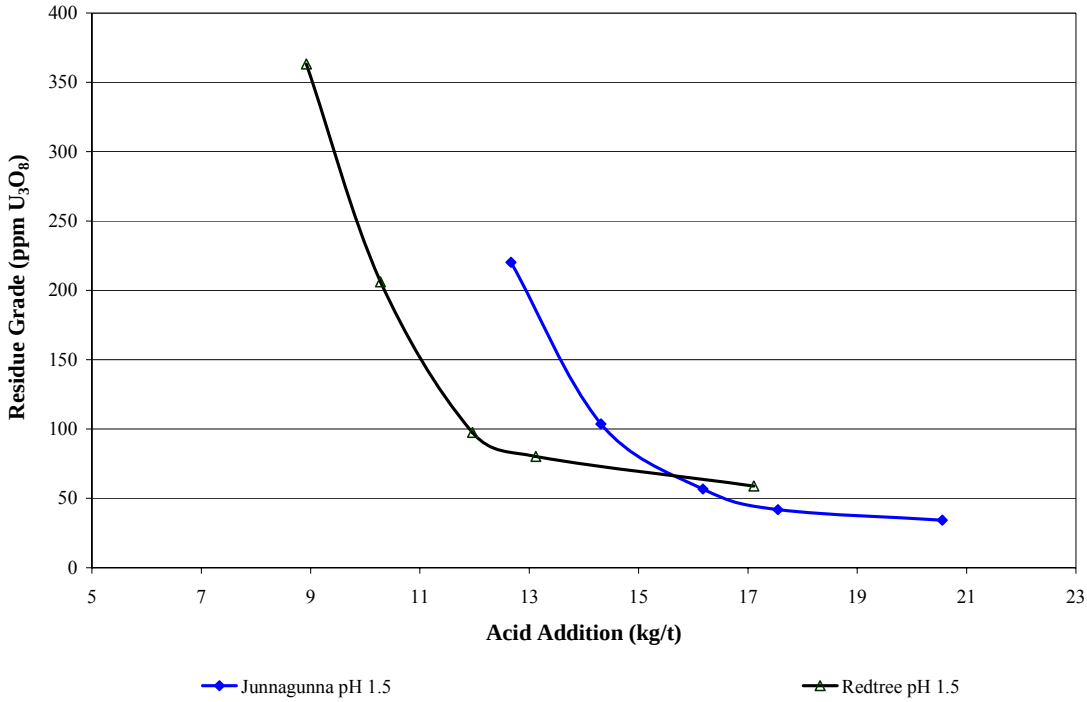


FIGURE 4.2 Acid Additions for Base Case Conventional Leaches

4.2.3 Optimisation Leaching

The initial optimisation leach tests were carried out at the coarse grind size distribution, as the base case leaches indicated that finer grinding was not likely to be necessary. Nonetheless leach tests at other grinds (P_{80} of 350 µm, 150 µm 75 µm) were also undertaken as part of the optimisation study.

The "base" leaching conditions were as defined in **Section 4.2.2**, but at the grind (P_{80} of 250 µm) identified in the preliminary leach series. Each of three parameters (temperature, pH and ORP) as summarised in the table below was varied in turn for each ore composite, while keeping all the other parameters at the "base" level.

Conditions for Optimisation Leach Series

Effect of pH	Effect of ORP	Effect of Temperature
Base case at pH 2.0	Base case at 450 mV	Base case at 50°C
Base case at pH 1.7	Base case at 550 mV	Base case at 30°C
Base case at pH 1.3	Base case with addition of 1.0 g Fe^{3+}/L	

The optimisation leaching results for the Junnagunna composite are summarised in **Table 4.4**. The Garee Redtree composite leaching results are summarised in **Table 4.5**. A total of 43 leach tests were carried out.

Most tests were carried out without additional ferric ion, but with the addition of sodium permanganate oxidant to achieve an oxidation potential (ORP) of 500 mV. The Junnagunna leaching tests achieved excellent uranium extractions ranging 95-98% and the Redtree

leaching tests also achieved relatively high uranium extractions from 92-98% depending on other leaching parameters. The effect of leaching parameters is discussed below.

(i) Effect of pH

The effect of pH on leaching performance for Junnagunna and Redtree was examined in four tests, as shown in **Tables 4.4** and **4.5**, respectively.

For Junnagunna, except for leaching at pH 2, 24 h uranium extractions were very similar at pH 1.3 to 1.7. Optimum conditions were leaching at pH 1.5-1.7 for 12 h. However for the Redtree ore, the extraction increased with decreasing pH. The 24 h extraction increased from 92% to 98% when the leaching pH was decreased from pH 2.0 to pH 1.3. The pH also had an impact on the initial leaching rate. For this ore, optimum conditions were leaching for 12 h at pH 1.3-1.5. For both ores, acid requirements were relatively low, with an acid addition of 20 kg/t sufficient at the "optimum" conditions. The uranium extraction data versus time for P_{80} = 250 μm is shown in **Figures 4.3** and **4.4**, with residue grade versus acid addition shown in **Figure 4.5**. The latter plots can be used to readily assess the extraction versus acid addition trade-off. For example, leaching Junnagunna at pH 1.7 for 24 h (acid = 16 kg/t) will yield the same uranium extraction as leaching at pH 1.5 for 18 h (acid = 19 kg/t)

The 24 h leach liquor compositions are compared in **Tables 4.6 and 4.7**. For all liquors, zirconium was less than 1 mg/L and vanadium was typically 10 and 30 mg/L after 24 h, for Redtree and Junnagunna, respectively.

TABLE 4.4
Junnagunna Optimisation Leach Results

(Head Grade – 1370 ppm U_3O_8)

Exp. ID	pH	Target ORP (mV)	Ferric Addition (g/L)	Leach Temperature (ºC)	P_{80} (µm)	Acid Addition (kg/t)	Oxidant Addition (kg/t)	Residue Grade (ppm U_3O_8)	Uranium Extraction* (%)
LC9 A	2.0	500	n/a	40	250	9.8	1.2	52	96.2
LC4 B	1.7	500	n/a	40	250	14.7	1.5	36	97.3
LC3 A	1.5	500	n/a	40	250	20.6	1.6	34	97.5
LC4 A	1.3	500	n/a	40	250	25.0	1.7	28	97.9
LC5 C	1.5	550	n/a	40	250	18.3	1.8	28	97.9
LC3 A	1.5	500	n/a	40	250	20.6	1.6	34	97.5
LC12 A[#]	1.5	500	n/a	40	250	20.0	2.9[#]	38	97.2
LC6 A	1.5	450	n/a	40	250	18.0	0.6	61	95.5
LC7A	1.5	500	n/a	30	250	14.3	1.1	55	96.0
LC3 A	1.5	500	n/a	40	250	20.6	1.6	34	97.5
LC10 A	1.5	500	n/a	50	250	24.1	1.8	27	98.0
LC8 B	1.5	500	1.0	40	250	16.6	1.3	31	97.7
LC3 A	1.5	500	n/a	40	250	20.6	1.6	34	97.5
LC14 B	1.5	500	n/a	40	350	18.8	1.4	40	97.1
LC3 A	1.5	500	n/a	40	250	20.6	1.6	34	97.5
LC9 C	1.5	500	n/a	40	150	19.4	1.5	41	97.0
LC11A	1.5	500	n/a	40	75	19.8	1.7	27	98.1

* after 24 h

[#] pyrolusite as oxidant, all other leaches used 10% potassium permanganate

TABLE 4.5
Redtree (Garee) Optimisation Leach Results

(Head Grade – 1704 ppm U_3O_8)

Exp. ID	Target pH	Target ORP (mV)	Ferric Addition (g/L)	Leach Temperature (ºC)	P_{80} (µm)	Acid Addition (kg/t)	Oxidant Addition (kg/t)	Residue Grade (ppm U_3O_8)	Uranium Extraction* (%)
LC9 B	2.0	500	n/a	40	250	11.8	1.0	130	92.4
LC14 A**	2.0	500	n/a	40	250	9.5	1.0	116	93.2
LC5 B	1.7	500	n/a	40	250	11.4	1.3	73	95.7
LC3 B	1.5	500	n/a	40	250	17.1	1.6	59	96.5
LC13 B**	1.5	500	n/a	40	250	16.7	1.4	55	96.8
LC5 A	1.3	500	n/a	40	250	20.4	1.6	31	98.2
LC6 B	1.5	550	n/a	40	250	17.5	1.8	44	97.4
LC3 B	1.5	500	n/a	40	250	17.1	1.6	59	96.5
LC12 B	1.5	500	n/a	40	250	17.0	2.8[#]	53	96.9
LC6 C	1.5	450	n/a	40	250	15.0	0.8	106	93.8
LC7 B	1.5	500	n/a	30	250	12.4	1.1	98	94.2
LC3 B	1.5	500	n/a	40	250	17.1	1.6	59	96.5
LC10 B	1.5	500	n/a	50	250	19.0	1.8	41	97.6
LC8 C	1.5	500	1.0	40	250	15.0	1.3	45	97.3
LC3 B	1.5	500	n/a	40	250	17.1	1.6	59	96.5
LC13 A	1.5	500	n/a	40	350	16.4	1.4	56	96.7
LC3 B	1.5	500	n/a	40	250	17.1	1.6	59	96.5
LC7 C	1.5	500	n/a	40	150	16.4	1.5	56	96.7
LC11 B	1.5	500	n/a	40	75	17.3	1.7	54	96.8

* after 24 h ** duplicate

[#] pyrolusite as oxidant

TABLE 4.6
Junnagunna – Final 24 h Leach Liquor Compositions (mg/L)

Exp. ID	pH	ORP (mV)	Temp. (ºC)	P_{80} (µm)	Al	Ca	Fe	Fe^{3+}	K	Mg	Mn	P	Si
LC9 A	2.0	500	40	250	394	339	2360	1388	149	219	529	8	456
LC4 B	1.7	500	40	250	595	355	3080	1936	302	284	550	26	605
LC3 A	1.5	500	40	250	804	427	4020	2499	272	369	657	47	681
LC4 A	1.3	500	40	250	954	452	4060	2546	268	409	605	80	856
LC5 C	1.5	550	40	250	657	388	3509	2654	170	313	674	63	592
LC3 A	1.5	500	40	250	804	427	4020	2499	272	369	657	47	681
LC12 A#	1.5	500	40	250	718	406	3660	2185	182	355	1330	45	652
LC6 A	1.5	450	40	250	859	394	4070	1144	184	384	262	42	707
LC7A	1.5	500	30	250	608	382	3070	1426	147	288	492	36	508
LC3 A	1.5	500	40	250	804	427	4020	2499	272	369	657	47	681
LC10 A	1.5	500	50	250	1220	384	4970	2924	297	526	714	41	771
LC8 B*	1.5	500	40	250	768	318	4500	2845	214	317	535	16	629
LC3 A	1.5	500	40	250	804	427	4020	2499	272	369	657	47	681
LC14 B	1.5	500	40	350	830	398	4230	2750	181	393	633	30	576
LC3 A	1.5	500	40	250	804	427	4020	2499	272	369	657	47	681
LC9 C	1.5	500	40	150	767	385	3630	2179	227	353	666	36	671
LC11A	1.5	500	40	75	830	409	4360	2734	214	387	677	47	756

* addition of 1.0 g/L ferric ion

pyrolusite as oxidant

TABLE 4.7
Redtree – Final Leach Liquor Compositions

Exp. ID	pH	ORP (mV)	Temp. (ºC)	P_{80} (µm)	Al	Ca	Fe	Fe^{3+}	K	Mg	Mn	P	Si
LC9 B	2.0	500	40	250	340	156	1340	687	149	97	448	13	381
LC14 A**	2.0	500	40	250	403	156	1530	819	130	114	409	10	333
LC5 B	1.7	500	40	250	572	190	2819	1573	151	160	491	45	540
LC3 B	1.5	500	40	250	698	204	3090	1902	248	195	579	43	580
LC13 B**	1.5	500	40	250	739	241	3510	2131	200	223	528	52	667
LC5 A	1.3	500	40	250	846	254	3909	2344	201	232	557	84	731
LC6 B	1.5	550	40	250	741	201	3470	2485	215	216	658	41	632
LC3 B	1.5	500	40	250	698	204	3090	1902	248	195	579	43	580
LC12 B#	1.5	500	40	250	672	241	3330	1855	189	201	1300	51	616
LC6 C	1.5	450	40	250	745	222	3060	873	172	209	280	48	625
LC7B	1.5	500	30	250	592	206	2290	660	154	165	487	43	481
LC3 B	1.5	500	40	250	698	204	3090	1902	248	195	579	43	580
LC10B	1.5	500	50	250	1060	177	4410	2364	285	285	694	42	613
LC8 C*	1.5	500	40	250	763	154	4140	2369	258	189	486	25	689
LC3 B	1.5	500	40	250	698	204	3090	1902	248	195	579	43	580
LC13 A	1.5	500	40	350	725	176	3970	2649	223	200	504	28	657
LC3 B	1.5	500	40	250	698	204	3090	1902	248	195	579	43	580
LC7 C	1.5	500	40	150	825	216	3580	1885	172	243	827	43	628
LC11 B	1.5	500	40	75	709	210	3790	2266	147	216	697	49	630

* addition of 1.0 g/L ferric ion ** duplicate

pyrolusite as oxidant

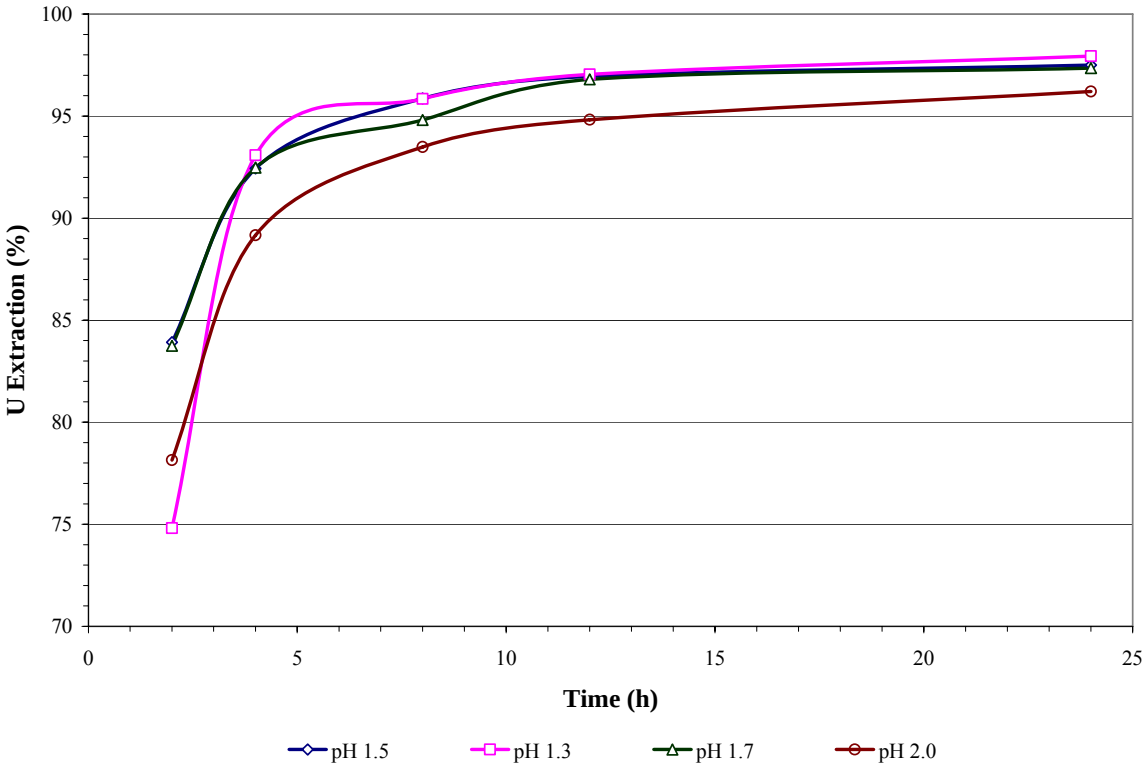


FIGURE 4.3 Effect of pH on the Leaching of Junnagunna Composite (40 °C, 500 mV)

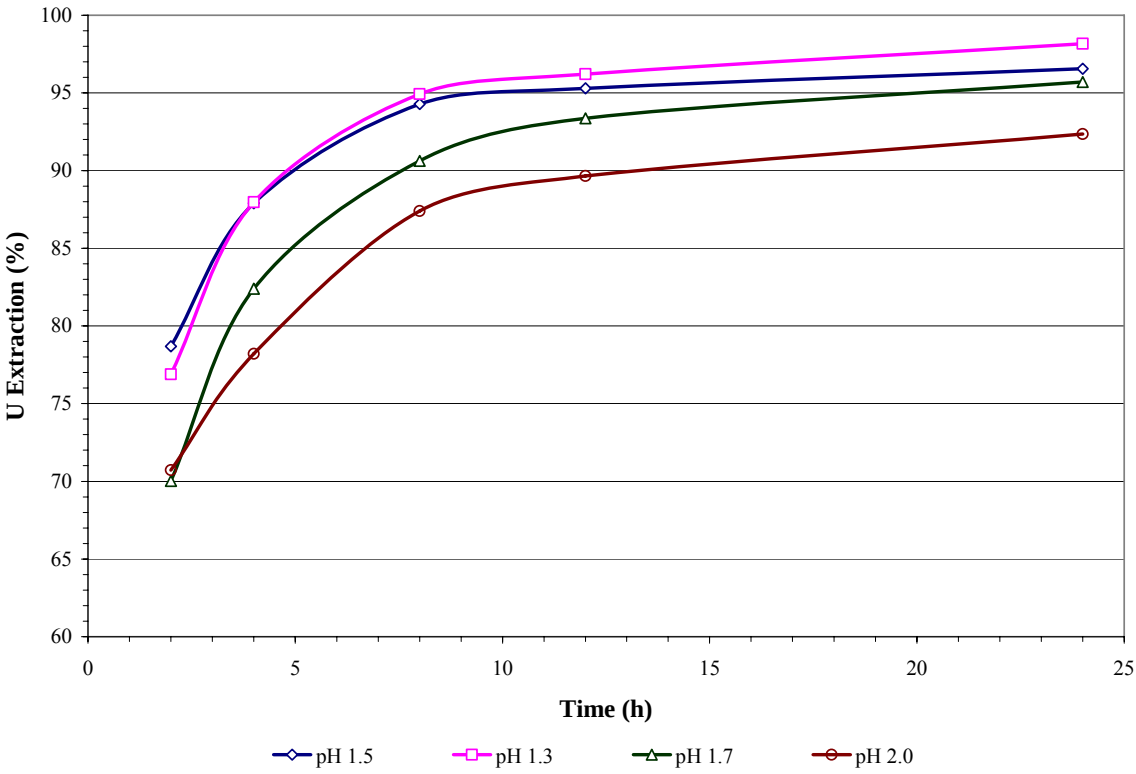
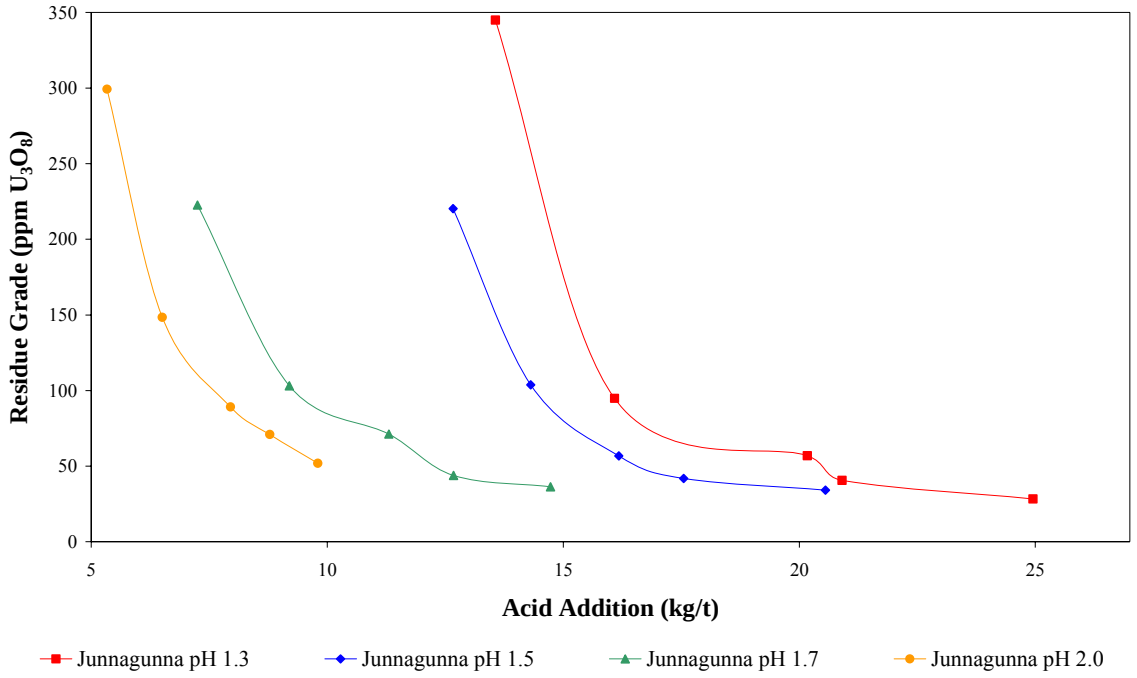


FIGURE 4.4 Effect of pH on the Leaching of Redtree Composite (40 °C, 500 mV)



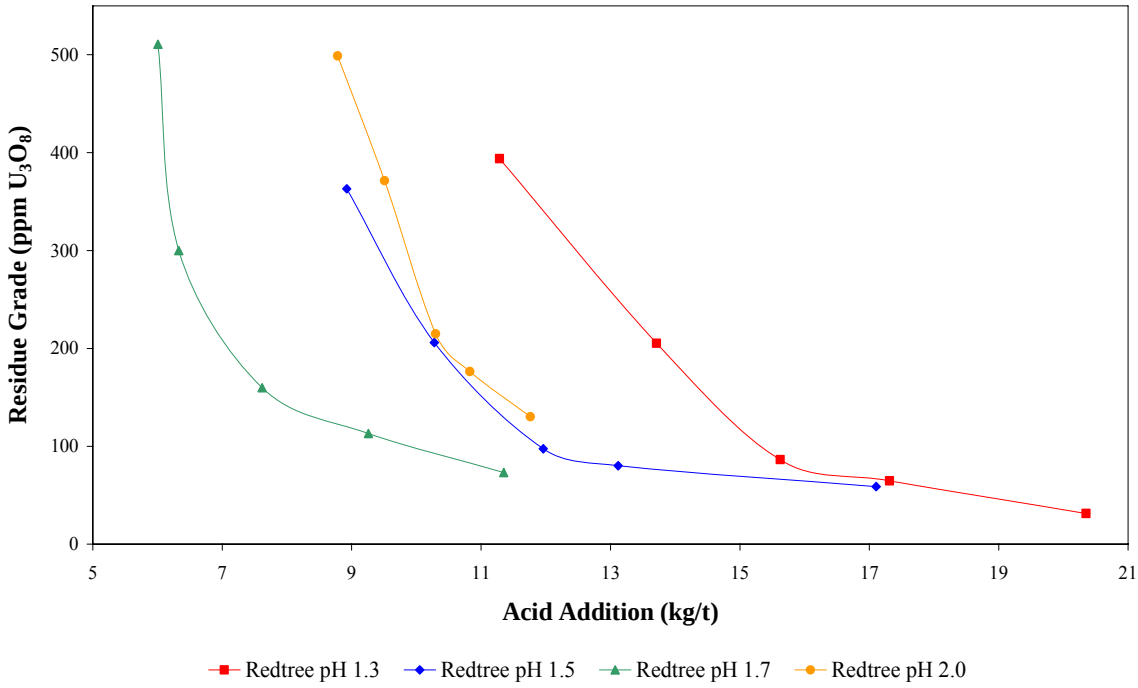


FIGURE 4.5 Residue Grade as a Function of pH - Junnagunna and Redtree Ores (40 °C, 500 mV)

(ii) Effect of Temperature

The effect of leaching temperature is shown in **Figure 4.6** for Junnagunna and **Figure 4.7** for Redtree. These tests were carried out under similar base case conditions with temperature as the only variable. As expected, the uranium leaching rate increased with increasing temperatures from 30 °C to 50 °C. For both ores, leaching at 30 °C significantly decreased the

extraction rate, and to a lesser extent, the final extraction of uranium. The initial rate of leaching was reduced at 40 °C, but extractions were quite similar to those at 50 °C after 12 h.

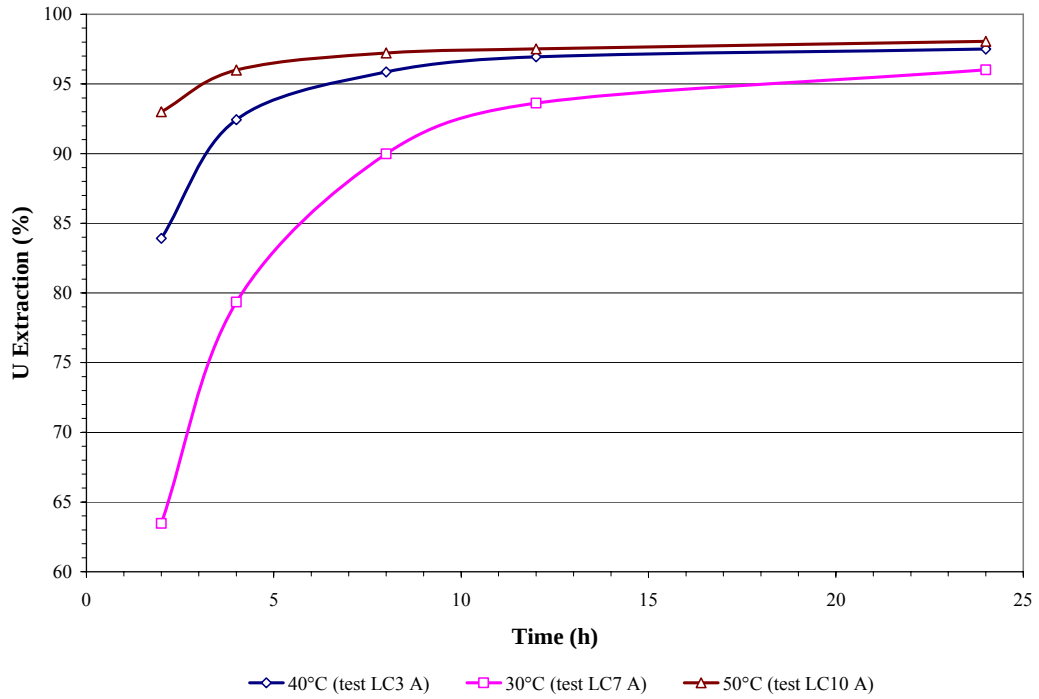


FIGURE 4.6 Effect of Temperature on Leaching of Junnagunna (pH 1.5, 500 mV)

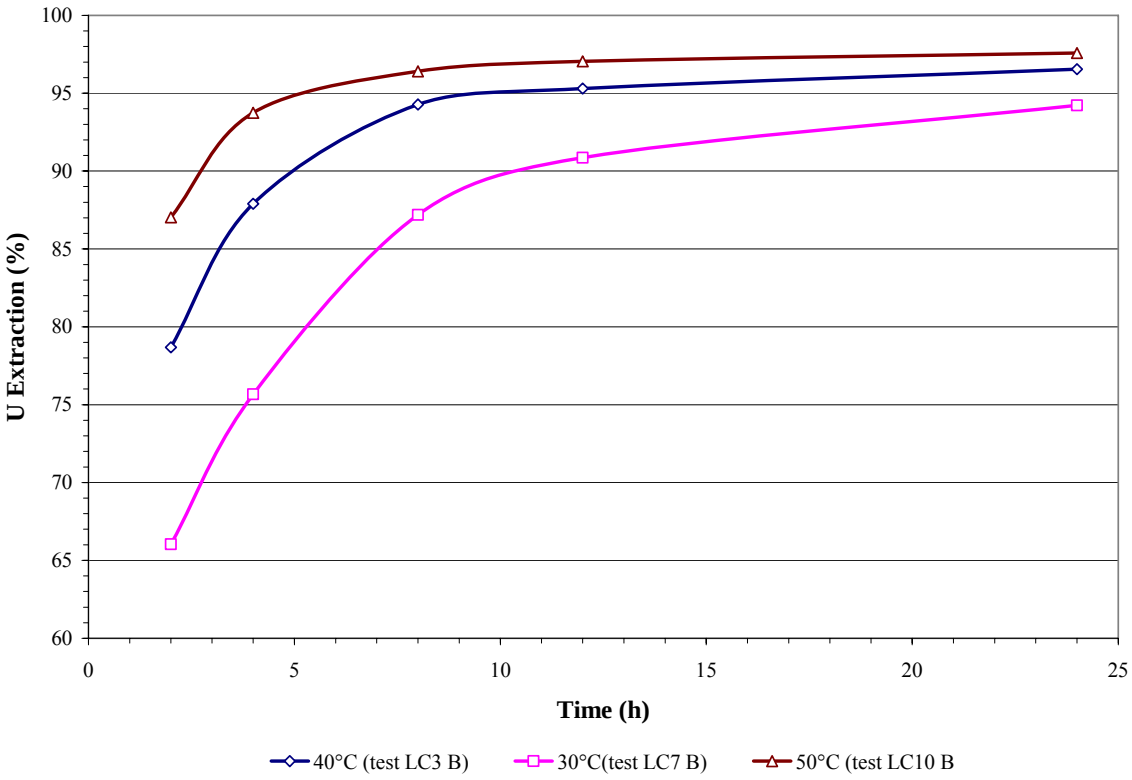


FIGURE 4.7 Effect of Temperature on Leaching of Redtree (pH 1.5, 500 mV)

The impact of temperature on acid addition and residue grades is shown in **Figures 4.8** and **4.9.** Although temperature has a significant effect on the initial extraction rate, there is also a

significant relative increase in the acid addition. At the highest temperature, after 8 h leaching, the rate of gangue dissolution, as reflected in the acid addition, is much greater than the decrease in the uranium residue grade. Whereas at 30 °C, the relative rates of uranium and gangue dissolution are still reasonably favourable after 24 h.

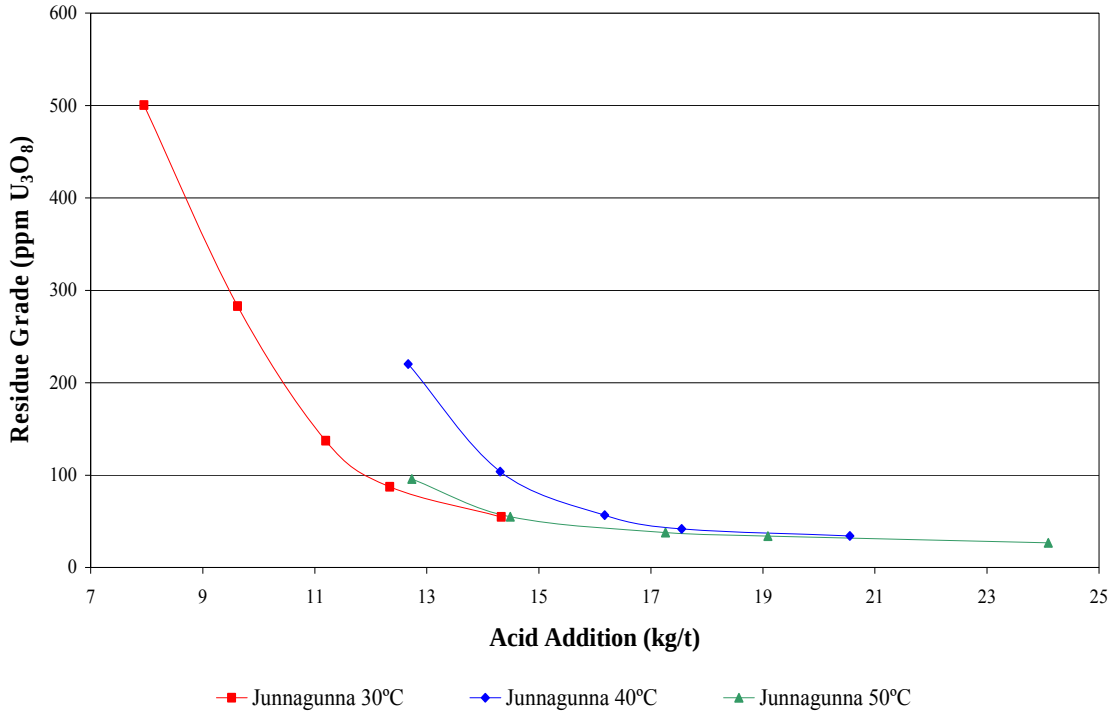


FIGURE 4.8 Effect of Temperature on Acid Addition for Junnagunna (pH 1.5, 500 mV)

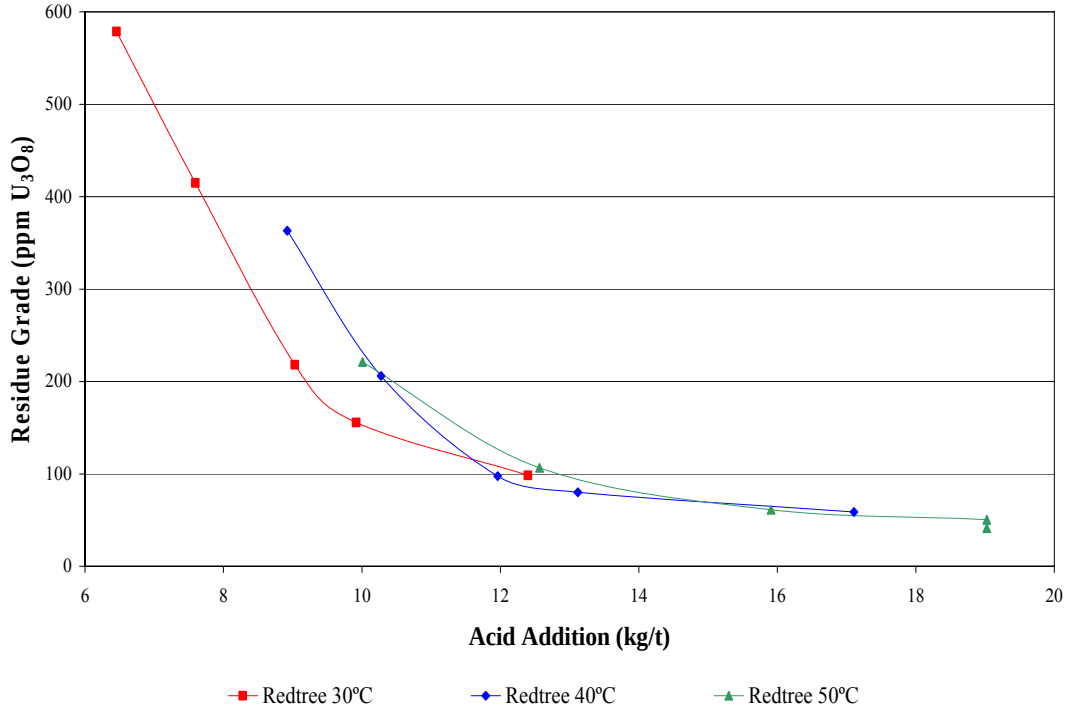


FIGURE 4.9 Effect of Temperature on Acid Addition for Redtree (pH 1.5, 500 mV)

(iii) Effect of ORP

The effect of oxidation potential is shown in **Figure 4.10** for Junnagunna and **Figure 4.11** for Redtree. In both cases, similar final uranium extraction results were achieved for leaching at ORP levels of 500-550 mV. Uranium extraction decreased when leaching at 450 mV. Addition of 1.0 g/L ferric ion at 500 had a slight impact on the rate of extraction, but there was little difference after 12 h. A similar result was achieved by leaching at 550 mV, and this approach would be preferred to adding iron.

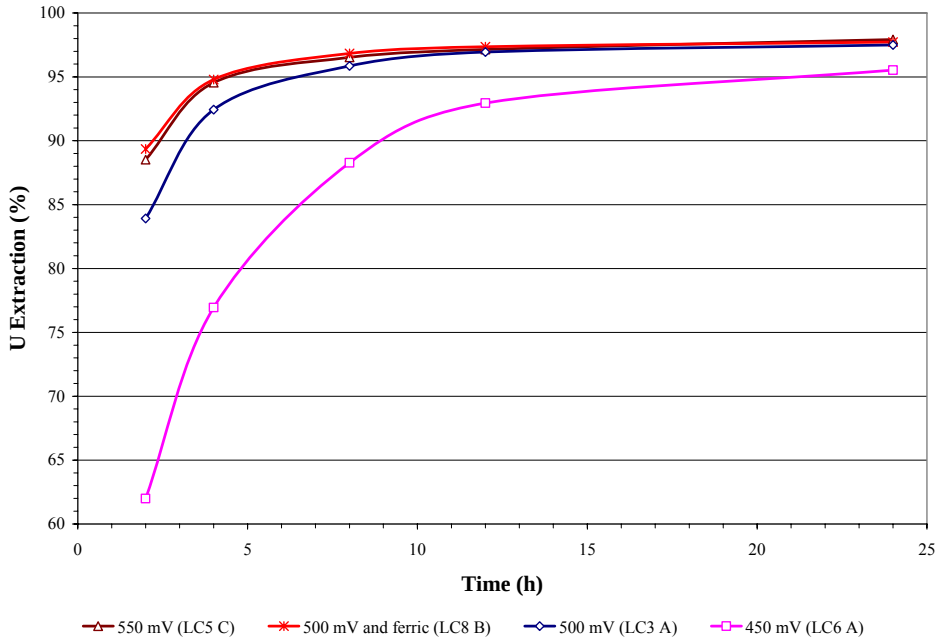


FIGURE 4.10 Effect of ORP on the Leaching of Junnagunna Composite

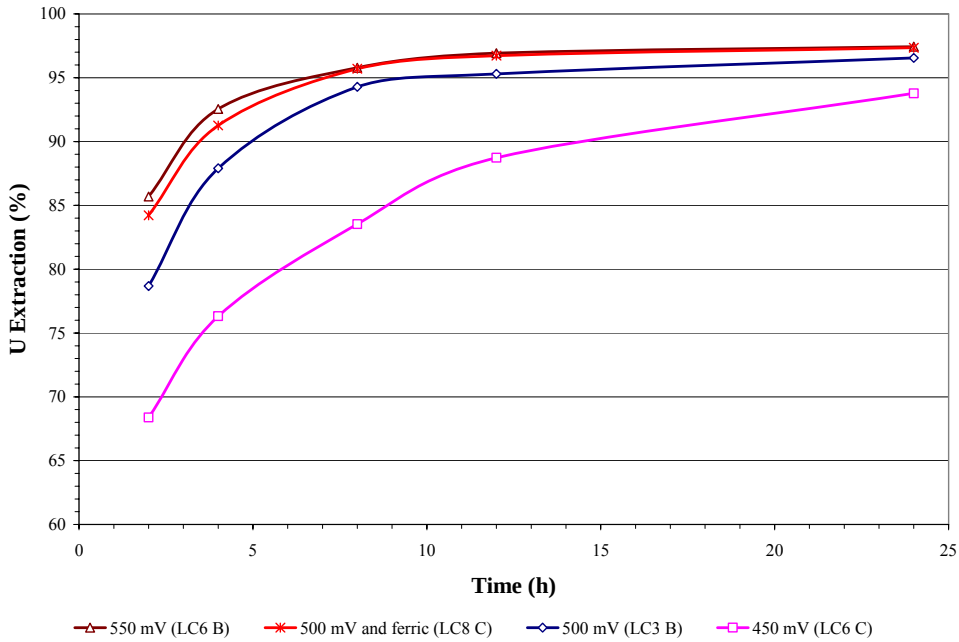


FIGURE 4.11 Effect of ORP on the Leaching of Redtree Composite

The effect of ORP on oxidant addition is shown in **Figures 4.12** and **4.13**. For both samples, there is a significant increase in demand for increasing the ORP from 450 to 500 mV, but only a further small addition is required to achieve 550 mV. The oxidant demand for both samples was very similar for both samples.

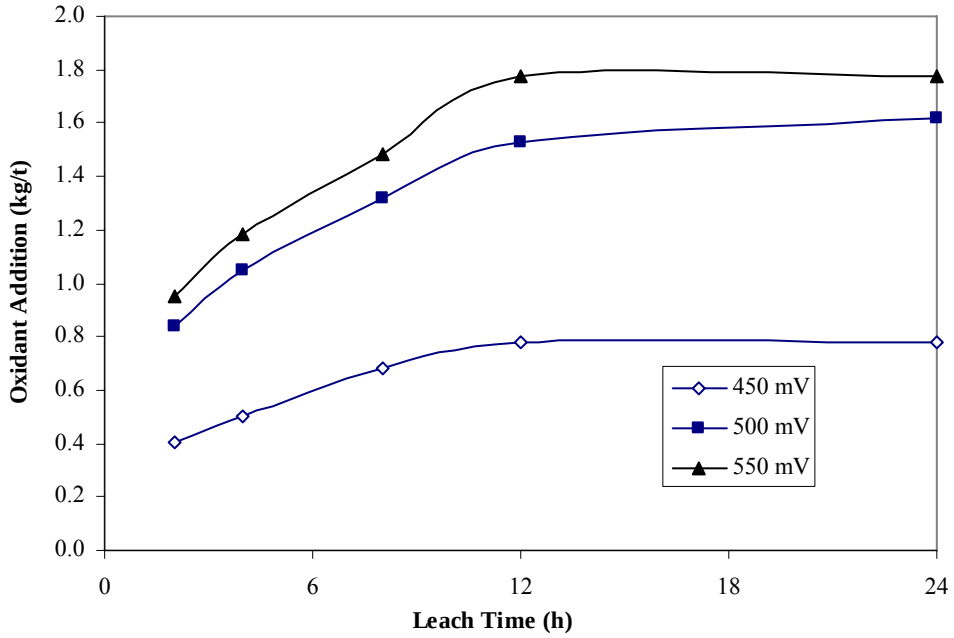


FIGURE 4.12 Effect of ORP on the Oxidant Demand for Redtree Composite

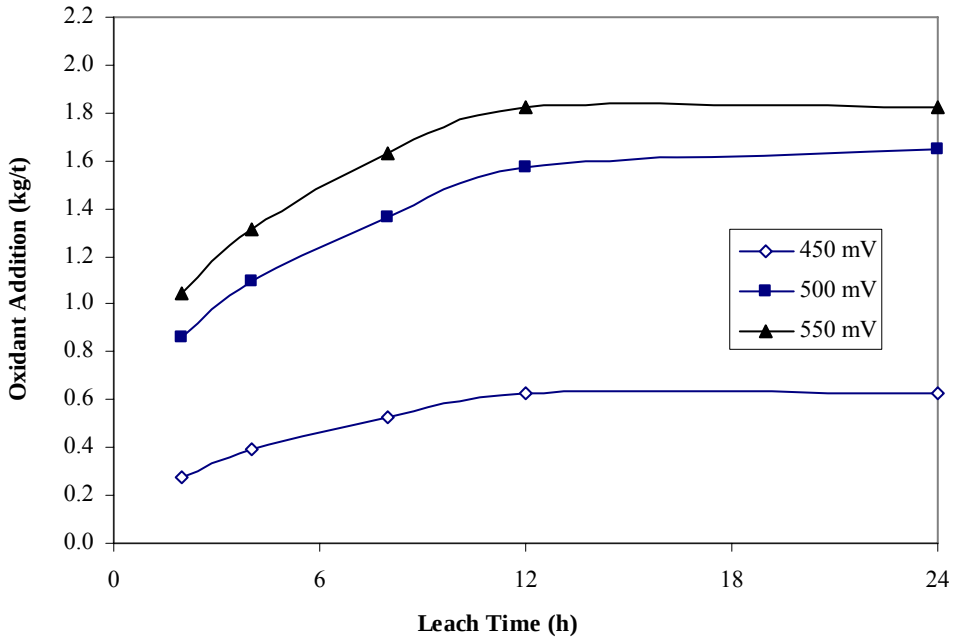


FIGURE 4.13 Effect of ORP on the Oxidant Demand for Junnagunna Composite

The ORP is adjusted to control the concentration of ferric ion. Ferric ion profiles are shown in **Figures 4.14** and **4.15**. At 450 mV, the ferric ion only just reached 1 g/L, whereas at the higher ORPs, ferric was between 1.0 to 2.5 g/L for the entire leach. The results for an addition

of 1.0 g/L ferric ion at 500 mV show an initial increase in ferric ion, but the final concentration was much the same. As the leaches where iron was added achieved the same uranium extraction results after 12 h as the leaches at 550 mV, it would appear that increasing the ferric ion concentration above say 2-2.5 g/L was of little benefit.

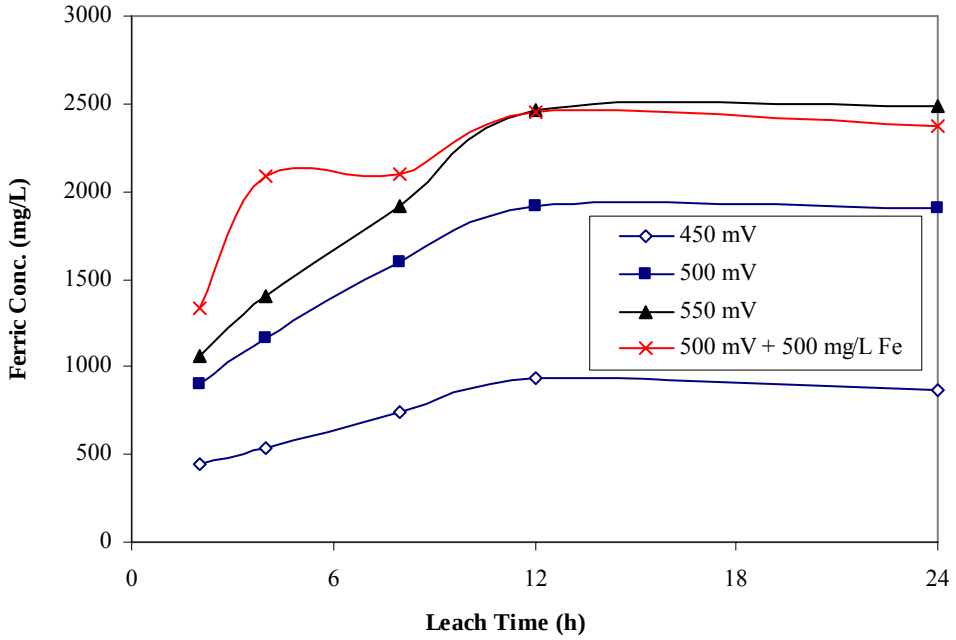


FIGURE 4.14 Effect of ORP on the Ferric Concentration for Redtree Composite

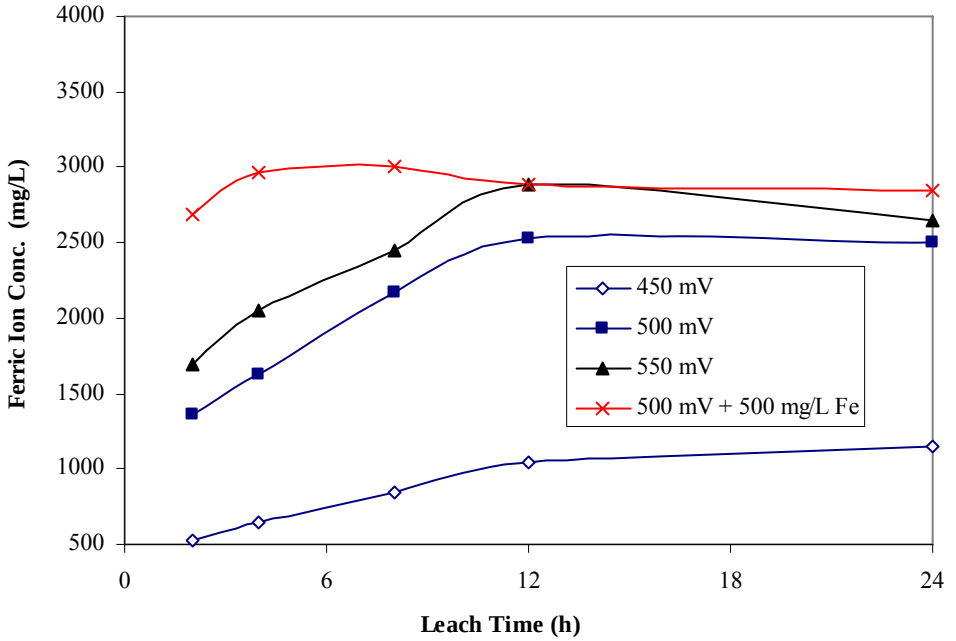


FIGURE 4.15 Effect of ORP on the Ferric Concentration for Junnagunna Composite

(iii) Effect of Grind Size

The effect of grind size on uranium extraction was examined at varying P_{80} grind sizes of 350, 250, 150 and 75 µm under base case conditions (pH 1.5, 40 °C and ORP of 500 mV). As shown in **Tables 4.3 and 4.4**, the total acid addition was virtually independent of grind size for both ores. Leach residue data is shown in **Figures 4.16** and **4.17**. These results indicate that, compared to the base case, there was no significant benefit to be obtained from finer grinding, apart from faster initial uranium leaching kinetics, noting that a similar effect can probably be achieved by increasing the ORP. Grinding to a P_{80} of 350 µm significantly reduced the rate of uranium extraction up to about 12 h for the Redtree sample. On this basis a P_{80} of 250 µm would probably be selected to target a 12 h leach time.

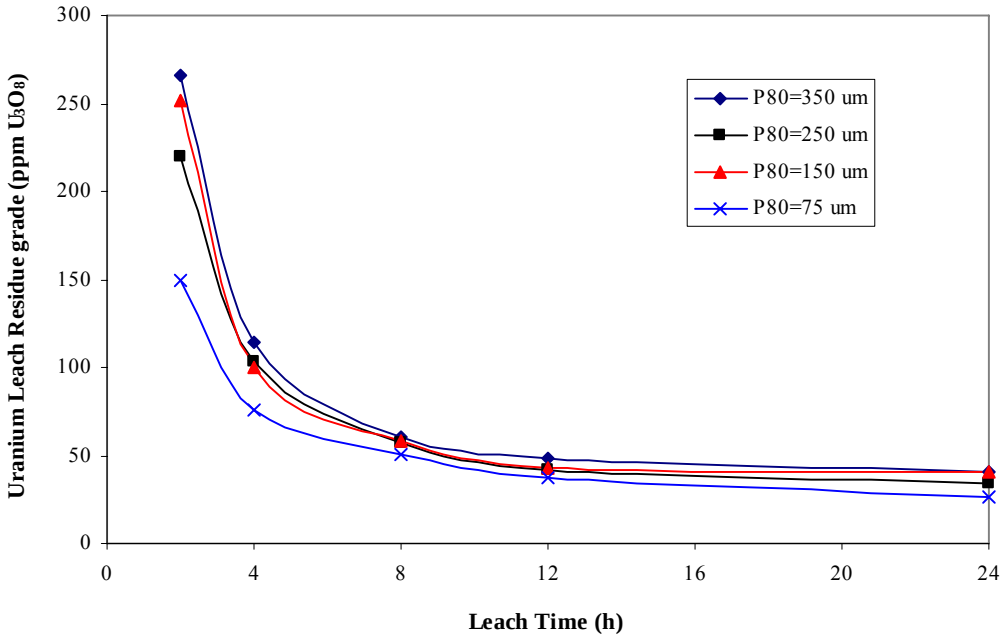


FIGURE 4.16 Effect of Grind Size on Leaching of Junnagunna Composite

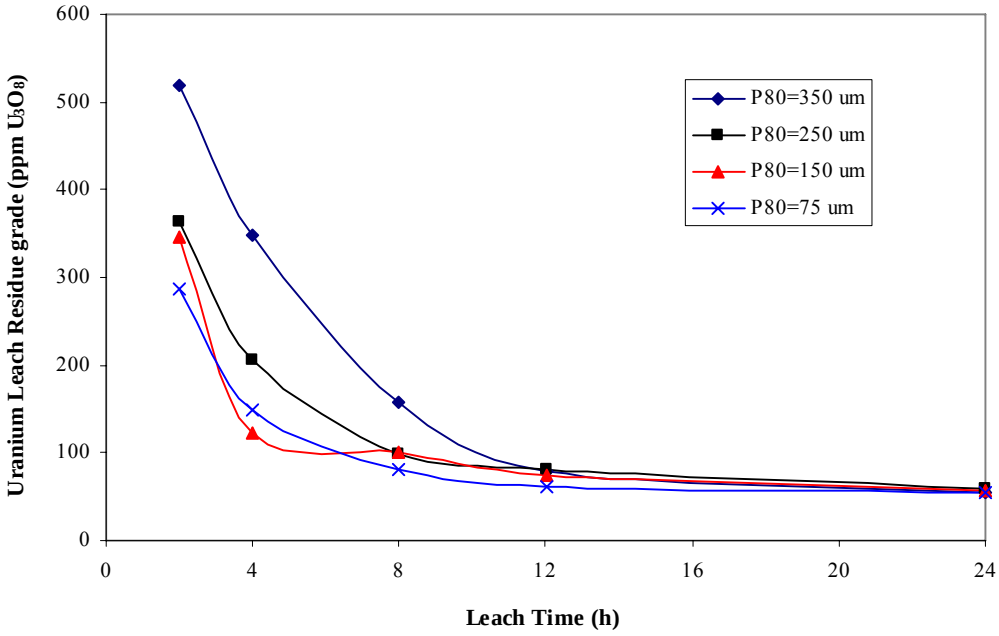


FIGURE 4.17 Effect of Grind Size on Leaching of Redtree Composite

4.2.4 Comparison of Oxidants

For ease of control, sodium permanganate was used in most leach test. Base case leaches for Junnagunna and Redtree were also carried out using pyrolusite to demonstrate that both oxidants gave equivalent results. The base case leach data for the two oxidants are compared in **Table 4.7.** The oxidation equations for the two oxidants are given below, and show that differences in acid consumption for the Fe^{2+} oxidation reaction need to be considered:

$$4H^+ + MnO_2 + 2Fe^{2+} \rightarrow Mn^{2+} + 2Fe^{3+} + 2H_2O \quad (1)$$

$$8H^+ + MnO_4^- + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O \quad (2)$$

When pyrolusite is used as an oxidant, for every mole of Fe^{2+} oxidised one mole of H_2SO_4 is consumed. As the ratio is 0.8 moles of H_2SO_4 consumed for every mole of Fe^{2+} for permanganate, acid additions due to Fe^{2+} oxidation are 20% lower when this oxidant is used. Thus for a sodium permanganate addition of 1.6 kg/t, the acid saving compared to MnO_2 would be 1.1 kg/t. As shown in **Table 4.8,** acid requirements for pyrolusite were in fact slightly less for pyrolusite after 24 h, but about 0.6 kg/t greater on average at 12 h when oxidant addition was stopped. For pyrolusite containing 75% reactive MnO_2, the equivalent addition to 1.6 kg/t sodium permanganate is 3.3 kg/t. This predicted requirement is close to the experimental data.

The results show that essentially the same extractions of uranium were obtained for the two oxidants after 24 h. **Figure 4.18** also indicates that the rate of leaching was almost identical for the samples, but noting that the initial rate for pyrolusite with Junnagunna was slower than permanganate, probably resulting from the additional time to reach ORP set-point with pyrolusite at the start of the leach. (as pyrolusite reacts relatively slowly, care is taken not to overdose at the start of leaching).

TABLE 4.8
Comparison of Leaching Data for Different Oxidants*

Exp. ID	Acid Addition (kg/t)	Oxidant Addition (kg/t)	ORP at 24 h (mV)	Residue Grade (ppm U_3O_8)	Uranium Extraction* (%)
Junnagunna					
LC3 A	20.6	1.6	485	34	97.5
LC12 A	20.0	2.9#	481	38	97.2
Redtree					
LC3 B	17.1	1.6	477	59	96.5
LC12 B	17.0	2.8#	472	53	96.9

* pH 1.5, 40°C, 500 mV, P_{80}=250 µm # pyrolusite as oxidant

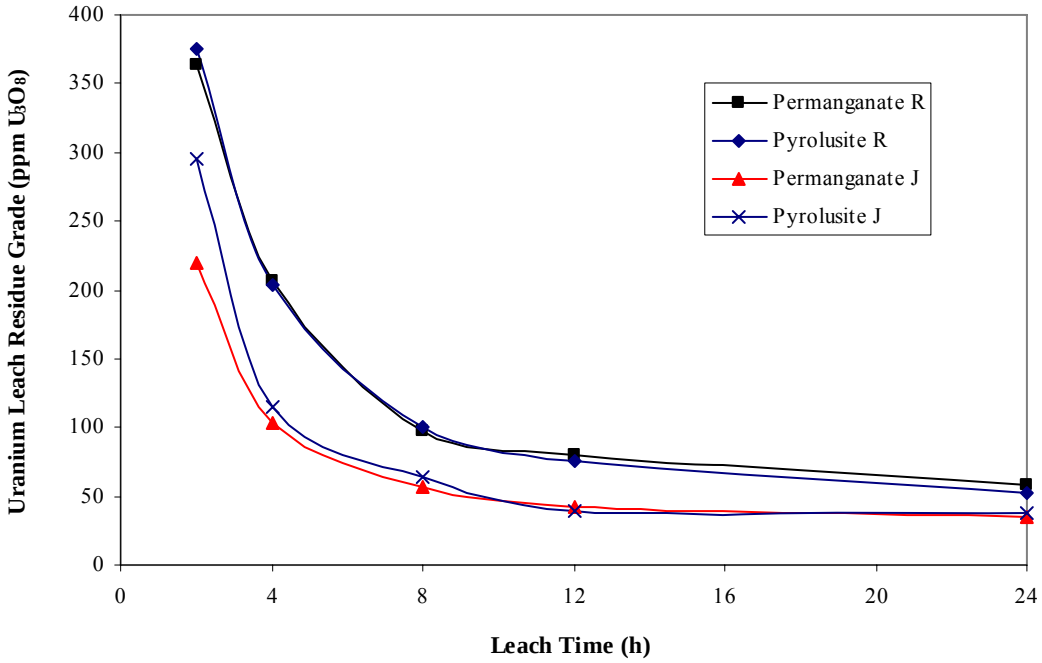


FIGURE 4.18 Effect of Oxidant Type on Leach Residue Grade (base case)

4.2.5 Leaching of Jack Ore

As per the agreed work plan, only one leach test was initially carried out on Jack ore, under the base case optimum conditions determined for the Junnagunna and Redtree. Base case leaches for the three samples are compared in **Table 4.9** and **Figure 4.19.** As seen in the figure, the rate of decrease in the residue grade between 2-8 h for Jack ore was substantially less than that of the other two samples. This result could be due to the very low ferric ion concentration in the Jack leach liquor, also shown in **Figure 4.19**.

As the extraction was considerably less than obtained for the other samples, and unlike the others, significantly less than the dilute leach result (see **Table 4.9**), additional tests were undertaken in an effort to improve extraction. Results are shown in **Table 4.10** and **Figure 4.20**. Addition of 1 g/L Fe, leaching at pH 1.2, and leaching at a finer grind of P_{80} = 150 µm at pH 1.5 with addition of Fe, all increased the extraction from 87% for base case conditions to 91-91.5%, after 24 h.

Optimum conditions for the Jack sample would either be leaching at pH 1.2, with other conditions at base case, or leaching at pH 1.5, with addition of 1 g/L Fe. Note that the latter conditions may occur if Jack ore was blended with either Junnagunna or Redtree because of the amount of iron dissolved from these ores. Further work is recommended to identify conditions that could increase extraction from the Jack ore.

TABLE 4.9
Comparison of Base Case Results for the Three Ores*

Sample	ID	Acid Addition (kg/t)	Oxidant Addition (kg/t)	Residue Grade (ppm U_3O_8)	Uranium Extraction (%)	Extraction Dilute Leach (%)
Jack	LC12 C	5.5	0.37	119	87.2	97.6
Junnagunna	LC3 A	20.6	1.6	34	97.4	99.0
Redtree	LC3 B	17.1	1.6	59	96.5	98.8

* pH 1.5, 40 °C, P_{80} = 250 µm, 500 mV, no ferric addition, 24 h

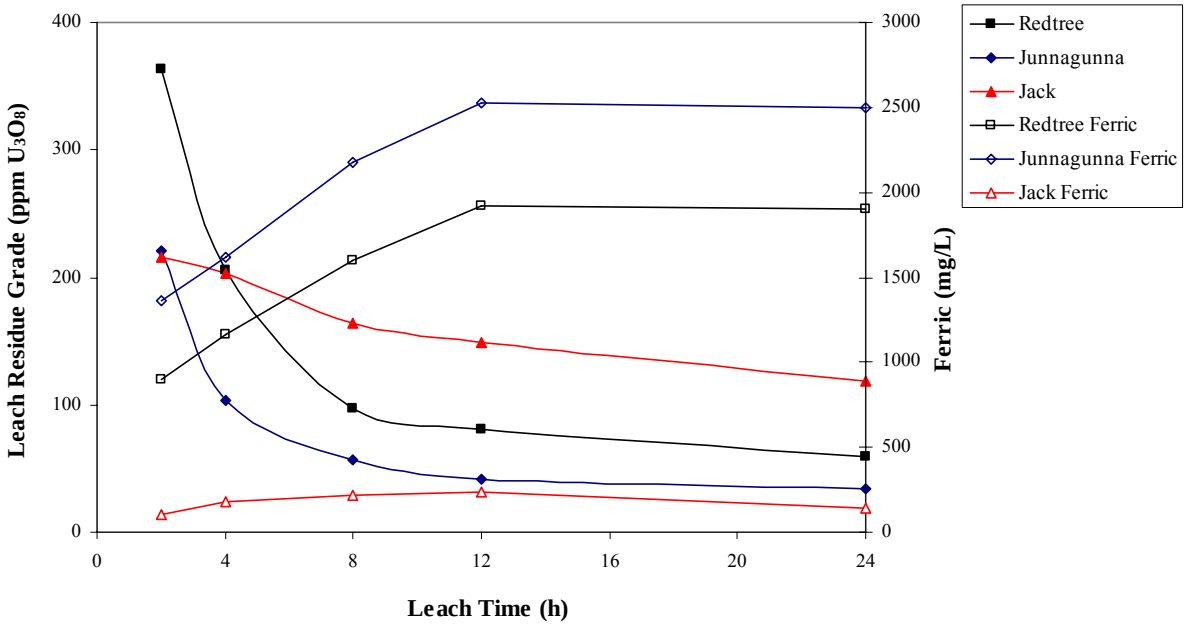


FIGURE 4.19 Comparison of Leaching for the Three Ores (base case conditions)

TABLE 4.10
Optimisation Leaching Results for Jack Sample*

Exp. ID	pH	ORP (mV)	Ferric Addition	Acid Addition (kg/t)	Oxidant Addition (kg/t)	Residue Grade (ppm U_3O_8)	Uranium Extraction (%)
LC12 C	1.5	500	none	5.5	0.37	119	87.2
LC15A	1.2	500	none	9.8	0.28	79	91.5
LC16A	1.5	500	1.0 g/L	4.0	0.14	83	91.0
LC16B	1.2	500	1.0 g/L	8.9	0.11	81	91.3
LC16C[#]	1.5	500	1.0 g/L	4.3	0.28	82	91.2

* 40 °C, P_{80} = 250 µm, 24 h [#] P_{80} = 150 µm

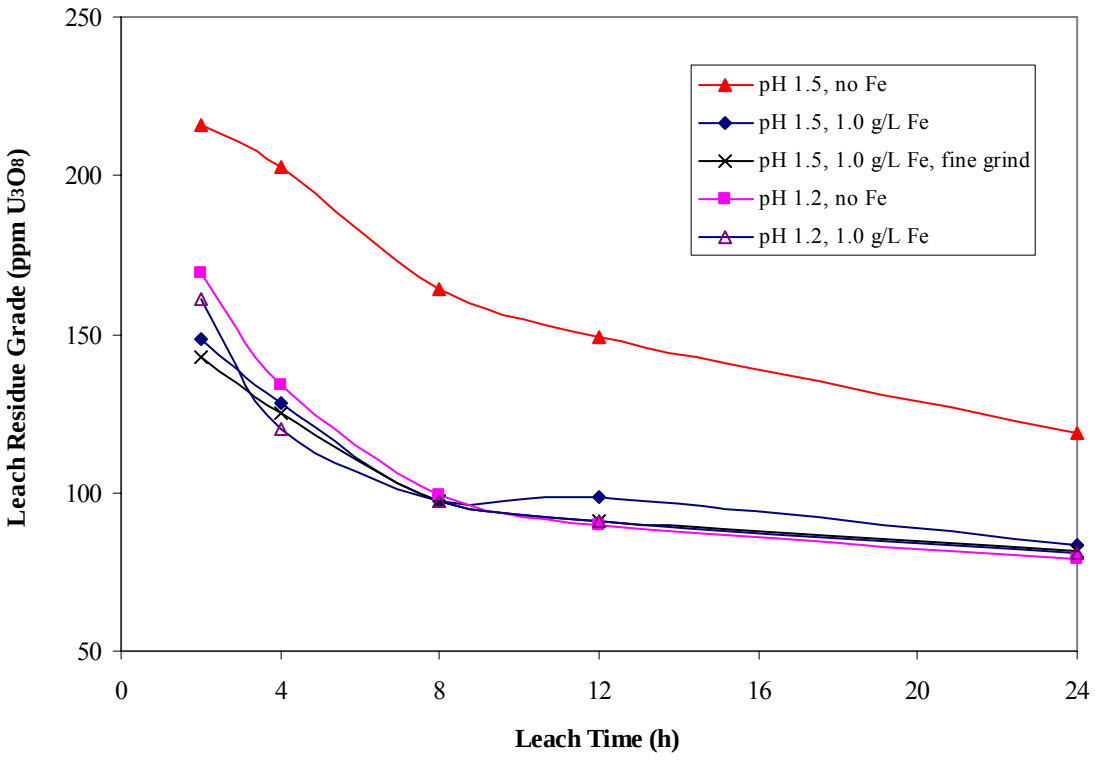


FIGURE 4.20 Effect of pH and Ferric Addition on Uranium Residue Grade - Jack

4.2.6 Leach Liquor Composition

- The 24 h leach liquor compositions are compared in **Tables 4.11 and 4.12**. For the Junnagunna and Redtree ores, iron was the dominant ion in solution. For the Junnagunna ore the concentrations of elements in solutions generally decreased in the order:

Fe>Al>Si>Ca>Mg≈K>P>As

- The Redtree ore contained about 6 times the level of arsenic than the Junnagunna ore, hence the much higher arsenic levels in solutution. For the Redtree ore the concentrations of elements in solution generally decreased in the order:

Fe>Al>Si>Ca≈As≈K≈Mg>P

Manganese was also present at a concentration of between 1300 and 1900 mg/L when pyrolusite was used as the oxidant. In most tests sodium permanganate was used as the oxidant, which resulted in a Mn concentration of ~ 550 mg/L and a sodium concentration of ~ 300 mg/L. When pyrolusite was used, the sodium concentration was only 40-90 mg/L. The high iron concentration, when converted to ferric ion, is sufficient to ensure rapid oxidation/dissolution of uranium.

For Junnagunna and Redtree ores, the following general impacts of leach variables were evident:

- The concentrations of all elements, except K, increased with decreasing pH;

- The concentrations of all elements, except Ca and P, increased with increasing temperature;
- Grind size had little impact on the concentrations of gangue elements in solution;
- The concentrations of all elements increased with increased leaching time, as shown in **Figure 4.21** for Junnagunna ore.

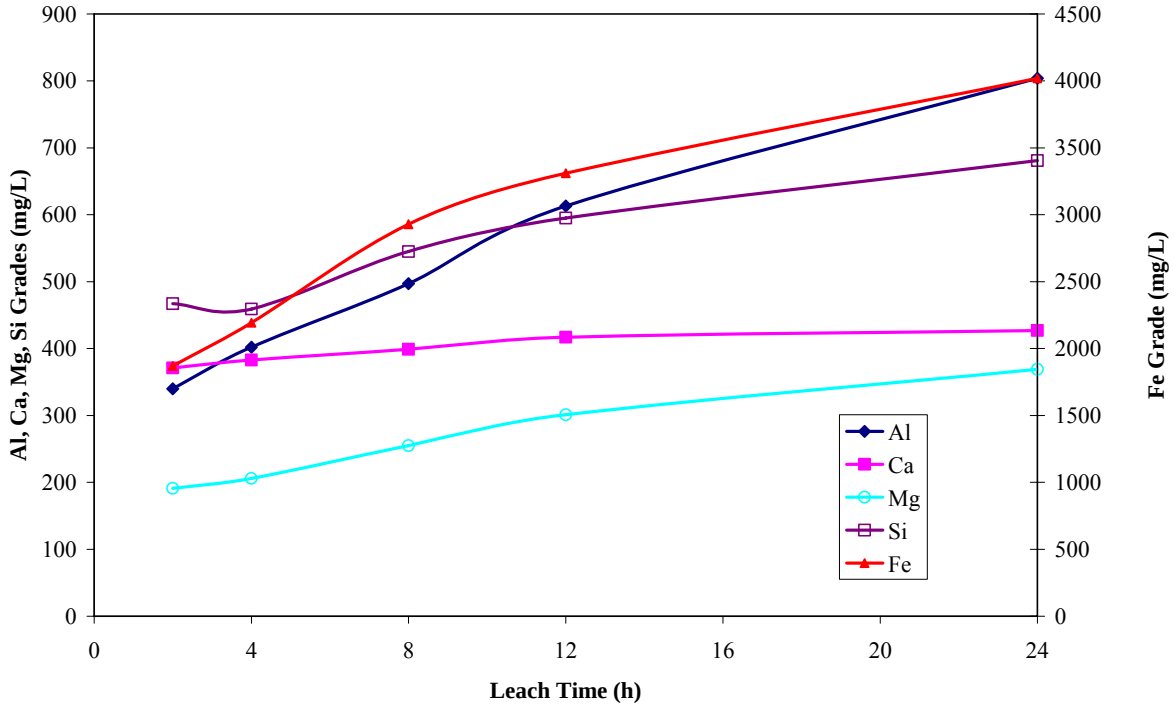


FIGURE 4.21 Gangue Element Solution Grades - Junnagunna

The final leach liquor compositions for the three ores, compared in **Table 4.11,** show that:

- The concentrations of all elements were marginally greater in the Junnagunna liquor compared to Redtree (except for As), which is reflected in the acid requirement;
- None of the gangue element concentrations in solutions would be expected to result in downstream processing problems. The Si concentrations are typical of many of the acid uranium leach liquors that are currently being processed, but noting that it is the form of the silica, rather than the total concentration, that results in silica problems;
- Ferric concentrations are reasonably high in Junnagunna and Redtree, which is a positive for leaching, but will result in some degree of iron loading if IX is used for uranium recovery;
- Ca concentrations are less than saturation for the Redtree and Jack ores;
- The concentrations of all ions, except for P and Ca, were considerably less in the Jack liquors, as reflected by the very low acid requirement. The low iron concentration could be impacting on the rate of uranium dissolution;

TABLE 4.11
Comparison of 24 h Leach Liquor Compositions* (mg/L)

Ore type	Acid (kg/t)	Oxide .(kg/t)	Al	Ca	Fe	Fe^{3+}	U/Fe^{3+}	K	Mg	Mn	P	Si
Junnagunna	20.6	1.8	804	427	4020	2500	0.57	272	370	660	47	680
Redtree	17.1	1.7	698	204	3090	1900	0.77	248	195	580	43	580
Jack	5.5	0.39	239	284	380	139	5.6	190	29	147	103	264

* pH 1.5, 500 mV, P_{80} = 250 µm

The concentrations of minor elements determined by ICP/MS are given in **Appendix G,** with "majors" summarised in **Table 4.12**. The concentrations of the minors, and elements that could report to final product as penalty elements, eg Mo, V, Zr, are low. Arsenic was at the greatest concentration and may warrant additional attention in regards to waste water treatment.

TABLE 4.12
Comparison of 24 h Leach Liquor Compositions* (mg/L)

Ore type	As	Co	Cr	Cu	Mo	Nd	Ni	Pb	Th	V	Y	Zn	Zr
Junnagunna	38	13	6	5	28	5	8	5	2	30	8	2	<1
Redtree	181	10	8	6	6	3	18	3	1	11	4	1	<1
Jack	51	14	14	13	3	<1	14	2	<1	26	4	1	<1

* Junnagunna and Redtree: pH 1.5, 500 mV, P_{80} = 350 µm Jack: pH 1.2, 500 mV, P_{80} = 250 µm

4.3 Examination of Leach Residues

4.3.1 Uranium versus Size Distribution

The leach final residues for the Junnagunna and Redtree samples at the P_{80} = 250 µm grind were sized, and the size fractions were analysed for uranium. When compared to the size versus U distribution for unleached ore, an indication of U extraction as a function of size was obtained. Results for the feed ore and residues are shown in **Tables 4.13** and **4.14**.

For Junnagunna, the overall extraction was 97.5%, with a residue grade of 34 ppm. The data in **Table 4.13** shows high extractions for all size fractions, with extraction decreasing slightly in the three coarsest fractions. Residue grades were greatest, marginally, for the three finest fractions.

For Redtree, the overall extraction was 96.5%, with a residue grade of 59 ppm. The data in **Table 4.14** also shows high extractions for all size fractions, with extraction again decreasing slightly in the three coarsest fractions. Residue grades were greatest, marginally, for the three finest fractions and the coarsest fraction.

Even though extractions were lowest for the coarsest fractions for both ores, finer grinding is not recommended as these lower extractions were a function of the reduced head grades in these fractions.

The data, see **Figure 4.22**, show that the uranium distribution in both leach feeds was concentrated in the fines, with uranium concentrations in the < 38 µm fines of 2580 and 3150 ppm U_3O_8 for Junnagunna and Redtree, respectively. The < 106 µm fractions of both ores represented about 40% of the total mass, but contained 65 and 57% of the uranium. As shown in **Figure 4.23**, leaching did not markedly change the size versus uranium distribution in the leached residues, with 40-50% of the unleached uranium in the < 106 µm fractions.

TABLE 4.13
Junnagunna - Distribution of Uranium Before and After Leaching (base case)

	Feed (1370 ppm U_3O_8)			Residue Grade (34 ppm U_3O_8)			
Size (µm)	Cumulative wt% Passing	Grade (ppm U_3O_8)	Cumulative U Passing (%)	Cumulative wt% Passing	Grade (ppm U_3O_8)	Uranium Extraction (%)	Cumulative U Passing (%)
425	99.9		100	99.7			100.0
300	94.0	293	98.7	91.5	16	94.7	92.7
212	70.7	489	89.7	68.7	15	97.0	73.6
150	54.1	785	79.5	51.1	14	98.2	59.5
106	40.0	1326	64.9	37.7	14	99.0	49.2
75	30.5	1499	53.7	29.4	15	99.0	42.3
53	23.3	1671	44.3	23.0	16	99.1	36.6
45	20.5	1910	40.1	20.3	20	99.0	33.7
38	17.9	1977	36.2	18.7	23	98.8	31.5
<38		2576	0.0	0	30	98.8	
Calc. Head		1370					

TABLE 4.14
Redtree - Distribution of Uranium Before and After Leaching (base case)

	Feed (1700 ppm U_3O_8)			Residue Grade (59 ppm U_3O_8)			
Size (µm)	Cumulative wt.% Passing	Grade (ppm U_3O_8)	Cumulative U Passing (%)	Cumulative wt.% Passing	Grade (ppm U_3O_8)	Uranium Extraction (%)	Cumulative U Passing (%)
425	99.4		100.0	99.7			100.0
300	89.1	469	97.0	90.5	40	91.5	89.3
212	64.9	1062	81.1	67.1	32	97.0	67.7
150	49.8	1236	69.7	48.9	31	97.5	51.1
106	36.9	1577	57.1	35.3	28	98.2	39.9
75	28.2	1630	48.4	27.0	30	98.2	32.7
53	22.1	2088	40.4	20.6	32	98.4	26.6
45	19.5	2215	37.0	17.8	36	98.4	23.7
38	17.1	2463	33.3	16.1	37	98.5	21.9
<38		3150			47	98.5	
Calc. Head		1620					

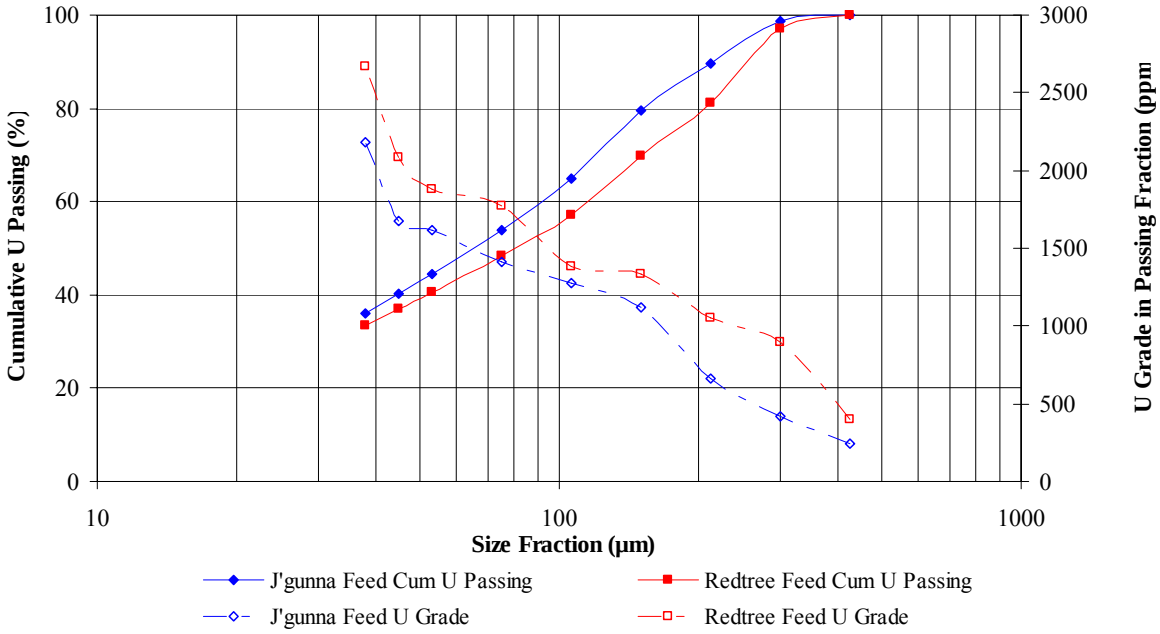


FIGURE 4.22 Distribution of Uranium in Leach Feeds

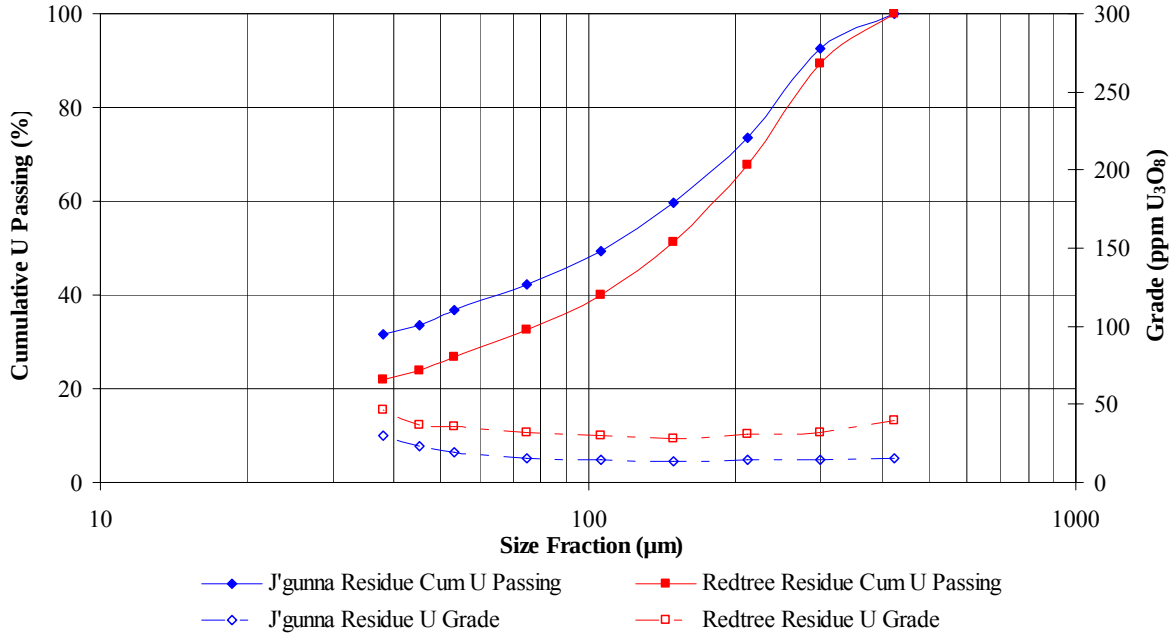


FIGURE 4.23 Distribution of Uranium in Leach Residues

4.3.2 XRD Examination

Quantitative XRD showed that the mineralogy of the Junnagunna, Redtree and Jack ores did not change significantly during leaching (see **Appendix H)**. Hydroxylapatite was detected in the Junnagunna ore, but not in the leach residue, indicating that it had most likely dissolved during leaching.

4.3.3 SEM Examination

The findings of the SEM examination are reported in **Appendix H**. In addition to the gangue minerals identified by XRD, and reported in **Section 3.3**, SEM analysis of the leach residues (3A, 3B and 12C) showed that other gangue minerals such as rutile/anatase (TiO_2), zircon ($ZrSiO_4$), pyrite (FeS_2), monazite ($(Ce,La,Nd,Th)PO_4$), florencite ($(Ce,La)Al_3(PO_4)_2(OH)_6$), galena (PbS), iron copper sulphide, copper sulphide and barite ($BaSO_4$) were also present in the samples.

The residual uranium minerals after leaching consisted of coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$), uranium phosphate, probably phosphuranylite ($KCa(H_3O)3(UO_2)_7(PO_4)_4O_4{\cdot}8(H_2O)$), and uraniferous zircon, where coffinite was the most common uranium mineral. They were almost always enclosed in quartz particles. Various amounts of arsenic were detected in most uranium minerals. Lead was found only in coffinite.

The major findings from the SEM examination were:

- Coffinite and the uranium phosphate similar in composition to phosphuranylite were found in all residues. Uraninite/pitchblende, uraniferous zircon and a uranium phosphate similar in composition to autunite were detected only in the residues of the Redtree and Jack samples;
- The uranium bearing minerals in the residues of Junnagunna and Redtree were enclosed within quartz, with the one exception of coffinite intimately intergrown with zircon in Redtree. They did not appear altered by leaching. It is likely that the acid solution could not penetrate the enclosing quartz, since no liberated or partially exposed uranium minerals were found. The coffinite intimately intergrown with zircon appeared to be refractory to the leaching conditions employed;
- The uranium phosphates in the residue of Jack ore were only partially dissolved even they were exposed to the leach liquor. Their solubility was limited under the test conditions. The other uranium minerals in this residue appeared to be soluble under the test conditions, since they were detected only as inclusions in quartz. Moreover, a uraninite/pitchblende grain and a uraniferous zircon grain, which were enclosed in quartz, were partially dissolved. Their dissolution was limited by the reduced permeability of the quartz particles.

4.4 Settling Testwork

Limited settling and filtration tests were carried out by ANSTO personnel on slurries from Junnagunna and Redtree generated in the laboratory program at the base case grind of P_{80} = 250 μm and 30 °C (pH 1.5, 500 mV).

The batch tests were performed in a 1 L measuring cylinder. Magnafloc E10 at a concentration of 0.025 wt% was the flocculant used. All leach slurries were diluted with filtered leach liquor to ~8 wt% solids. The leached slurry settling tests were performed at a temperature of 30°C. Settling data, which can be found in **Appendix I,** is summarised in **Table 4.14,** with the settling rate curves in **Figure 4.24**. These preliminary flocculant and thickener requirements indicate that solid/liquid separation by settling would be applicable. Further optimisation was carried out in the bulk leach test work phase.

TABLE 4.15
Batch Settling Data

Leach Test	Feed (wt%)	Flocculant Added (g/t)	Settled Density (wt%)	Mass Flux (t/m^{2}h)	Unit Thickener Area (m^2/t solids/day)
LC7 A - Junnagunna 30 ºC	7.5	62.5	39.9	0.103	0.406
LC7 B - Redtree 30 ºC	6.6	71.6	37.6	0.142	0.294

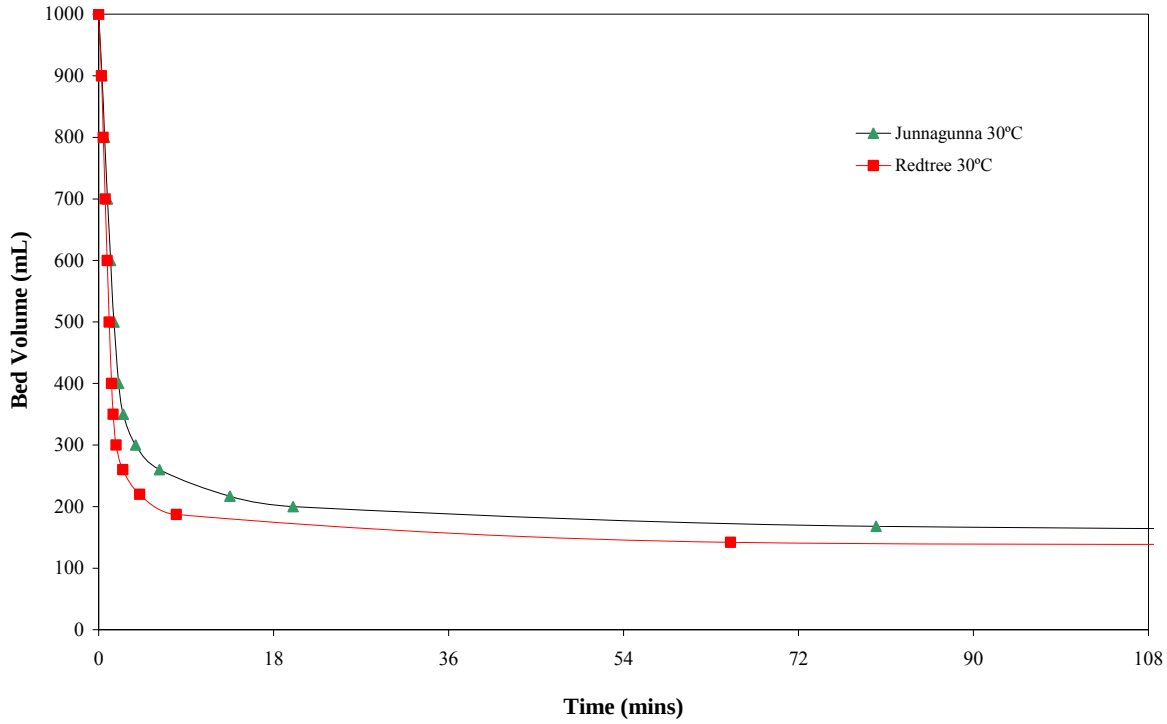


FIGURE 4.24 Batch Settling Rates for Leach Residues

4.5 Summary

4.5.1 Dilute Leaches

Dilute leaching tests on pulverised ore under ideal leach conditions showed that the uranium mineralisation was very amenable to leaching, with extractions of 98.6-99% achieved for the Junnagunna and Redtree samples. Extraction from the lower grade Jack ore was 97.6%. Compared to other ores tested by ANSTO Minerals, the concentrations of ions dissolved were low, decreasing in the order Si>Al≈Ca>K>Mg. Gangue dissolution was greatest for Garee Lower lens, and lowest for Jack Lens, noting that Fe dissolution cannot be estimated because iron was added to the leach solution.

4.5.2 Base Case and Initial Leaches

The Junnagunna and Garee Redtree samples were readily leached under conventional leaching conditions (55 wt% solids, 40 °C, pH 1.5, P_{80} of 250 µm and ORP of 500 mV),

achieving uranium extractions of 96.5-97.5% after 24 h. As very little uranium dissolution occurred between 12 and 24 h, a 12 h leaching time would be sufficient. The rate of leaching of uranium also responded to ORP, and an ORP of 550 mV is recommended. For these conditions uranium extraction was 97% for both ores, with acid additions of only 18 and 14 kg/t for Junnagunna and Redtree, respectively. Predicted pyrolusite requirements were also low at 3.0 kg/t for both ores.

The only conventional leach result conducted on the Jack sample, under base case conditions shows that reagent requirements were less than half those for Redtree, but uranium extraction was only 87% after 24 h.

4.5.3 Optimisation Tests on Junnagunna and Redtree

The optimisation tests on the Junnagunna and Redtree samples showed that:

- Varying the P_{80} grind sizes in the range 350 - 75 µm had negligible impact on uranium extraction and acid addition. Finer grinding resulted in faster initial uranium leaching kinetics, but a similar effect can was achieved by increasing the ORP. Grinding to a P_{80} of 350 µm significantly reduced the rate of uranium extraction up to about 12 h for Redtree. On this basis a P_{80} of 250 µm would probably be selected to target a 12 h leach time.
- Leach pH over the range 1.3 – 1.7 had little impact on uranium recovery for Junnagunna ore. At pH 2, extraction was reduced by 1% to ~ 96%. For the Redtree sample, the 24 h extraction increased from 92% to 98% when the leaching pH was decreased from pH 2.0 to pH 1.3. The pH also had an impact on the initial leaching rate. The optimum pH for both ores was 1.5, or perhaps slightly lower for Redtree;
- Acid addition was low for both ores, ranging from 10-25 kg/t and 10-20 kg/t for Junnagunna and Redtree, respectively, for all conditions examined;
- The pyrolusite requirement for both ores was ~3.0 kg/t for optimum leach conditions. Note, the use of potassium permanganate and pyrolusite as oxidants produced equivalent results;
- The uranium leaching rate increased with increasing temperatures from 30 °C to 50 °C. For both ores, leaching at 30 °C significantly decreased the extraction rate, and to a lesser extent, the final extraction of uranium. The initial rate of leaching was reduced at 40 °C, but extractions were quite similar to those at 50 °C after 12 h. Although temperature has a significant effect on the initial extraction rate, there was also a significant relative increase in the acid addition. The optimum temperature appeared to be ~ 40 °C;

For both samples, similar final (24 h) uranium extraction results were achieved for leaching at ORP levels of 500-550 mV. Uranium extraction decreased significantly when leaching at 450 mV. Addition of 1.0 g/L ferric ion at 500 mV had a slight impact on the rate of extraction, but there was little difference after 12 h. A similar result was achieved by leaching at 550 mV, and this approach would be preferred to adding iron. For both samples, there was a significant increase in demand for oxidant to increase the ORP from 450 to 500 mV, but only a further

small addition was required to achieve 550 mV. The oxidant demand for both samples was very similar for both samples. The optimum ORP is considered to be 550 mV.

4.5.4 Jack Ore Sample

- Under base conditions, the extraction of uranium from the Jack ore sample was 87%, considerably less than the dilute leach result of 97%, and significantly less than the 96-97% extraction from the other two samples under base case conditions. This result could be due to the very low ferric ion concentration (0.2 g/L) in the Jack leach liquor;
- Addition of 1.0 g/L Fe, leaching at pH 1.2, and leaching at a finer grind of P_{80} = 150 µm at pH 1.5 with addition of Fe, all increased the extraction from 87% for base case conditions to 91-91.5%, after 24 h.
- Optimum conditions for the Jack sample would either be leaching at pH 1.2, with other conditions at base case, or leaching at pH 1.5, with addition of 1.0 g/L Fe. Note that the latter conditions may occur if Jack ore was blended with either Junnagunna or Redtree because of the amount of iron dissolved from these ores. Further work is recommended to identify conditions that could increase extraction from the Jack ore.
- Reagent requirements for Jack ore were very low, less than half those for the Redtree composite.

4.5.5 Leach Liquor

- For the Junnagunna and Redtree ores, iron was the dominant ion in solution. For the Junnagunna ore the concentrations of elements in solutions generally decreased in the order:

  $$Fe>Al>Si>Ca>Mg\approx K>P>As$$

- The Redtree ore contained about 6 times the level of arsenic than the Junnagunna ore, hence the much higher arsenic levels in solutution. For the Redtree ore the concentrations of elements in solution generally decreased in the order:

  $$Fe>Al>Si>Ca\approx As\approx K\approx Mg>P$$

  The following general impacts of leach variables were evident:

  - The concentrations of all elements, except K, increased with decreasing pH;
  - The concentrations of all elements, except Ca and P, increased with increasing temperature;
  - Grind size had little impact on the concentrations of gangue elements in solution;
  - The concentrations of all elements increased with increased leaching time;
  - The concentrations of all elements, except As were marginally greater in the Junnagunna liquor compared to Redtree, which was reflected in the acid requirement;

- None of the gangue element concentrations in solutions would be expected to result in downstream processing problems. The Si concentrations were typical of many of the acid uranium leach liquors that are currently being processed, but noting that it is the form of the silica, rather than the total concentration, that results in silica problems;
- Ferric concentrations were reasonably high, which is a positive for leaching, but will result in some degree of iron loading if IX is used for uranium recovery;
- The concentrations of all ions, except for P and Ca, were considerably less in the Jack liquors, as reflected by the very low acid requirement.

4.5.6 Unleached Uranium

- The residual uranium minerals after leaching consisted of coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$), uranium phosphate, probably phosphuranylite ($KCa(H_3O)3(UO_2)_7(PO_4)_4O_4{\cdot}8(H_2O)$), and uraniferous zircon, where coffinite was the most common uranium mineral. The uranium minerals were almost always enclosed in quartz particles. Various amounts of arsenic were detected in most uranium minerals.

5. BULK LEACH TESTS

5.1 Bulk Leach Conditions

The bulk leach was conducted according to the following parameters selected on the basis of the laboratory leach test program results. These parameters were:

Temperature:	40 ^{o}C
pH:	1.5
Grind size:	P_{80} 250 µm
Duration	12 h
Oxidant	pyrolusite
ORP	500 mV

5.2 Bulk Leach Sample Preparation

Originally it was intended to conduct the bulk leach on 90 kg of a single ore. However, the client requested that the bulk leach be conducted on a composite composed of equal portions of the three ore types. As there was only just over 22 kg remaining of two of the three ore types the ore types were blended as follows:

Junnagunna	22.3 kg
Garee Upper Lens:	13.5 kg
Garee Lower Lens:	13.5 kg
Jack Lens	22.1 kg

The total composite was 70.4 kg. The composite was dry ground to the required grind size by Metcon Laboratories. The particle size distribution for the composite is given in **Figure 5.1**.

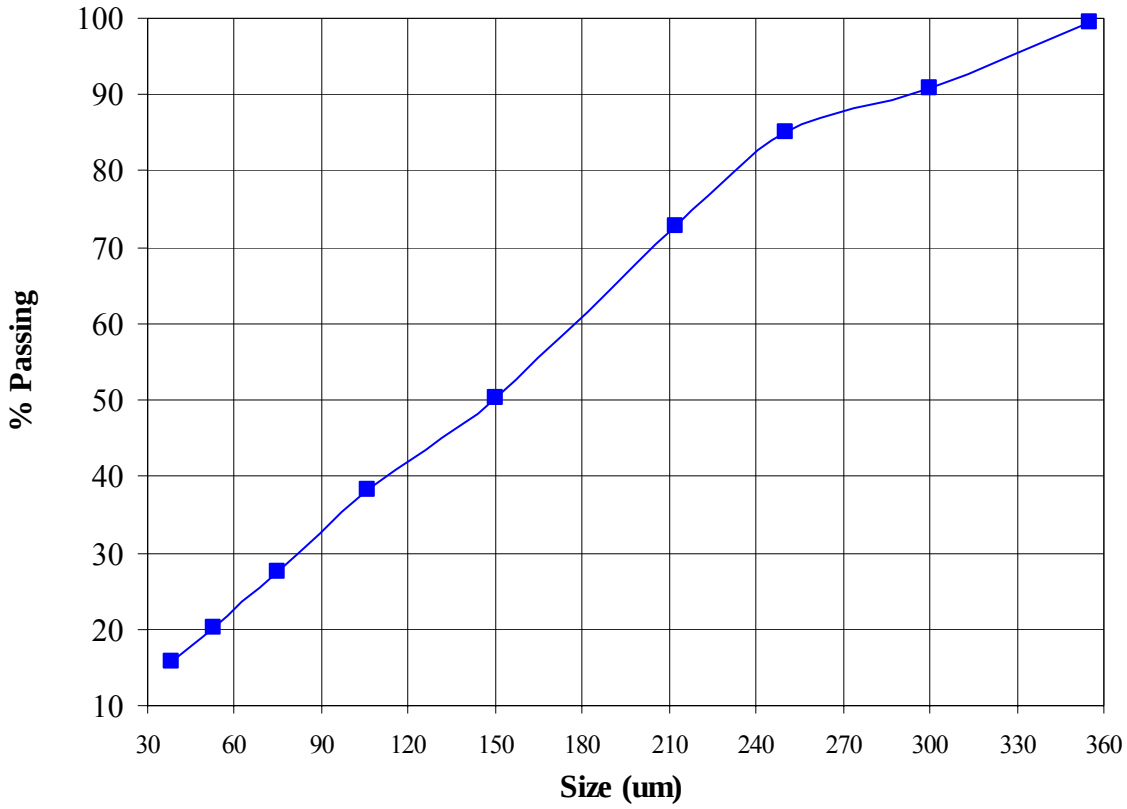


FIGURE 5.1 Particle Size Distribution

5.3 Bulk Leach Test Results

ANSTO was requested to conduct the Bulk Leach as well as the rheology test work on the residue slurry. FLSmidth was assigned to conduct the vacuum filtration and settling testwork.

5.3.1 Leaching Results

The head grade for the composite sample was 1360 ppm U_3O_8, this was very close to the calculated head grade of 1560 ppm U_3O_8.

The head and residue grades for the major elements are given in **Table 5.1**

TABLE 5.1
Solid Analyses (%)

	U_3O_8 (ppm)	Al	Ca	Fe	K	Mg	S	Si
Head	1360	1.30	0.063	1.22	0.502	0.078	0.026	42.9
Residue	52	1.25	0.044	0.49	0.065	0.065	0.031	43.5

The operating parameters and reagent consumptions are summarised in **Table 5.2**.

TABLE 5.2
Operating Parameters and Reagent Consumptions

Temperature (^oC)	pH	ORP (mV)	Acid Addition (kg/t)	Pyrolusite Addition (kg/t)
40	1.5	550	23.7	6.44

The control on the test was very good and all parameters were maintained at or close to target for the duration of the test. The acid and oxidant additions were greater than measured for the individual ore samples. The acid addition, at 23.7 kg/t, was higher than in any of the previous tests with the exception of test LC4 A, which was a test on Redtree ore at pH 1.3. From the three tests conducted under similar conditions on the individual ores (tests LC5 C, LC6 B and LC16 A) the calculated expected acid addition in the Bulk Leach is 13.6 kg/t. (Calculated using the acid additions from the above tests and the relative weights of the ores used in the bulk leach). The oxidant addition was also high at 6.4 kg/t. Three other tests were conducted using pyrolusite as the oxidant. The highest oxidant consumption in any of those tests was 3.6 kg/t, test LC11 C, conducted on Junnagunna ore. The high level of oxidant addition may be due to the high ORP required for this test, all other tests using pyrolusite were conducted at an ORP of 500 mV. This test also had the highest iron dissolution, the final iron and ferric ions in solution being ~3g/L higher than the expected levels (calculated from the data from the tests on the individual ores under the same conditions; LC5 C, LC6 B and LC 16 A). The material for the bulk leach was ground by Metcon Laboratories in a mild steel mill with mild steel balls. It is likely that some of the steel reported to the ground material and leached. This iron from the steel would at least partly leach and consume both oxidant and acid. The oxidation of metallic iron to ferric consumes three times as much oxidant as the oxidation of ferrous ions to ferric.

The uranium extraction was 96.2% for the bulk leach. This was below the extraction achieved on the Junnagunna and Redtree ores, but higher than the extraction achieved on Jack ore. From the three tests conducted under similar conditions on the individual ores (tests LC5 C, LC6 B and LC16 A) the calculated extraction expected in the Bulk Leach is 95.6%. The actual extraction was 96.2%. This increase may be due to the elevated ORP and iron levels enhancing the leaching of uranium from the Jack ore component of the composite. **Table 5.3** summarises the extractions for the major elements. The detailed experimental data are given in **Appendix F**.

TABLE 5.3
Extractions (%)

U	Al	Fe	K	Mg
96.2	2.8	30.5	4.6	17.8

In **Figure 5.2,** the bulk leach residues are compared to the residues from the leach residues for Junnagunna and Redtree conducted under the same conditions. The curve for the bulk leach shows that 8 hours was sufficient to leach the uranium. This was much faster than in the leach

tests on Junnagunna and Redtree where uranium was still being leached after 12 hours. This may be due to the elevated iron levels in solution enhancing reaction kinetics.

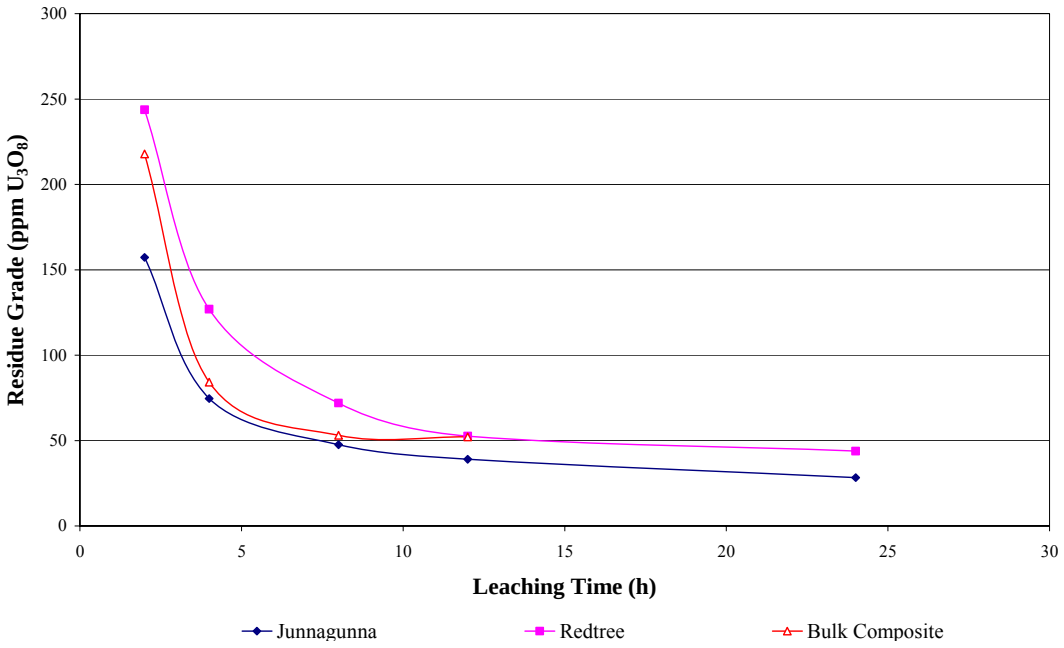


FIGURE 5.2 Residue Profiles at 550 mV

The final solutions for the individual tests are compared to the bulk leach final solution in **Table 5.4**.

The Bulk Leach was conducted over 12 hours, whereas the leaches on the individual ores were conducted over 24 hours. The expected final solution values were calculated using the analyses from the individual tests and the fraction of the ore used to make the composite, to produce a weighted average. When the weighted average after 12 hours is compared to the actual bulk leach solution it can be seen that, generally, the expected value from the weighted average is lower than the actual bulk solution, and that the values are much closer when the weighted average after 24 hours is used. The reason for this is unclear.

TABLE 5.4
Product Solution Comparisons (mg/L)

	Test	Time	Al	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U
Junnagunna	LC5 C	12 h	506	388	3017	2882	152	247	680	359	63	6700	592	1233
Redtree	LC6 B		568	193	2620	2461	160	162	662	317	41	6630	632	1351
Jack	LC16 A		158	107	1310	759	112	34	58	49	47	2788	231	803
Junnagunna	LC5 C	24 h	804	427	4020	2499	272	369	657	380	66	7870	681	1417
Redtree	LC6 B		698	204	3090	1902	248	195	579	291	42	6260	580	1473
Jack	LC16 A		228	120	1427	846	172	32	98	65	41	2788	231	803
Bulk leach	Actual	12 h	609	312	5350	5016	236	170	3750	86	79	9910	589	1208
	Expected*	12 h	422	227	2339	2066	143	149	481	247	50	4982	406	1234
		24 h	586	248	2866	1762	232	199	454	249	49	5688	503	1248

* weighted averages from individual leach tests

For most elements, the actual solution values are close to the weighted averages after 24 hours. The exceptions are as follows:

- Higher Fe: as mentioned earlier this was due to the mild steel grinding media and mill components partly dissolving in the leach.
- Higher Mn: due to pyrolusite being used as the oxidant.
- Lower Na: in the individual tests LC5 C and LC6 B sodium permanganate was used as the oxidant, thereby artificially raising the sodium levels in the product solutions.
- Higher S: due to the extra acid added due to the metallic iron dissolving. Also pyrolusite dissolution consumes acid, thereby increasing the sulphate tenor of the solution.

5.3.2 Vendor Settling and Filtration Results

A summary of the FLSmidth settling test results are given in **Table 5.5** (and compared with the ANSTO settling test results) and a summary of the filtration test results are given in **Table 5.6**. The detailed report from FLSmidth has been included as **Appendix J**.

TABLE 5.5
Settling Test Results

Parameter	FLSmidth	Junnagunna	Redtree
Thickener feed tonnage (t/h)	30	30	30
Feed solids (wt%)	45		
Feedwell solids (wt%)	7.5	7.5	6.6
Flocculant addition rate* (g/t)	50-100	62.5	71.6
Flocculant type	800HP	E 10	E 10
Rise rate (m/h)	4.1		
Free settling rate (m/h)	30	5.9	5.9
Expected underflow solids (wt%)	60-61		
Underflow stress yield (Pa)	14-19		
Flux rate ($t/m^2/h$)	0.38	0.103	0.142
Thickener diameter (m)	10	19.3	16.4
Number of thickeners	1		

* Magnafloc 800HP for FLSmidth tests, Magnafloc for ANSTO tests

TABLE 5.6
Filtration Test Results

Parameter	Result
Filter type	HBF
Feed solids (wt%)	60
Solids feed rate (t/h)	30
Vacuum (kPag)	-70
Cake thickness (mm)	11
Cake moisture (wt%)	23
Cake wash ratio (kg/kg solids)	1.0
Filtration rate ($kg/m^2/h$)	472
Filtration area required (m^2)	63.5
Selected filter	2.5M65
Selected model filtration area available (m^2)	65
Number of filters required	1

The FLSmidth report does not quote a soluble loss. However, after washing with a cake wash ratio of 1.0 kg/kg solids the uranium level in the filter cake was very low at 43 ppm. (This is lower than the final residue from the leach, which was 52 ppm, but is probably due to further uranium leaching taking place as the filtration tests were conducted two or three days after the leach had finished.) This suggests that practically all the water soluble uranium had been washed from the filter cake and that the soluble uranium loss was almost certainly well below 1%.

5.3.3 Rheology Results

The slurry at 60 wt% solids did not have a stress yield, at 64 wt% the stress yield was 32 Pa. The Bingham plastic parameters are summarised in **Table 5.7**. The detailed results are given in **Appendix K**.

TABLE 5.7
Bingham Plastic Parameters

	wt%	60	64
μ_p	Pa.s	0.026	0.113
τ_y	Pa	0	17
Static (τ_y)	Pa	0	32

5.4 Summary

The bulk leach results corresponded well with the tests on individual ores under the same or similar conditions.

The uranium extraction was 96.2% after 12 hours and 96.1% after 8 hours. The rapid reaction kinetics in comparison to the individual tests was likely due to the elevated iron levels in solution. The expected extraction was 95.6%. The reason for the higher than expected

extraction is likely due to the high ORP increasing the extraction of uranium from the Jack ore portion.

The solution product in the bulk leach also corresponded well to the expected values from the final product solutions from leaches on the individual ores.

The product slurry from the bulk leach proved extremely difficult to filter. It took over a week to separate the solids and solution by pressure filtration.

The product slurry settled reasonably well and the filtration testwork conducted by FLSmidth indicated that the leach product slurry was amenable to filtration. The slurry filtration rate was reasonable and the filter cake could be washed to recover more than 99% of the soluble uranium without excessive wash water.

6. ION EXCHANGE EXPERIMENTS

This section covers the batch testwork to assist in predicting the performance of an ion exchange process step after solid-liquid separation (CCD), or as a resin-in-pulp (RIP) process if solid liquid separation after leaching is an issue. The build up of impurities (especially sulphate and chloride) in recycle streams needs to be considered in practice for these systems. The program below was undertaken on a bulk leach liquor produced from a blend of the ore composites.

6.1 Experimental Details

6.1.1 Leach liquors

A quantity of leach liquor generated for the ion exchange and solvent exchange tests was prepared in a bulk leach conducted at pH 1.5. The leach conditions are shown in **Section 5.1** and the bulk liquor assay is shown in **Table 6.1**. Also included are the compositions of the undiluted PLS and diluted PLS solutions used for the ion exchange testwork.

A portion of the leach liquor was diluted with pH 1.5 wash water, from the bulk leach slurry filtration, at a ratio of 60 vol% product solution: 40% pH 1.5 wash solution to represent clarified PLS. The product solution was diluted to simulate the expected dilution from a CCD circuit. This ratio was determined from the settling and thickening data assuming thickener underflow densities of 60% solids and a mix efficiency decreasing through the CCD circuit, which is normal in plants. The diluted solution was used for IX tests with Amberjet 4400. The undiluted PLS, simulating a feed to a Resin-in-Pulp circuit, was used for tests with the Ambersep 920.

TABLE 6.1
Bulk Leach Liquor, 'RIP' Feed and 'Clarified Liquor' Compositions (mg/L)

Sample	pH	Al	As	Ca	Fe	K	Mg	Mn	Mo	P	S	Si	U_3O_8	V
Bulk Leach	1.8	609	100	312	5,350	236	170	3,750	13	79	9,910	589	1,605	21
RIP feed	1.5	933	96	329	4,510	2.4	269	3,690	14	60	10,080	618	1,540	27
IX feed'	1.5	680	56	244	3,240	2	194	2,650	10	42	7,490	432	939	19

'RIP PLS' free acid = 4 g/L H_2SO_4; Clarified PLS free acid = 3.5 g/L H_2SO_4

These solutions were assayed several days after the leach had been completed. As the slurry filtered very slowly the bulk leach product solution was in contact with the solids for up to a week after the leach was finished. This is the likely reason for the elevated Mg and Al levels in the RIP feed when compared to the bulk leach product solution as these two elements will slowly leach over time. The decrease in pH in the RIP feed can be explained by the lower iron tenor in solution. Iron slowly precipitates over time generating acid. The decrease in the potassium was probably caused by jarosite precipitation.

6.1.2 Resins

Previous work conducted by ANSTO Minerals using RIP resins was reviewed and Ambersep 920 (Rohm & Haas) was identified as a suitable candidate for test work. For the clarified process liquor, a similar review of test work identified Amberjet 4400 (also supplied by Rohm & Haas) as a suitable resin. The resin properties are provided in **Table 6.2**.

TABLE 6.2
Resin Properties

Property	Ambersep 920	Amberjet 4400
Matrix	Macroreticular, cross linked polystyrene	Styrene divinylbenzene copolymer containing $N^+(CH_3)_3$ functional groups
Physical form	Opaque beads	Insoluble light amber beads
Ionic form as shipped	Cl^-	Cl^-
Total exchange capacity	≥ 1.0 eq/L (Cl^- form)	≥ 1.40 eq/L (Cl^- form)
Moisture holding capacity	48 to 60 % (Cl^- form)	40 to 48 % (Cl^- form)
Shipping weight	700 g/L (43.7 lb/ft^3)	730 g/L
Harmonic mean size	0.750 - 0.950 mm	0.58 ± 0.05 mm
Uniformity coefficient	≤ 1.50	≤ 1.2
Fine contents	< 0.710 mm : 5.0 %	< 0.425 mm : 0.5 % max
Coarse beads	> 1.180 mm : 4.0 %	Not provided
Maximum reversible swelling	$Cl^- \rightarrow OH^-$: 20 % approximately	$Cl^- \rightarrow OH^-$: 30 %

Prior to use, both resins were conditioned by contacting them with sulphuric acid and water to convert exchange sites to the $[N^+(CH_3)_3]_2SO_4$ form from the chloride form. The conditions used for the conversion are in **Table 6.3** along with the final resin compositions which show complete chloride removal[4].

The conditioned Ambersep 920 resin was screened at 600 µm and the Amberjet 4400 was screened at 300 µm and 600 µm for the ion exchange test work.

[4] Determined by 1 M nitric acid strips of the converted resins with analysis of the strip solutions by ICP-OES for S and ISE for Cl.

TABLE 6.3
Resin Conversion Conditions and Compositions

Reagent	Concentration g/L	Duration (Hours)	Bed Volumes
H_2SO_4	200	3	19
H_2O	-	3	24

Final composition	Sulphate (g/L wsr)	Chloride (g/L wsr)
Ambersep 920	43.2	<0.2
Amberjet 4400	62.6	<0.2

6.1.3 Analysis

Solutions generated in all tests were submitted for assay by ICP-OES. In loading tests, solutions were assayed for U, Fe, S, Si, Zr, V, Mo. The uranium composition of resins were determined using DNA (delayed neutron analysis) while resin strips by nitric acid (1 M) and ICP-OES assay of the strip solution were used to determine other elements (Al, Bi, Ca, Fe, K, Mg, Mn, S, P, Si, V, Mo), as well as uranium. Chloride was also determined in some solutions using a chloride selective electrode.

6.1.4 Test Methods and Program

Standard ANSTO Minerals methods from AM-I-016-001 Ion Exchange Techniques for Uranium Recovery were used for all tests involving resin work. The uranium precipitation test work used methods extracted from *ANSTO Minerals Technical Note: AM/TN/2011_05_17 Uranium Precipitation Methods, D. Wilkins, 2011*.

The test program in **Table 6.4** was completed. All tests were performed at 35˚ C. Feed solutions for both ion exchange and solvent extraction tests were set to pH 1.5.

TABLE 6.4
Test Program (IX and SX)

Test	Description
LC-1	Equilibrium tests to provide equilibrium isotherms (6-7 points). Undiluted PLS/AMBERSEP 920
LC-2	Equilibrium tests to provide equilibrium isotherms (6-7 points). Diluted PLS/AMBERJET 4400
LC-3	Loading rate curve PLS (undiluted PLS)/AMBERSEP 920
LC-4	Loading rate curve PLS (diluted PLS)/AMBERJET 4400
LC-5	Column breakthrough with 100 bed volumes of neat PLS/AMBERSEP 920
LC-6	Column breakthrough with 100 bed volumes of diluted PLS/AMBERJET 4400
LC-7	AMBERSEP 920 elution isotherm using 1 M H_2SO_4
LC-8	AMBERJET 4400 elution isotherm using 1 M H_2SO_4
LC-9	AMBERSEP 920 elution rate curve in 1 M H_2SO_4
LC-10	AMBERSEP 920 elution rate curve in 1 M H_2SO_4
LC-11	Column elution using loaded AMBERSEP 920 resin (from LC-5) and 1 M H_2SO_4
LC-12	Column elution using loaded AMBERJET 4400 resin (from LC-6) and 1 M H_2SO_4
LC-13	Equilibrium Loading Curve/Alamine 336 - Diluted PLS
LC-14	SX Phase Disengagement tests
LC-15	Bulk load using diluted PLS & strip using 100 g/L ammonium sulphate
LC-16	Equilibrium-stripping isotherm with 100 g/L ammonium sulphate
LC-17	Uranyl peroxide precipitation from IX eluate at pH 3.5
LC-18	Ammonium diuranate precipitation from SX strip liquor at pH 7.5

6.2 Results

6.2.1 Loading Isotherms

The loading isotherms for Ambersep 920 and Amberjet 4400 shown in **Figures 6.1** and **6.2,** respectively, are based on all data in **Appendix L**. The curves are described by Langmuir equations with loading determined according to equations (3) and (4).

$$L = \frac{0.204C}{1 + 0.004C} \text{ for Ambersep 920} \qquad (3)$$

$$L = \frac{0.608C}{1 + 0.007C} \text{ for Amberjet 4400} \qquad (4)$$

Where L is the resin loading at equilibrium and C is the uranium concentration in the leach liquor at equilibrium.

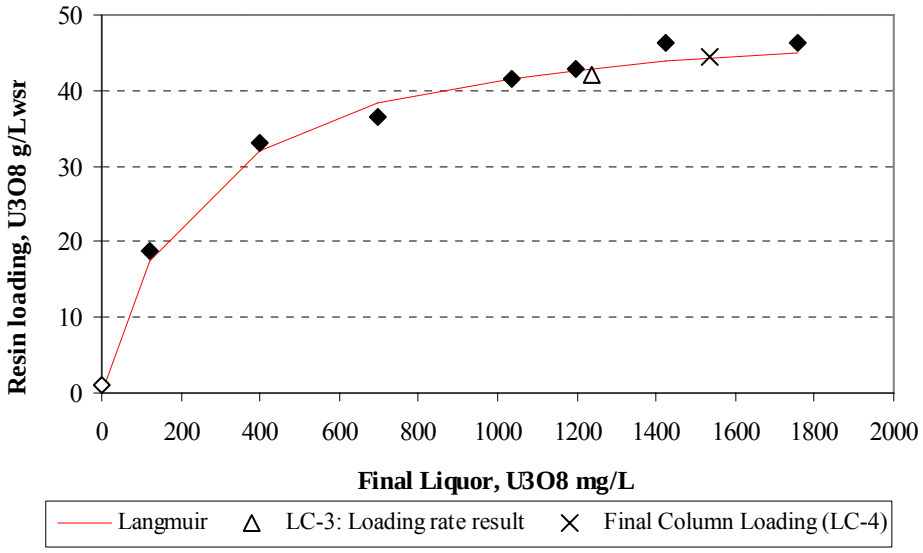


FIGURE 6.1 Loading Isotherm for Ambersep 920 (pH 1.5, 35 °C)

The maximum loading attainable for Ambersep 920 was 51 g/L wsr and for Amberjet 4400 90 g/L wsr. The favourable uranium equilibria for both resins are clearly illustrated. Operating at an anticipated concentration of 1,450 mg/L U_3O_8, Ambersep 920 will load ~ 42 g/L wsr U_3O_8, while Amberjet 4400 will load ~ 63 g/L wsr U_3O_8 from PLS containing 1,000 mg/L U_3O_8.

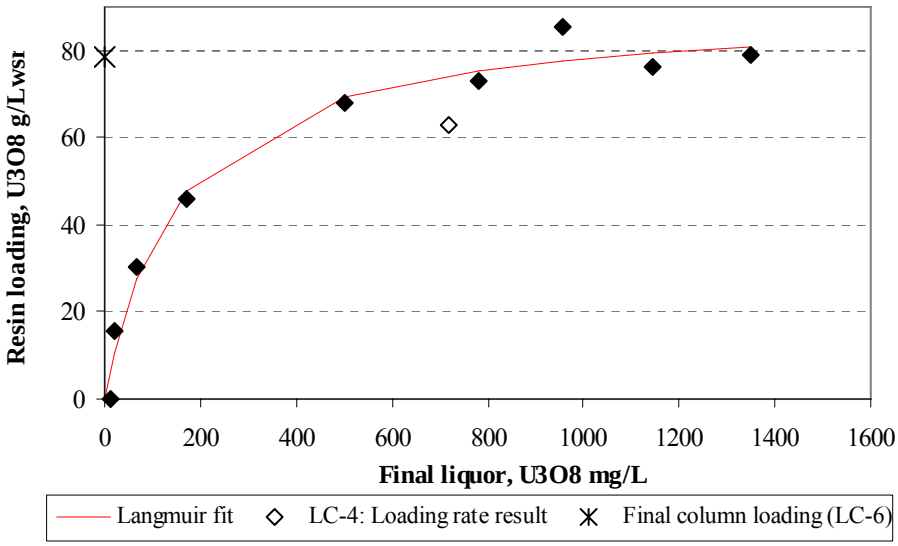


FIGURE 6.2 Loading Isotherm for Amberjet 4400 (pH 1.5, 35 °C)

6.2.2 Uranium Loading Rates

The loading rate profiles were determined at pH 1.5 and 35° C for 24 h. The individual profiles are shown in **Figure 6.3** and the two rates are also compared. The figures were compiled from data summarised in **Appendix L**. The results are shown as progressive resin loading expressed as a percentage of the equilibrium loading on the resin after 24 h.

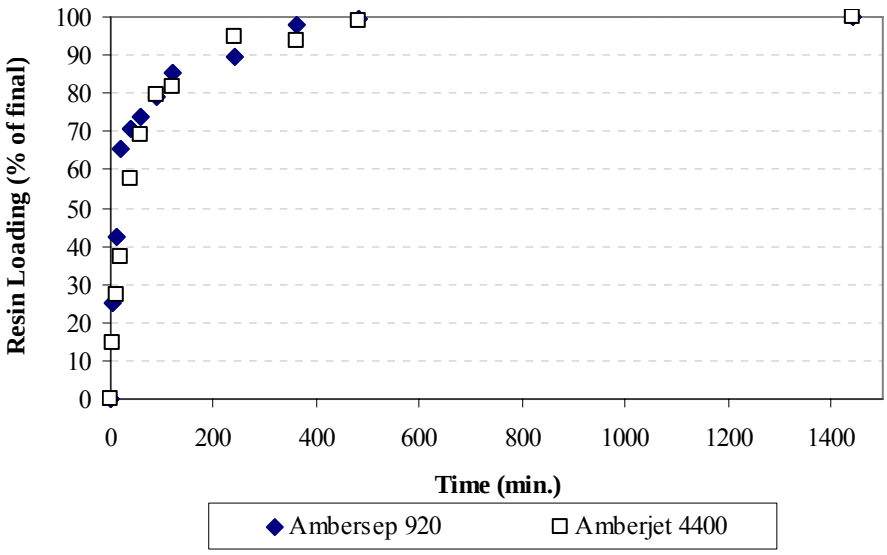


FIGURE 6.3 Ambersep 920 and Amberjet 4400 Loading Rates (pH 1.5, 35 ^{o}C)

Based on values for t_{50} and t_{75} (times required to reach 50% and 75% of equilibrium loading, Ambersep 920 demonstrated marginally faster kinetics, but both resins showed very favourable loading rates. The resin loadings and kinetics are summarised in **Table 6.5**. The difference in the loading capacities is in line with total exchange capacity.

TABLE 6.5
Kinetic Parameters for Ambersep 920 and Amberjet 4400

Resin	t_{50} (min.)	t_{75} (min.)	Final Resin Loading (g/L wsr U_3O_8)	k
Ambersep 920	14.5	64.5	42	21.0
Amberjet 4400	32	77	63	26.6

6.2.3 Column Breakthrough Curves

Column breakthrough curves were produced for each resin using leach solution delivered downflow to the column at a flow rate of 4 BV/h (1.05 m/h). The loading was conducted at 35 ^{o}C for delivery of 100 BV of feed. A fraction of column effluent was taken every 2 BV and analysed for uranium and impurities. **Figures 6.4** and **6.5** contain the breakthrough profiles for Ambersep 920 and Amberjet 4400, respectively, by plotting uranium in the column effluent against the volume of the feed treated. All column breakthrough results are contained in **Appendix L**.

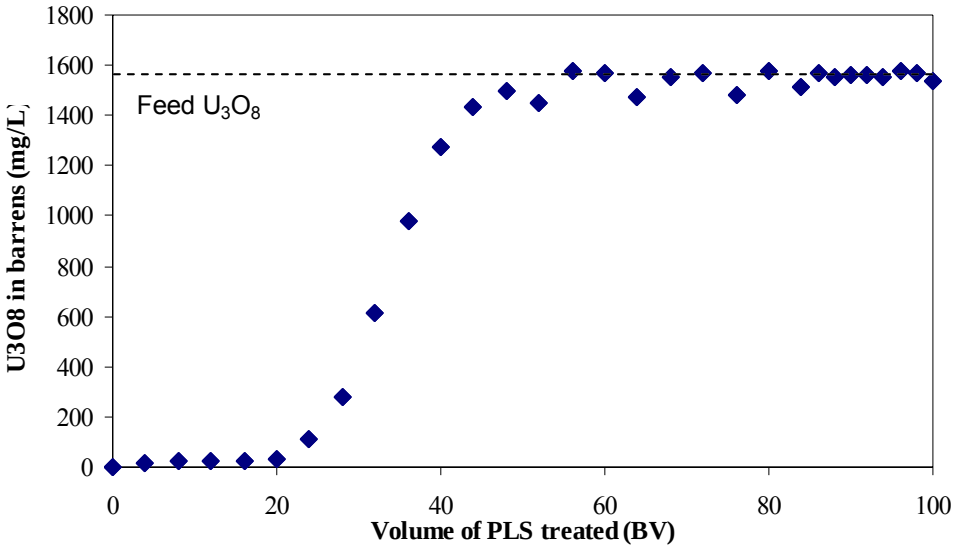


FIGURE 6.4 Uranium Breakthrough Curve for Ambersep 920 (pH 1.5, 35 °C, Feed =1,540 mg/L U_3O_8)

Ambersep 920 reached saturation loading after 50 BV of feed delivered. Breakthrough (2% of feed concentration) occurred after 20 BV of feed containing 1540 mg/L U_3O_8 were treated. The curve shows a sharp exchange zone. The final Ambersep 920 loading was 45.3 g/L wsr U_3O_8, which agrees with the isotherm in **Figure 6.1**.

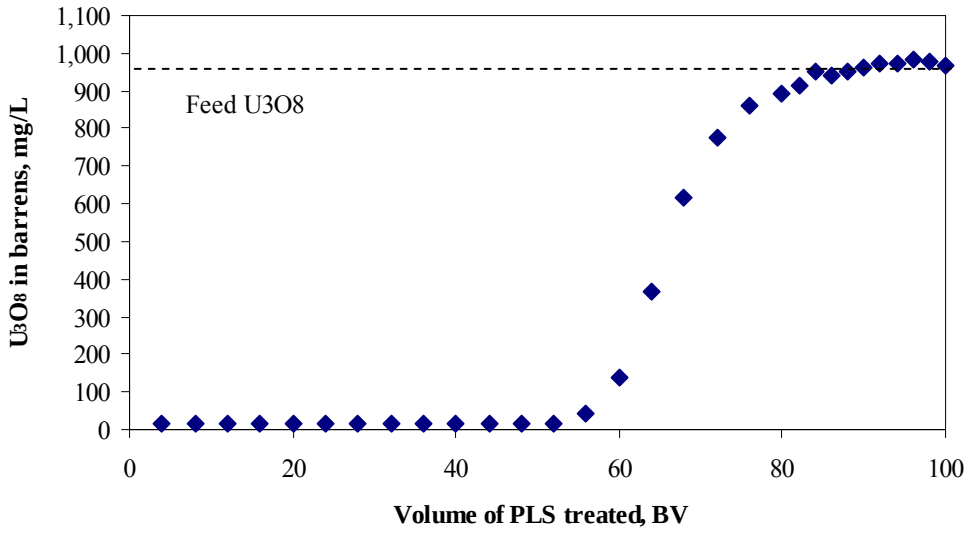


FIGURE 6.5 Uranium Breakthrough Curve for Amberjet 4400 (pH 1.5, 35 °C, Feed = 940 mg/L U_3O_8)

Amberjet 4400 reached saturation at close to 100 BV of feed treated. The column indicated a slightly elongated exchange zone with breakthrough occurring after 54 BV of feed containing 940 mg/L U_3O_8 were treated. The final resin loading was 79 g/L wsr U_3O_8. The column results reflected the higher capacity of Amberjet over Ambersep 920 in **Table 6.2** (1.4 eq/L wsr compared to 1.0 eq/L wsr).

The loaded resin compositions in **Table 6.6** show that other solution impurities also loaded with the uranium. The iron (III) and phosphorous could be present as significant impurities in the final uranyl peroxide produced from the eluate downstream if they elute simultaneously with uranium. Consideration may have to be given to a scrubbing step prior to elution to remove the impurities.

Previous work conducted by ANSTO has demonstrated that iron (III) can be removed using dilute sulphuric acid or a reducing eluant. Conditions would need to be managed to minimise uranium losses. Alternatively, scrubbing the loaded resin with a solution containing high uranium concentrations at an appropriate pH has been shown to decrease iron and thorium on loaded resin as well as upgrade the uranium loading (Chia, D.E., 1986).

Any build up of silica on the Ambersep 920 would be managed by caustic strips of the resin before the silica can interfere with loading efficiencies.

TABLE 6.6
Loaded Resin Compositions (g/L wsr M)

	U_3O_8	Fe	SO_4	Si	P
Ambersep 920	45.3	1.61	59.4	17.6	0.4
Amberjet 4400	78.7	0.5	94.3	1.7	0.6

6.2.4 Elution Isotherms

The elution behaviour of each resin was characterised by performing equilibrium measurements, elution rate measurements and column elution behaviour with 1 M sulphuric acid and at 35 ^{o}C. The isotherms for the resins are given in **Figures 6.6** and **6.7**.

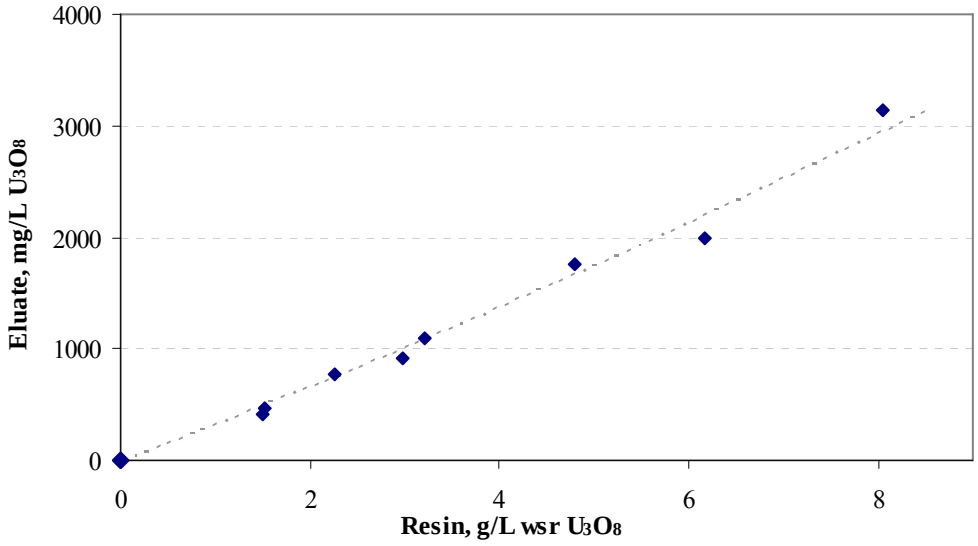


FIGURE 6.6 Ambersep 920 Isotherm in 1 M Sulphuric Acid (35 ^{o}C)

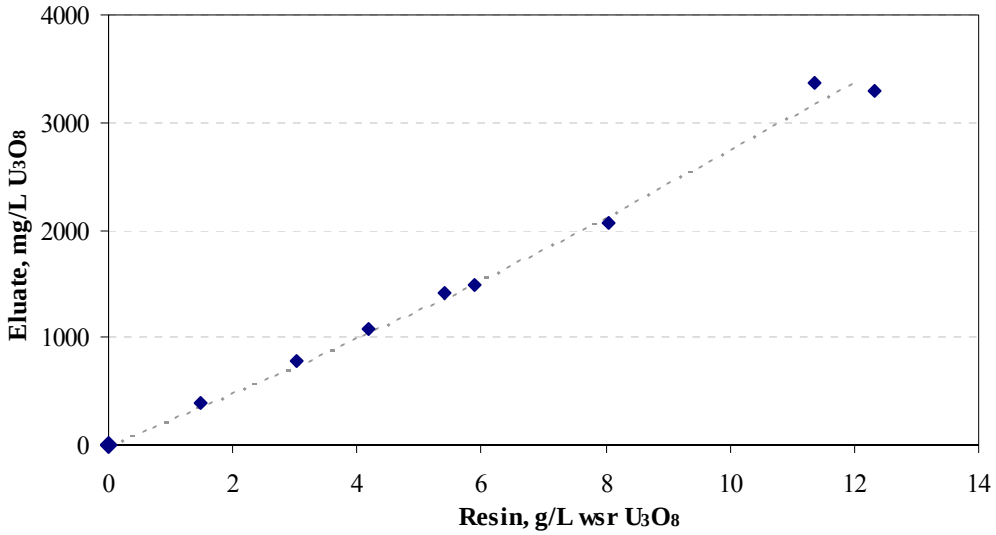


FIGURE 6.7 Amberjet 4400 Isotherm in 1 M Sulphuric Acid (35 °C)

The two isotherms in sulphuric acid were fitted using the following equations:

$$L = \frac{0.003C}{1 + 4.3x10^{-5}C} \quad \text{For Ambersep 920} \qquad (5)$$

$$L = \frac{0.004C}{1 + 6.02x10^{-5}C} \quad \text{For Amberjet 4400} \qquad (6)$$

where L = resin loading and C= the eluate concentration. The isotherms appear close to linear over the uranium concentration range investigated.

6.2.5 Elution Rates in Sulphuric Acid

Uranium loaded Ambersep 920 and Amberjet 4400 resins, generated in tests LC-5 and LC-6, were contacted with 1 M sulphuric acid in bottle roll tests at 35 °C. The rate of uranium elution was determined by monitoring the variation in the uranium concentration of the eluant over 24 h. All data used to plot **Figures 6.8** and **6.9** are contained in **Appendix L**.

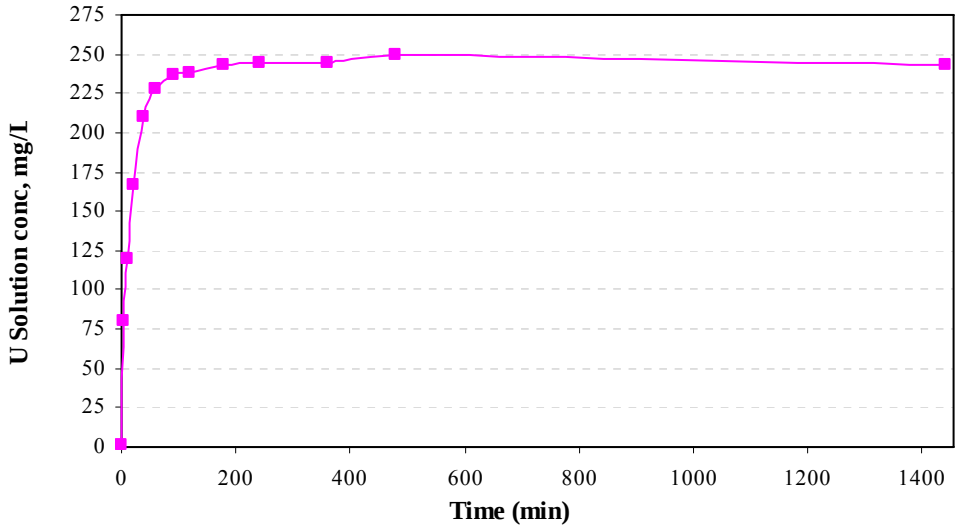


FIGURE 6.8 Uranium Elution Rate for Ambersep 920 (35 °C, 45 g/L wsr U_3O_8)

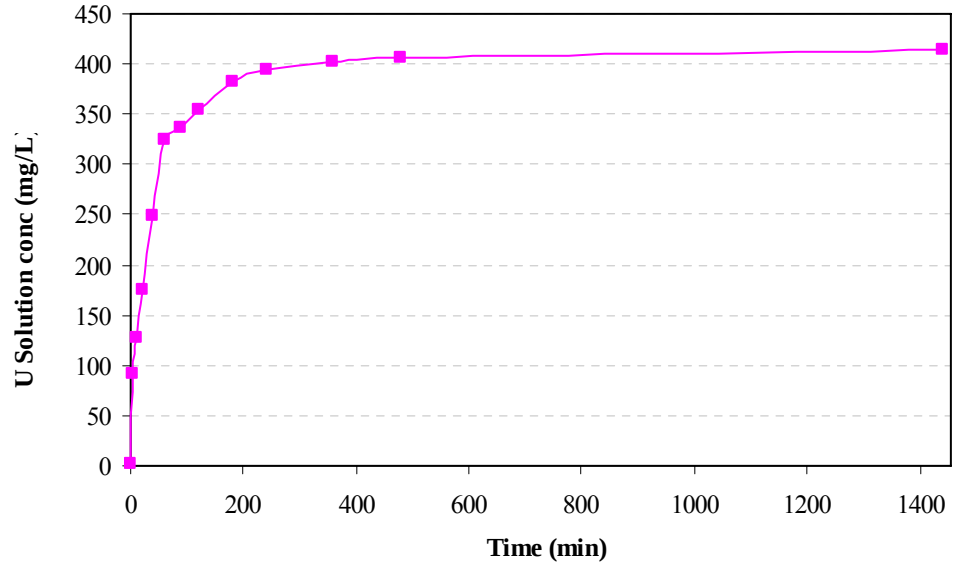


FIGURE 6.9 Uranium Elution Rate for Ambersep 920 (35 °C, 79 g/L wsr U_3O_8)

The kinetic parameters are summarised in **Table 6.7** and indicate that both resins were eluted efficiently by the sulphuric acid; and a final resin concentration of 1 g/L wsr U_3O_8 indicated practically complete elution. The Ambersep 920 eluted more rapidly and marginally more quantitatively than the Amberjet 4400.

TABLE 6.7
Elution Kinetics Parameters

Resin	t_{50} (min.)	t_{75} (min.)	Resin Loading (g/L wsr U_3O_8)	
			Initial	Final
Ambersep 290	9	22	45.3	0.8
Amberjet 4400	26	53	78.7	1.4

6.2.6 Column Elution Curves

Loaded resins from LC-5 and LC-6 were contacted in a column with 1 M sulphuric acid at 35˚C. The eluant was delivered to the column at a flow rate of 1 BV/h (0.09 m/h). The uranium concentrations in 20 x 1 BV eluate fractions were measured to generate an elution curve for each resin in **Figures 6.10** and **6.11**. All data used is in **Appendix L**. A summary of the solution compositions for both bulk eluates and for the uranyl peroxide feeds are given in **Table 6.8**.

Both elution curves indicate that uranium elution is achieved well within 20 BV of eluant delivered to the column with a stripped resin composition of ≤ 1 g/L wsr U_3O_8[5] reached after 7 BV of eluate for the Ambersep 920 and 14 BV for Amberjet 4400. The elution behaviour of the two impurities, iron and phosphorous are also included. Iron appears to elute prior to the uranium, particularly for Amberjet 4400. Phosphorous elution is coincident with uranium for both resins and this may impact to some extent on precipitate purity during product recovery when direct precipitation of the uranium from the eluate is undertaken.

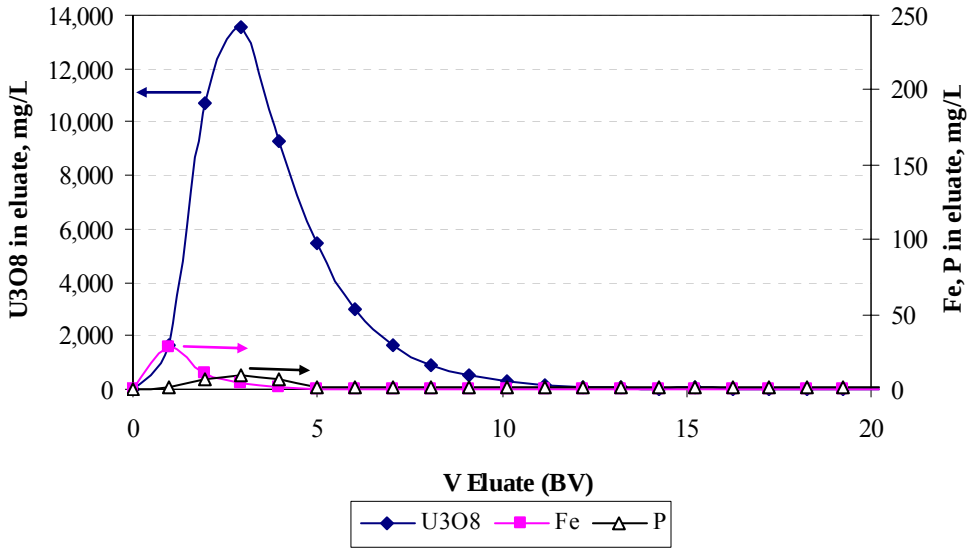


FIGURE 6.10 Ambersep 920 Uranium and Impurity Elution Using 1 M Sulphuric Acid (35 °C)

[5] A final resin composition of 1 g/L wsr U_3O_8 is considered completely eluted.

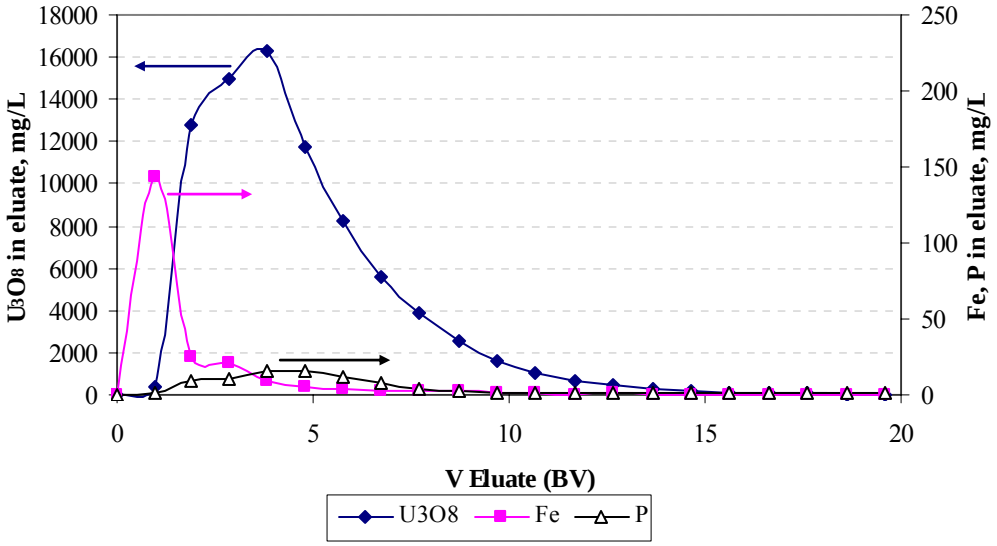


FIGURE 6.11 Amberjet 4400 Uranium and Impurity Elution using 1 M Sulphuric Acid (35 °C)

TABLE 6.8
Bulk Eluate and Uranyl Peroxide Feed Solution Compositions (mg/L)

Bulk eluate	U_3O_8	Fe	V	Mo	Zr	P	Si
Ambersep 920	2,351	2	<1	<2	2	2	196
Amberjet 4400	3,991	11	<1	<2	2	4	17

Uranyl peroxide feed	U_3O_8	Fe	V	Mo	Zr	P	Si
Ambersep 920	4,964	2	<1	<2	4	3	277
Amberjet 4400	5,668	5	<1	<2	2	6	21

The variation of the uranium concentrations in the bulk eluate for both resins are compared in **Figure 6.12** and show that bulk eluates can contain up to 8.8 g/L U_3O_8 and 11.3 g/L U_3O_8 for the Ambersep and Amberjet after collection of 4 and 5 BV, respectively[6]. The sulphuric acid required, expressed on a gram U_3O_8 basis is also shown (right hand axis)

[6] Portions of this eluate were used for uranyl peroxide precipitation.

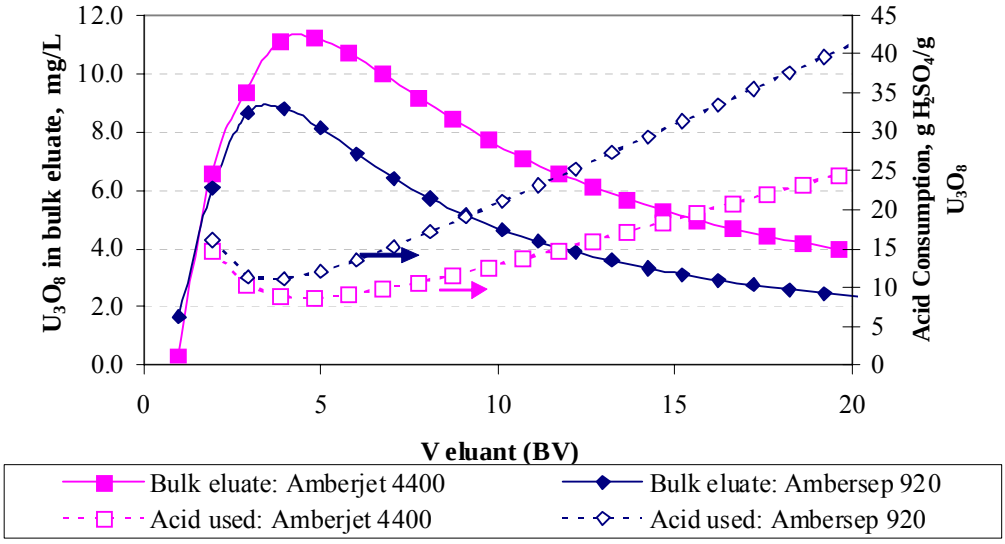


FIGURE 6.12 Uranium Bulk Eluate Concentrations from Ambersep and Amberjet Resins (1 M Sulphuric Acid, 35 °C)

6.2.7 Uranyl Peroxide Precipitation

Portions of each eluate generated from the two resins were collected and used for the precipitation of uranyl peroxide to provide an indication of the impurity deportment from the eluate to the final solids. The conditions for this test were based on previous experience gained by ANSTO Minerals, but no optimisation was conducted at this stage.

The method and results are contained in **Appendix L** and is based on a two stage process where gypsum (pH 1.5) and iron hydroxide (pH 3.5) were precipitated first and removed, prior to uranyl peroxide precipitation using hydrogen peroxide at pH 3.5 and 35 °C according to equation (7).

$$UO_2(SO_4)_3 + H_2O_2 + 2NaOH + xH_2O \rightarrow UO_4.xH_2O + 2H_2SO_4 + Na_2SO_4 \qquad (7)$$

Fractions 2-10 of the Ambersep 920 eluate and fractions 2-15 of the Amberjet eluate were used for the precipitation tests to generate solutions containing 5 – 5.5 g/L U_3O_8 and provide 1.6 g and 2.7 g of uranium, as U_3O_8, for precipitation. The quantities of uranium were relatively small, but only sufficient product for analysis was required.

The gypsum/$Fe(OH)_3$ solids waste was assayed by XRF and the uranyl peroxide precipitate was assayed by digesting it in nitric acid and diluting the solution to an exact volume. Elements were determined by ICP-OES and ICP-MS. The uranyl peroxide compositions are contained in **Table 6.7**.

The uranium composition of the uranyl peroxide indicates that the precipitate stoichiometry was very close to $UO_4.2H_2O$ (theoretical = 70.4% U). In **Table 6.9**, the impurity compositions are also compared with various commercial specifications for uranyl peroxide. Iron nearly met specification, but phosphorous exceeded specifications and more attention needs to be paid to managing it. Previous work at ANSTO has shown that phosphorous can precipitate

with the gypsum/$Fe(OH)_3$ cake to some degree, the conditions of this process need to be examined and optimised to achieve maximum rejection as iron phosphate, while maintaining low uranium losses. Alternatively, as mentioned in **Section 6.2.3**, scrubbing operations prior to elution may provide a solution.

TABLE 6.9
Uranyl Peroxide Compositions (expressed as M/U%)

Element	Ambersep 920U	Amberjet 4400	Cameco		Comurhex		Converdyn	
			No penalty	Limit of Rejection	No penalty	Limit of Rejection	No penalty	Limit of Rejection
Ag	<0.07	<0.04	-	-	-	-	0.01	0.04
Al	0.07	0.08	-					
As	<0.04	<0.03	0.05	0.15	1.00	2.50	0.01	0.04
B	<0.04	<0.02	0.01	0.15	0.20	0.20	0.01	0.10
Ba	<0.04	<0.03	-	-	-	-	0.01	0.04
C	n.m.	n.m.			0.20	1.00	0.01	0.20
Ca	0.32	0.47	3.00	4.00	1.00	5.00	0.05	1.00
Cd	<0.04	<0.02	-	-	-	-	0.01	0.04
Cl	<0.3	0.38	-	-	0.15	0.25	0.05	0.10
CO_3	n.m.	n.m.	-	-	2.00	3.00	0.20	0.50
Cr	<0.04	<0.03	-	-	-	-	0.01	0.04
F	<0.03	0.05	-	-	0.15	0.30	0.01	0.10
Fe	0.23	0.19	1.00	2.00	-	-	0.15	0.50
Hg	<0.04	<0.02	-	-	-	-	0.01	0.04
K	0.41	0.26	1.00	2.00	-	-	0.20	1.00
Mg	<0.04	<0.03	3.00	4.00	-	-	0.02	0.50
Mn	<0.04	<0.03	-	-	-	-	-	-
Mo	<0.03	<0.02	0.10	0.30	0.10	0.30	0.10	0.30
Na	0.2	0.26	1.00	2.00	1.00	7.50	0.50	3.00
PO_4	0.86	0.83		0.50	1.00	1.00	0.10	1.00
Pb	<0.03	<0.02	-	-	-	-	0.01	0.04
S	4.08	2.56	1.00	3.50	0.00	0.00	0.00	0.00
Se	<0.03	<0.02	-		-	-	0.01	0.04
SiO_2	0.43	0.28	1.07	2.00	0.50	2.50	0.50	2.00
SO_4	12.24	7.68	-		3.00	10.00	1.00	4.00
Th	<0.03	<0.02	0.50	2.00	1.00	4.00	0.10	0.50
Ti	<0.04	<0.03	0.05	0.10	-	-	0.01	0.05
U*	71	71	65	-			75	65
V	<0.03	<0.02	0.10	0.50	0.00	0.00	0.10	0.75
V_2O_5	n.m.	n.m.	-	-	0.30	0.30	-	-
Zr	<0.03	<0.02	0.10	0.50	0.20	2.00	0.01	0.50

* U as a percent of dried peroxide product.

The gypsum/iron cake composition in **Appendix L** shows that some uranium losses occurred during the preliminary precipitation. XRF assays show that the gypsum from the Amberjet eluate contained 0.67% U_3O_8 and from the Ambersep 920 eluate, the gypsum contained 0.44% U_3O_8. The uranium in gypsum represented 12% and 6% of the uranium in feed for Amberjet and Ambersep, respectively. This slurry can be recycled to the leach circuit and the wash liquor can be combined with the filtrate to recover this uranium. However, there will be a cost associated with recovering the uranium recycled to leach in the gypsum/iron cake.

The relatively high levels of sulphur in the uranyl peroxide is likely due to insufficient washing of the cake. Precipitates formed during batch processes are invariably harder to filter, due to smaller particle size and less dense particles, than in a continuous operation. It is expected that a precipitate formed from similar solutions under plant conditions would contain a lower level of water soluble contaminants, such as sodium, sulphur and phosphorus, than the above products.

6.3 Conclusions

Uranium can be recovered effectively using Ambersep 920, an RIP resin with 750 < d < 950 μm, and Amberjet 4400 (d = 580 ± 50 μm). Resin loadings of 45 and 78 g/L wsr U_3O_8 were obtained. Both resins demonstrated favourable loading and elution kinetics and in column elution tests quantitative elution was achieved for ≤ 15 BV of 1 M H_2SO_4 delivered. The eluted resins contained < 1 g/L wsr U_3O_8.

Precipitation of uranyl peroxide from the eluates generated a product for which the composition compared favourably to a Cameco, Comurhex and Converdyn (upper limit) purity specification. Iron phosphate precipitation during the iron removal stage or resin scrubbing prior to elution, may provide a solution to the high levels of phosphorus in the uranyl peroxide product.

7. SOLVENT EXTRACTION EXPERIMENTS (AFTER SOLID-LIQUID SEPARATION)

This section covers the batch testwork required to assist in predicting the performance of an SX process step after solid-liquid separation (CCD). As with the ion exchange work the recycle of raffinate to the CCD circuit will result in the concentration of species that may be detrimental to the selectivity and capacity of the solvent. This possibility would need to be addressed by modelling and possibly by mini plant operation.

Solvent extraction could be used in place of ion exchange for recovery of uranium from a CCD overflow or it could be used for purification of the eluate after ion exchange recovery (either in-solution or in-pulp IX). This work component is aimed at the former situation, as a mini-plant operation would be required to generate sufficient eluate for tests in the latter situation. However, this is a well understood operation in uranium processing.

7.1 Solvent

A mixture of 5 vol.% Alamine and 2 vol.% Isodecanol in Shellsol 2046 was used as the solvent. This solvent composition is widely used in the industry. The solvent was pre-equilibrated to pH 1.5 with dilute sulphuric acid at an O/A = 2.

7.2 Feed Solution

The feed solution for the solvent extraction work was the product solution from the bulk leach diluted with Sydney tap water at a ratio of 60 product solution:40 Sydney tap water. The product solution was diluted to simulate the expected dilution from a CCD circuit. This ratio was determined from the settling and thickening data assuming thickener underflow densities of 60% solids and a mix efficiency decreasing through the CCD circuit, which is normal in plants.

The feed was adjusted to pH 1.5 for solvent extraction testwork. The feed analysis is given in **Table 7.1.**

TABLE 7.1
Leach Feed Analysis

Element	Concentration (mg/L)	Element	Concentration (mg/L)
Ag	1	Na	54
Al	623	P	43
As	56	Pb	4
B	2	Si	437
Ba	<1	Se	<1
Ca	221	V	<1
Cd	<1	Zr	<1
Mg	199	S (g/L)	7.4
		Cl (g/L)	0.43
Fe (g/L)	3.1	F (g/L)	0.02
Fe^{2+}(g/L)	1.1	U (g/L)	0.97
Mn (g/L)	2.8	ORP (mV)	475
Free Acid (g/L)	3.8	pH	1.5

7.3 Loading Curve

One batch loading curve was carried out at pH 1.5 and 35 ^{o}C. Experimental details are in **Appendix M** and the equilibrium loading curve is shown in **Figure 7.1**. The McCabe-Thiele graph indicates that a two stage extraction process operating at 85% efficiency, with an A/O = 4.3 is sufficient to extract 99% of the uranium from a feed of 970 mg/L U resulting in a raffinate with <10 mg/L U.

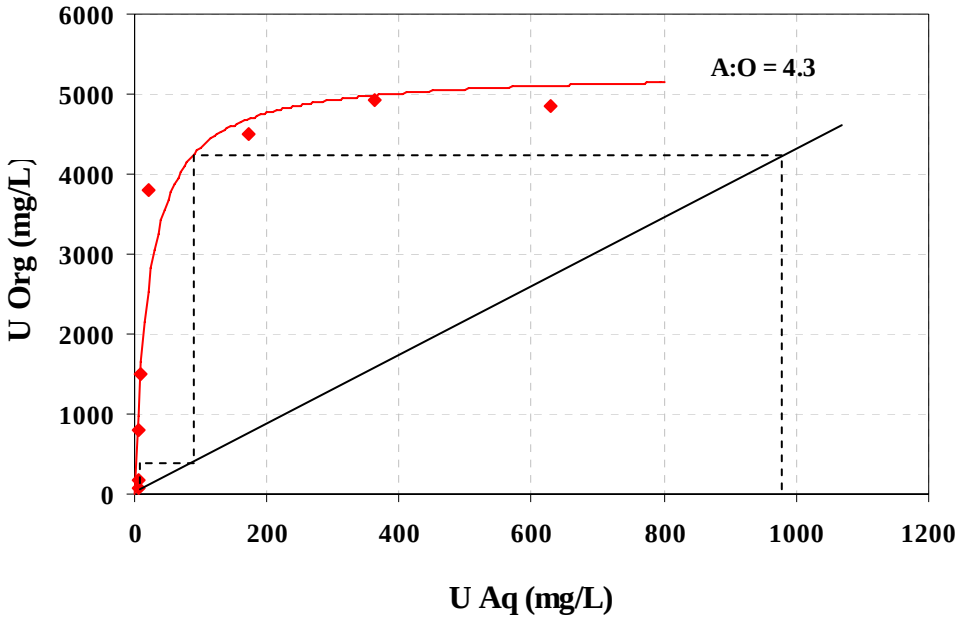


FIGURE 7.1 Uranium Loading Curve at 35 °C

7.4 Phase Disengagement

The phase disengagement was carried out in a calibrated square container. Mixing was provided with an overhead stirrer at 1800 rpm. The solvent and aqueous were mixed at an O/A = 1 for 3 minutes. The stirrer was then stopped and the aqueous phase separation was measured as a function of time. Experimental details are presented in **Appendix M**. Results of the phase disengagement tests are shown in **Figure 7.2** and **Figure 7.3.**

The time to achieve full phase disengagement was the same for both of <1 minute, though aqueous continuous was slightly faster in the first 30 seconds.

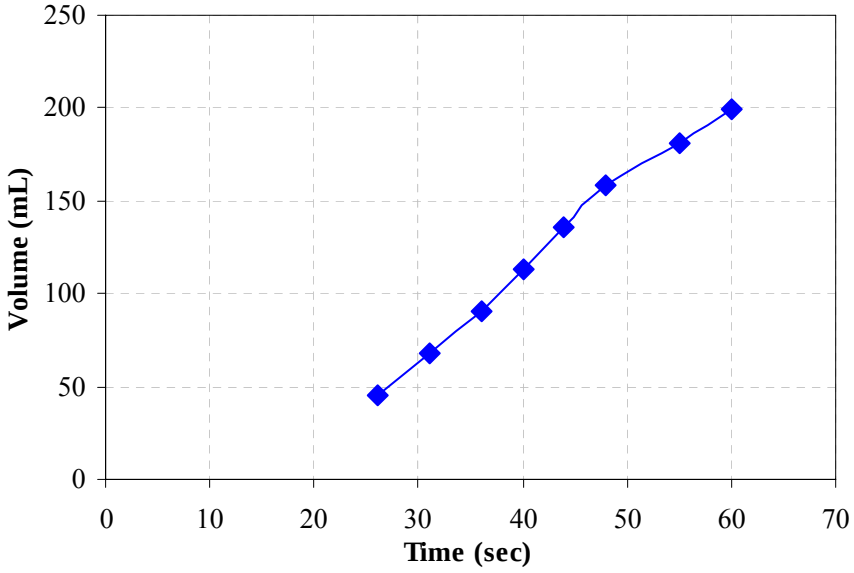


FIGURE 7.2 Phase Disengagement Test-Organic Continuous

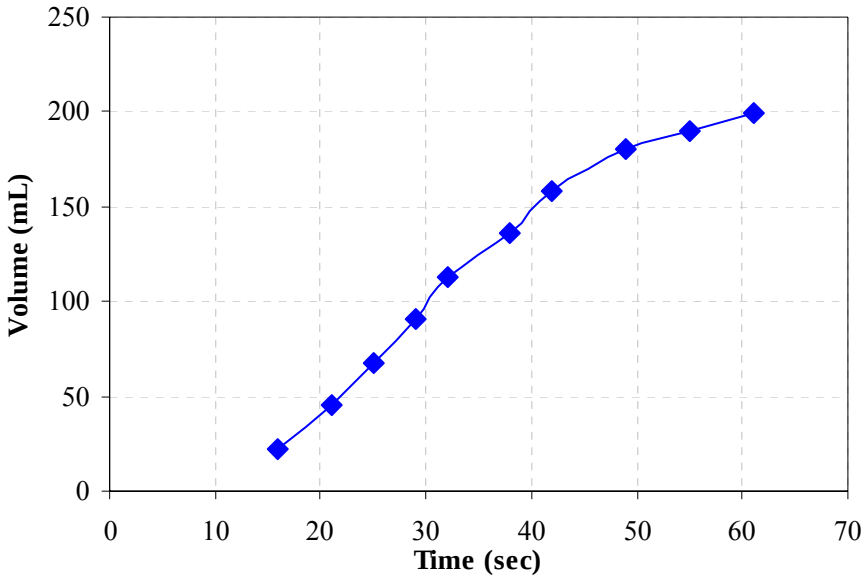


FIGURE 7.3 Phase Disengagement Test-Aqueous Continuous

7.5 Bulk Loading

A bulk loading test was carried out to provide loaded solvent for the strip curve and bulk strip. Bulk solvent (2 L) was contacted with leach feed (6.5 L) at an A:O = 3.25 twice at 35 ^{o}C. The pH was controlled to pH 1.5. Experimental details are presented in **Appendix M** and the bulk loading summary is in **Table 7.2**. A solvent loading of 4.7 g/L U was achieved.

The loaded solvent was stripped with 1 M Na_2CO_3 for most impurities and 5 M H_2SO_4 for Fe. The resultant solutions were analysed for impurities, see **Table 7.3**.

TABLE 7.2
Bulk Solvent Loading

	Stage 1	Stage 2
Organic Feed	Fresh Organic Solution	Organic Loaded in Stage 1
Aqueous Feed	Leach feed (pH 1.5)	
A/O	3.25	3.25

Solution	U (g/L)	
	Stage 1	Stage 2
Initial Aqueous	0.97	0.97
Raffinate	0.02	0.26
Loaded org. Conc.	2.9	4.7
Extraction (%)	98	74

TABLE 7.3
Impurities in the Loaded Solvent

Elements	Loaded Solvent mg/L	Elements	Loaded Solvent mg/L
Ag	4.5	P	<3
As	<3	Pb	<3
B	3.7	S (g/L)	2.1
Ba	<3	Se	<3
Ca	3.8	Si	15
Cd	<3	Ti	<3
Cr	<3	V	<3
Fe	6.8	Y	<3
K	<20	Zr	<3
Mg	<3	U (g/L)	4.7
Mo	<3	U_3O_8 (g/L)	5.6
Na	<20		

7.6 Stripping

7.6.1 100 g/L Ammonium Sulphate Strip Curve

Uranium stripping with ammonium sulphate/ammonia is the most widely adopted stripping technology. The stripping reaction occurs in accordance with the following equation.

$$(R_3NH)_4UO_2(SO_4)_3 + 4OH^- \rightarrow 4R_3N + UO_2(SO_4)_3^{4-} + 4H_2O \quad (8)$$

A batch strip curve was carried out using 100 g/L ammonium sulphate at 35 ^oC. The loaded solvent and ammonium sulphate were contacted at various ratios at pH 4.2. The equilibrium pH was measured after a stable contact reading was obtained (5-20 minutes). Some localised precipitation was observed especially at the high O/A's. Experimental details are in **Appendix M**. The Stripping curve for uranium is presented in **Figure 7.4**.

The McCabe-Thiele diagram suggests that 94% stripping may be achieved in a two stage process at an O/A = 5.4, leaving approximately 200 mg/L U in the organic phase. In practice up to three stripping stages are used, with gradual pH control from pH 3.5 – 5. Counter current testwork is required to obtain exact concentrations of the stripped solvent and loaded strip liquor, especially with regard to impurity deportment.

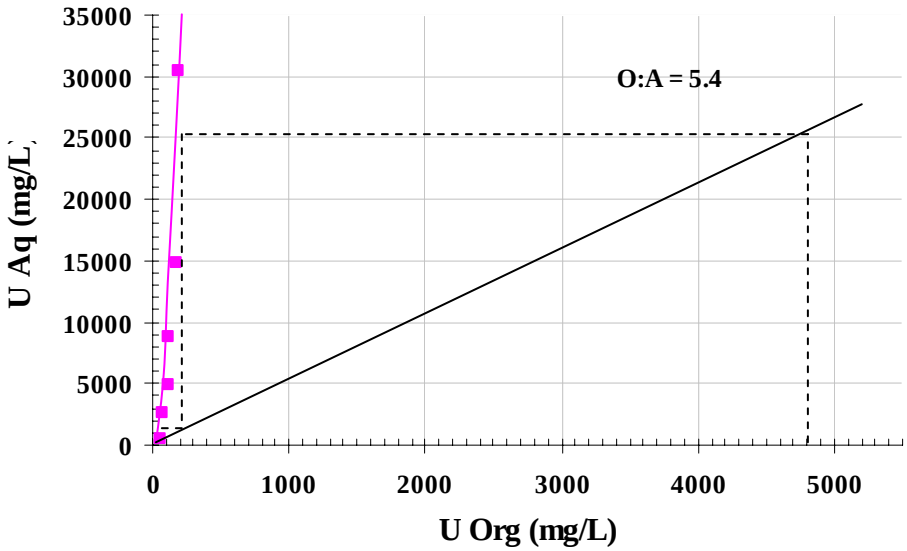


FIGURE 7.4 Uranium Stripping Curve at 35 °C

7.6.2 Bulk 100 g/L Ammonium Sulphate Strip

A bulk batch strip was performed at an O/A = 4.8 with 100 g/L ammonium sulphate at 35 °C. The pH was controlled using the same method as for the strip curve. Details are presented in **Appendix M** and results are summarised in **Table 7.4**. Comparative impurity loading data is presented in **Table 7.5.**

The single stage achieved 96% U removal from the Alamine 336 solution, resulting in 25.7 g/L U in the loaded strip and 228 mg/L uranium in the stripped organic.

TABLE 7.4
Bulk Strip with 100 g/L Ammonium Sulphate at pH 4.2

	U (g/L)
Loaded Organic	4.7
Loaded Strip	25.7
Stripped Organic	0.23
Stripping (%)	96

TABLE 7.5
Bulk Loaded Strip (full Analysis)

Elements	Loaded Strip mg/L	Elements	Loaded Strip mg/L
Ag	<10	P	4
As	<10	Pb	<10
B	<10	S (g/L)	31.8
Ba	<10	Se	<10
Ca	28	Si	<5
Cd	<1	Ti	<10
Cr	<1	V	<10
Fe	6	Y	4
K	<10	Zn	<1
Mg	2	Zr	<1
Mo	<1	U (g/L)	25.7
Na	<10	U_3O_8 (g/L)	30.3

7.7 Ammonium Diuranate Precipitation

Ammonium Diuranate, $(NH_4)_2U_2O_7$ is precipitated from ammonium sulphate as outlined by the following reaction:

$$2UO_2SO_4 + 6NH_4OH \rightarrow (NH_4)_2U_2O_7 + 2(NH_4)_2SO_4 + 3H_2O \quad (9)$$

The stoichiometric requirement is 0.18 kg of NH_3 consumed per kg of U_3O_8 precipitated. The precipitation reaction generates ammonium sulphate which can be then recycled back to the strip circuit, with a bleed for impurity control.

The uranium precipitation was carried out at 30 ^oC by the addition of 205% stoichiometric excess of NH_4OH over a period of 2 hours. This was excessive in this test, possibly due to the pH being controlled too high at pH 7.5. Generally the pH should be controlled at pH 7 - 7.5 with the addition of 13 M NH_4OH aiming for a stoichiometric excess of 10-20 %. Experimental details of the tests are presented in **Appendix M**. Complete uranium recovery from the loaded strip solution was achieved in the process with < 1 mg/L U in the barren and (> 99%) uranium recovery.

The composition of the ADU product is compared against the Converdyn specification given in **Table 7.6**.

TABLE 7.6
Uranium Product Analysis (% of U)

Feed Type	ADU	Std Specification for Uranium Ore Concentrate ASTM C967-08	Converdyn* Standard Concentrates	Converdyn* Maximum Limit Concentrates
Element	% of U	% of U	% of U	% of U
Ag	<0.03		0.01	0.04
As	<0.01	0.05	0.01	0.04
B	<0.01	0.005	0.01	0.10
Ba	<0.01		0.01	0.04
Ca	<0.1	0.05	0.05	1.00
Cd	<0.01		0.01	0.04
Cr	<0.01		0.01	0.04
Fe	0.02	0.15	0.15	0.50
Hg	<0.01		0.01	0.04
K	<0.1	0.20	0.20	1.00
Mg	<0.01	0.02	0.02	0.50
Mo	<0.01	0.10	0.10	0.30
Na	<0.01	0.50	0.50	3.00
P	<0.01	0.10		
PO_4	<0.03		0.10	1.00
Pb	<0.01		0.01	0.04
S	<1	1.00	1.00	4.00
Se	<0.01		0.01	0.04
Si	<0.06			
SiO_2	<0.1	0.50	0.50	2.00
Th	<0.01	1.00	0.10	0.50
Ti	<0.01	0.01	0.01	0.05
U	79[#]	65	75	65
V	<0.01	0.06	0.10	0.75
Zr	<0.01	0.01	0.01	0.50
F	0.01	0.01	0.01	0.10
Cl	**0.39**	0.05	0.05	0.10

* concentrates not meeting or exceeding the "maximum limits concentrate" may be rejected. When concentrates fail the "standard Concentrate" requirements but do not exceed the "maximum limit concentrates" values, surcharges will be assessed according to the surcharge schedule.
[#] U as a percent of dried ADU product.

The precipitate was washed and dried then a known weight was dissolved in 10 mL of water and 10 mL of conc. nitric acid. The solution was assayed for Ag, As, B, Ba, Ca, Cd,Cr, Fe, Hg, K, Mg, Mo, Na, P, Pb, S, Se, Si, Th, Ti, U, V, Zr by ICPOES and ICP-MS, Cl and F by ISE.

7.8 Comparison of Uranium Products

The two uranium peroxide products from ion exchange are compared to the ammonium diuranate product from the solvent extraction in **Table 7.7**.

TABLE 7.7
Uranium Product Comparison (wt.%)

Element	ADU after SX	Amberjet 4400	Ambersep 920U	Element	ADU after SX	Amberjet 4400	Ambersep 920U
Ag	<0.02			Mg	<0.01	<0.02	<0.03
Al		0.06	0.05	Mn		<0.02	<0.03
As	<0.01	<0.02	<0.03	Mo	<0.01	<0.02	<0.03
B	<0.01			Na	<0.01	0.18	0.14
Ba	<0.01	<0.02	<0.03	Ni		<0.02	<0.03
Bi		0.03	0.04	P	<0.01	0.19	0.20
Ca	<0.1	0.34	0.23	Pb	<0.01	0.10	0.09
Cd	<0.01			S	<1	1.8	2.9
Cl	0.31	0.38	<0.3	Se	<0.01		
Co		0.02	0.03	Si	<0.05	<0.09	<0.15
Cr	<0.01	<0.02	<0.03	Th	<0.01		
Cu		0.05	0.05	Ti	<0.01	<0.02	<0.03
F	0.01	0.05	<0.03	U	79.2	71.2	71.0
Fe	<0.02	0.14	0.16	V	<0.01	<0.02	<0.03
Hg	<0.01			Zn		0.073	<0.03
I		0.18	0.29	Zr	<0.01	<0.02	<0.03
K	<0.1	<0.2	<0.1				

The products were similar and very close to the theoretical maximums for uranium content.

7.9 Conclusions

The main findings were as follows:

- Uranium loading was very favourable, with a maximum equilibrium loading of up to 4.7 g/L U achieved in the batch test.
- The impurity load on the solvent was very low, both Mo and Zr at 0.01% of U.
- Stripping the solvent with ammonium sulphate/ammonia was found to be favourable.
- A batch bulk strip followed by precipitation of ammonium diuranate with ammonia addition produced an ADU product and barrens of <1 mg/L U.
- ADU precipitation produced a product meeting most of the strict Converdyn specifications except for chloride which could be removed by better washing of the final uranium precipitate. However, under counter current solvent extraction conditions, the chloride would not load to the same extent as for the batch loading tests.

8. CONCLUSIONS

8.1 Leach Tests

8.1.1 Dilute Leaches

Dilute leaching tests on pulverised ore under ideal leach conditions showed that the uranium mineralisation was very amenable to leaching, with extractions of 98.6-99% achieved for the Junnagunna and Redtree samples. Extraction from the lower grade Jack ore was 97.6%. Compared to other ores tested by ANSTO Minerals, the concentrations of ions dissolved were low, decreasing in the order Si>Al≈Ca>K>Mg. Gangue dissolution was greatest for Garee Lower lens, and lowest for Jack Lens.

8.1.2 Base Case and Initial Leaches

The Junnagunna and Garee Redtree samples were readily leached under conventional leaching conditions (55 wt.% solids, 40 °C, pH 1.5, P_{80} of 250 µm and ORP of 500 mV), achieving uranium extractions of 96.5-97.5% after 24 h. As very little uranium dissolution occurred between 12 and 24 h, a 12 h leaching time would be sufficient. The rate of leaching of uranium also responded to ORP, and an ORP of 550 mV is recommended. For these conditions uranium extraction was 97% for both ores, with acid additions of only 18 and 14 kg/t for Junnagunna and Redtree, respectively. Predicted pyrolusite requirements were also low at 3.0 kg/t for both ores.

Only one leach was initially conducted on the Jack sample and that was under base case conditions. This showed that reagent requirements were less than half those for Redtree, but uranium extraction was only 87% after 24 h.

8.1.3 Optimisation Test on Junnagunna and Redtree

The optimisation tests on the Junnagunna and Redtree samples showed that:

- Varying the P_{80} grind sizes in the range 350 - 75 µm had negligible impact on uranium extraction and acid addition. Finer grinding resulted in faster initial uranium leaching kinetics, but a similar effect was achieved by increasing the ORP. Grinding to a P_{80} of 350 µm significantly reduced the rate of uranium extraction up to about 12 h for Redtree. On this basis a P_{80} of 250 µm would probably be selected to target a 12 h leach time.
- Leach pH over the range 1.3 – 1.7 had little impact on uranium recovery for Junnagunna ore. At pH 2, extraction was reduced by 1% to ~ 96%. For the Redtree sample, the 24 h extraction increased from 92% to 98% when the leaching pH was decreased from pH 2.0 to pH 1.3. The pH also had an impact on the initial leaching rate. The optimum pH for both ores was 1.5, or perhaps slightly lower for Redtree;
- Acid addition was low for both ores, ranging from 10-25 kg/t and 10-20 kg/t for Junnagunna and Redtree, respectively, for all conditions examined;
- The pyrolusite requirement for both ores was ~3.0 kg/t for optimum leach conditions. Note, the use of potassium permanganate and pyrolusite as oxidants produced equivalent results;

- The uranium leaching rate increased with increasing temperatures from 30 °C to 50 °C. For both ores, leaching at 30 °C significantly decreased the extraction rate, and to a lesser extent, the final extraction of uranium. The initial rate of leaching was reduced at 40 °C, but extractions were quite similar to those at 50 °C after 12 h. Although temperature has a significant effect on the initial extraction rate, there was also a significant relative increase in the acid addition. The optimum temperature appeared to be ~ 40 °C;
- For both samples, similar final (24 h) uranium extraction results were achieved for leaching at ORP levels of 500-550 mV. Uranium extraction decreased significantly when leaching at 450 mV. Addition of 1.0 g/L ferric ion at 500 mV had a slight impact on the rate of extraction, but there was little difference after 12 h. A similar result was achieved by leaching at 550 mV, and this approach would be preferred to adding iron. For both samples, there was a significant increase in demand for oxidant to increase the ORP from 450 to 500 mV, but only a further small addition was required to achieve 550 mV. The oxidant demand for both samples was very similar for both samples. The optimum ORP is considered to be 550 mV.

8.1.4 Jack Ore Sample

- Under base conditions, the extraction of uranium from the Jack ore sample was 87%, considerably less than the dilute leach result of 97%, and significantly less than the 96-97% extraction from the other two samples under base case conditions. This result could be due to the very low ferric ion concentration (0.2 g/L) in the Jack leach liquor;
- Addition of 1.0 g/L Fe, leaching at pH 1.2, and leaching at a finer grind of P_{80} = 150 µm at pH 1.5 with addition of Fe, all increased the extraction from 87% for base case conditions to 91-91.5%, after 24 h;
- Optimum conditions for the Jack sample would either be leaching at pH 1.2, with other conditions at base case, or leaching at pH 1.5, with addition of 1.0 g/L Fe. Note that the latter conditions may occur if Jack ore was blended with either Junnagunna or Redtree because of the amount of iron dissolved from these ores. Further work is recommended to identify conditions that could increase extraction from the Jack ore.
- Reagent requirements for Jack ore were very low, less than half those for the Redtree composite.

8.1.5 Leach Liquor

- For the Junnagunna and Redtree ores, iron was the dominant ion in solution. For the Junnagunna ore the concentrations of elements in solutions generally decreased in the order:

$$Fe>Al>Si>Ca>Mg\approx K>P>As$$

- The Redtree ore contained about 6 times the level of arsenic than the Junnagunna ore, hence the much higher arsenic levels in solutution. For the Redtree ore the concentrations of elements in solution generally decreased in the order:

  Fe>Al>Si>Ca≈As≈K≈Mg>P

  The following general impacts of leach variables were evident:

  - The concentrations of all elements, except K, increased with decreasing pH;
  - The concentrations of all elements, except Ca and P, increased with increasing temperature;
  - Grind size had little impact on the concentrations of gangue elements in solution;
  - The concentrations of all elements increased with increased leaching time;
  - The concentrations of all elements were marginally greater in the Junnagunna liquor compared to Redtree, which was reflected in the acid requirement;
  - None of the gangue element concentrations in solutions would be expected to result in downstream processing problems. The Si concentrations were typical of many of the acid uranium leach liquors that are currently being processed, but noting that it is the form of the silica, rather than the total concentration, that results in silica problems;
  - Ferric concentrations were reasonably high, which is a positive for leaching, but will result in some degree of iron loading if IX is used for uranium recovery;
  - The concentrations of all ions, except for P and Ca, were considerably less in the Jack liquors, as reflected by the very low acid requirement.
  - The concentrations of the minor elements that could report to final product as penalty elements, eg Mo, V, Zr, were low. Arsenic was present at 40-180 mg/L for Redtree ore and may warrant additional attention in regards to waste water treatment. However, the arsenic levels in solution when the Redtree was combined with Junnagunna and Jack was lower at ~100 mg/L. It is likely that the vast majority of arsenic will precipitate as ferric arsenate during a neutralisation process. However, this still has to be proven.

8.1.6 Unleached Uranium

- The residual uranium minerals after leaching consisted of coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$), uranium phosphate, probably phosphuranylite ($KCa(H_3O)3(UO_2)_7(PO_4)_4O_4{\cdot}8(H_2O)$), and uraniferous zircon, where coffinite was the most common uranium mineral. They were almost always enclosed in quartz particles. Various amounts of arsenic were detected in most uranium minerals.

8.1.7 Bulk Leach

The bulk leach results corresponded well with the test on individual ores under the same or similar conditions.

The uranium extraction was 96.2% after 12 hours and 96.1% after 8 hours. The rapid reaction kinetics in comparison to the individual tests was likely due to the elevated iron levels in solution. The expected extraction was 95.6%. The reason for the higher than expected extraction is likely due to the high ORP and ferric ion concentration increasing the extraction of uranium from the Jack ore portion.

The solution product in the bulk leach also corresponded well to the expected values from the final product solutions from leaches on the individual ores.

8.1.8 Ion-Exchange

Uranium can be recovered effectively using Ambersep 920, an RIP resin with 750 < d < 950 μm, and Amberjet 4400 (d = 580 ± 50 μm). Resin loadings of 45 and 78 g/L wsr U_3O_8 were obtained. Both resins demonstrated favourable loading and elution kinetics and in column elution tests quantitative elution was achieved for < 20 BV of 1 M H_2SO_4 delivered. The eluted resins contained < 1 g/L wsr U_3O_8.

Precipitation of uranyl peroxide from the eluates generated a product for which the composition compared favourably to a Cameco, Comurhex and Converdyn (upper limit) purity specification.

8.1.9 Solvent Extraction

The laboratory batch testwork was performed using a mixture of 5 vol.% Alamine 336 and 2 vol.% Isodecanol in Shellsol 2046. This solvent composition is widely used in industrial purification of uranium.

The main findings were as follows:

- Uranium loading was very favourable, with a maximum equilibrium loading of up to 4.7 g/L U achieved in the batch test.
- The impurity load on the solvent was very low.
- Stripping the solvent with ammonium sulphate/ammonia was found to be favourable.
- A batch bulk strip followed by precipitation of ammonium diuranate with ammonia addition produced an ADU product and barrens of <1mg/L U.
- ADU precipitation produced a product meeting most of the strict Converdyn specifications except for chloride which could be removed by better washing of the final uranium precipitate. In addition, under counter current solvent extraction conditions, the chloride would not load to the same extent as for the batch loading tests, which would decrease the chloride in the strip liquor and UOC product.

9. RECOMMENDATIONS

- Conduct leach tests using solution either from site or a synthetic solution to simulate expected leach make-up solution;
- Conduct optimisation tests on the expected composite feed;

- Conduct downstream neutralisation testwork, on liquors generated from Redtree ore and a composite of all three ores, to ensure that the arsenic can be effectively immobilised into an iron precipitate;
- Conduct a continuous pilot operation on the expected feed composite to confirm data generated in batch tests, and to generate slurry/solution for continuous downstream piloting;
- Conduct filtration, settling and rheology test work on the product slurry from the continuous test work;
- Conduct downstream continuous test work, i.e. ion-exchange and/or solvent extraction;
- Consider tailings neutralisation treatment and recycle of liquor.

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APPENDIX A

Sample Details

SAMPLE DETAILS

The samples from Westmoreland were chosen to be as representative intervals of specific recognizable lenses, which account for the majority of the resource base. Samples from both the Redtree and Junnagunna deposits have been provided. The intervals have been sampled in 5 metre sub-intervals, as this was a convenient quantity for each sample bag. A brief description of the sample intervals is given in **Table A1**.

Table A1

	Hole ID	From (m)	To (m)	U_3O_8 (ppm)	wt (kg)	Total (kg)
Junnagunna "Steep"	JDD08-023	45	65	2250	70	
Mineralisation	JDD08-023	80	90	2910	34	
	JDD08-026	20	70	850	179	283
Garee Upper Lens	WDD08-009	30	50	540	69	
(Redtree)	WDD08-012	35	55	540	68	
	WDD08-037	12	36	610	86	
	WDD08-040	16	36	5270	74	297
Garee Lower Lens	WDD08-011	62	82	2580	73	
(Redtree)	WDD08-012	60	80	510	68	
	WDD08-040	88	103	3210	74	196
Jack Lens	WDD08-054	1.5?	20	90	35	
Mineralisation (Redtree)	WDD08-055	0	25	1040	69	104

Redtree - Garee Lens - Upper and Lower

The Garee Lens occurs on the eastern side of the Redtree dyke. Mineralisation occurs as flat lying, bedding parallel zones. This lens was modelled as a single entity in 2006. Based on the results of the 2008 drilling program, this area is now modelled as having an upper and lower lens. **The upper lens** is associated with a characteristic coarse pebble conglomerate band. **The lower lens** is associated with a thicker more variable stratigraphy consisting of coarse pebbly sandstones with pebble conglomerate bands. Mineralisation is associated with hematite and chlorite alteration. Hematite is dominant in the upper Garee Lens while chlorite is dominant in the lower lens.

Redtree- Jack Lens

The Jack lens is a shallow, flat lying zone of mineralisation that occurs on the western side of the dyke zone. Mineralisation is associated with the equivalent horizon that hosts the upper Garee Lens. Mineralisation is typically associated with strong hematite alteration. The Jack Lens contains a higher proportion of secondary uranium minerals (autunite and torbenite) than the Garee Lens.

Junnagunna

Mineralisation at Junnagunna has two broad occurrence types:

- Flat lying mineralisation occurs as thin, extensive horizontal lenses which occur immediately below the contact between Seigal Volcanics and the Westmoreland Conglomerate.
- Steep mineralisation which occurs as steep zones adjacent to the Dyke and fault zone. This mineralisation occurs in the Westmoreland Conglomerate and adjacent but outside the main fracture and fault zone which hosts the dyke.

Mineralisation at Junnagunna shows broad similarities with Redtree. Strongest mineralization is associated with chlorite±hematite altered coarse pebbly sandstones broadly similar to that encountered at Redtree. Strongly silicified and fractured rock found immediately adjacent to the dyke is generally poorly mineralized.

Multi-element Analyses

Multi-element analyses for each individual 1 m interval have been provided. Averaged assays are shown in **Tables A2 and A3**.

TABLE A2
Average Composition of Lens Samples (wt.%)

	Junnagunna Steep	Garee Upper	Garee Lower	Jack Lens
Al	1.43	1.19	1.66	1.41
Ca	0.21	0.05	0.06	0.07
Fe	1.59	2.18	2.58	1.13
K	0.57	0.46	0.62	0.62
Mg	0.13	0.06	0.12	0.08
S	**0.04**	**0.01**	**0.05**	**0.01**
Si	-	-	-	-
	(ppm)			
U_3O_8	2003	1740	2100	565
As	**64**	**295**	**171**	**52**
Ba	94	61	122	68
Be	2.3	1.0	1.6	1.0
Bi	10.2	0.0	8.0	4.6
Co	24.7	7.7	30.8	18.6
Cr	13.1	12.0	12.0	9.9
Cu	55.7	22.8	52.3	37.0
La	13.2	14.5	21.3	28.0
Mn	125	149	172	90
Mo	**60.4**	**5.6**	**23.5**	**12.7**
Ni	9.7	8.8	27.3	8.2
P	**803**	**154**	**199**	**294**
Pb	155	123	121	42
Sr	10.4	85.1	22.7	71.3
V	**336**	**157**	**177**	**229**
Zn	30.4	14.3	7.2	6.6

The data in **Table A2** shows that:

- All samples are low in Ca and Mg, indicating a virtual absence of calcite and dolomite. In fact the concentrations of all major gangue elements are very low, suggesting that acid requirements should not be high;
- Total S is very low, indicating that sulphide concentrations should not be of concern;
- Uranium concentrations in 3 of the samples are 1700-2100 ppm U_3O_8, which is considerably greater than the average for the deposit of 900-1000 ppm;
- Minor elements, which could cause issues in terms of process performance or product quality, are As, Mo and V.

QEMSCAN Analyses

SGS laboratories were used to undertake QEMScan analysis on 20 pulp samples from the 2008 drilling program. The results of this previous work (client reference) indicated that uranium occurred predominantly as uraninite and coffinite with lesser torbenite and autunite. No Ningyoite was identified.

TABLE A3
Average Composition of Interval Samples

	HoleID	From	To	U3O8	U3O8	Al	Ca	Fe	K	Mg	Na	S	Si
Junnagunna Steep				XRF	ICP								
	JDD08-023	45	65	2250	2200	1.49	0.06	1.50	0.60	0.13	0.03	0.04	
	JDD08-023	80	90	2910	2588	1.35	0.50	1.67	0.54	0.12	0.02	0.05	
	JDD08-026	20	70	850	824	1.46	0.07	1.59	0.56	0.14	0.02	0.04	
Avg				2003	1871	1.43	0.21	1.59	0.57	0.13	0.02	0.04	
Garee Upper	WDD08-009	30	50	540	538	1.30	0.03	1.70	0.49	0.08		0.02	
	WDD08-012	35	55	540	552	1.32	0.12	2.68	0.53	0.05		0.00	
	WDD08-037	12	36	610	691	1.20	0.02	1.41	0.47	0.05	0.00	0.01	
	WDD08-040	16	36	5270	5065	0.96	0.03	2.94	0.36	0.06	0.01	0.00	
Avg				1740	1712	1.19	0.05	2.18	0.46	0.06	0.01	0.01	
Garee Lower	WDD08-011	62	82	2580	2465	1.43	0.04	4.35	0.43	0.21		0.05	
	WDD08-012	60	80	510	523	1.86	0.06	1.42	0.78	0.05		0.03	
	WDD08-040	88	103	3210	2696	1.69	0.07	1.97	0.66	0.11	0.02	0.06	
Avg				2100	1894	1.66	0.06	2.58	0.62	0.12	0.02	0.05	
Jack Lens	WDD08-054	1.5	20	90	75	1.62	0.01	0.58	0.74	0.06	0.01	0.00	
	WDD08-055	0	25	1040	923	1.21	0.13	1.68	0.49	0.10	0.01	0.02	
Avg.				565	498.7	1.41	0.07	1.13	0.62	0.08	0.01	0.01	

	HoleID	From	To	As	Ba	Be	Bi	Co	Cr	Cu	La	Mn	Mo	Ni	P	Pb	Sr	Ti	V	Zn
	JDD08-023	45	65	78.2	103.5	2.6	9.9	20.9	11.4	53.1	12.5	132.5	78.8	8.9	119.5	193.4	11.7	0.0	333.0	30.2
	JDD08-023	80	90	66.3	83.0	2.1	8.6	28.3	14.8	58.1	11.0	130.3	38.8	8.6	2086.0	198.8	11.2	0.0	469.8	46.8
	JDD08-026	20	70	47.0	96.8	2.2	12.1	25.1	13.2	55.8	16.2	111.6	63.6	11.7	202.2	73.9	8.4	0.1	203.7	14.3
Avg.				63.8	94.4	2.3	10.2	24.7	13.1	55.7	13.2	124.8	60.4	9.7	802.6	155.4	10.4	0.0	335.5	30.4
	WDD08-009	30	50	32.4	49.5	0.9	0.0	4.6	9.6	52.3	17.0	149.7	1.7	13.5	77.5	141.3	24.6	0.0	126.2	47.8
	WDD08-012	35	55	117.2	61.5	0.7	0.0	6.3	12.2	9.9	18.5	201.3	12.8	6.9	293.0	35.5	176.7	0.0	159.2	2.9
	WDD08-037	12	36	44.5	53.1	1.0	0.0	8.6	9.6	10.6	11.9	92.2	2.8	4.6	116.9	48.1	71.6	0.0	99.1	2.6
	WDD08-040	16	36	986.6	78.5	1.3	0.0	11.1	16.7	18.5	10.5	151.9	5.0	10.3	129.5	267.3	67.7	0.0	244.5	4.1
Avg.				295.2	60.7	1.0	0.0	7.7	12.0	22.8	14.5	148.8	5.6	8.8	154.2	123.0	85.1	0.0	157.2	14.3
	WDD08-011	62	82	359.4	100.5	1.8	23.6	39.2	15.6	42.9	20.0	245.7	4.2	55.0	135.0	150.5	8.0	0.0	129.8	9.1
	WDD08-012	60	80	43.6	95.0	0.9	0.4	22.4	11.1	70.6	22.0	150.9	52.8	8.7	221.5	43.4	46.9	0.1	235.5	5.1
	WDD08-040	88	103	108.6	170.0	2.0	0.0	30.8	9.3	43.4	22.0	119.1	13.7	18.4	240.7	168.8	13.3	0.1	166.5	7.5
Avg.				170.5	121.8	1.6	8.0	30.8	12.0	52.3	21.3	171.9	23.5	27.3	199.1	120.9	22.7	0.1	177.2	7.2
	WDD08-054	1.5	20	14.8	50.0	0.8	2.3	3.5	8.5	14.8	10.0	58.0	0.7	5.3	108.3	5.0	60.8	0.0	147.2	3.0
	WDD08-055	0	25	90.0	86.5	1.3	7.0	33.7	11.4	59.3	46.0	121.5	24.7	11.2	479.0	78.5	81.8	0.1	310.5	10.3
Avg.				52.4	68.3	1.0	4.6	18.6	9.9	37.0	28.0	89.8	12.7	8.2	293.7	41.7	71.3	0.1	228.8	6.6

APPENDIX B

Results from Previous ANSTO Work

TABLE B.1
Uranium Minerals in Westmoreland Ore Samples (Previous Studies)

	Relative Volume Percent of Uranium Minerals									
Sample Description	Uraninite	Coffinite	Autunite	Ningyoite	Brannerite	Carnotite	Bassetite	Sklodowskite	Boltwoodite	Torbernite
Low grade, oxidised ore	16		2			31	9			42
Higher grade, oxidised ore	67	2.7	7.3	2		13	5.4			2.5
Low grade, fresh ore (chloritic)	62	17	5.5	13			2.5			
Higher grade, fresh ore	45	2.1	19	31			2.9			
Junnagunna	29	64	7							
Junnagunna	38	62								
Junnagunna Composite	41	59								
Junnagunna Composite	44	56								
Junnagunna Composite	58	42								
Junnagunna Composite	21	78			1					
Huarabagoo	78	3	19							
Huarabagoo	65	34	1							
Huarabagoo	31	10	18	34	7					
Huarabagoo Composite	76	24								
Huarabagoo Composite	53	47								
Huarabagoo Composite	80	10	3	7						
Redtree	83	6	3	5		3				
Redtree	85	1	5	8			1			
Redtree	82			4		14				
Outcamp	19	81								
Black Hills						12		72	16	

TABLE B.2
Leaching Data for Westmoreland Ore Samples (Previous Studies)

		wt %									pH 1.5		
Sample Name	Sample Description	Al	Fe	Mg	P	Ti	Si	V	U3O8	Particle Size (% <75 µm)	H2SO4 Addition (kg/t)	H2O2 Addition (kg/t)	U Extraction (%)
A	Low grade, oxidised ore	1.2	0.9	0.06	0.13	0.04	53.6	0.05	**0.060**	40	12.6	1.7	**93.2**
B	Higher grade, oxidised ore	1.1	2.0	0.05	0.11	0.04	48.8	0.13	**0.286**	34	10.8	1.1	**93.7**
C	Low grade, fresh ore (chloritic)	1.1	0.5	0.06	0.14	0.03	47.6	0.05	**0.053**	33	11.3	1.2	**78.2**
D	Higher grade, fresh ore	1.1	0.7	0.07	0.14	0.03	46.5	0.07	**0.201**	33	11.3	1.6	**83.1**
JUL 176	Junnagunna	1.7	1.2	0.17	<0.1	0.06	44.1	0.03	**0.048**	35	13.5	1.2	**96.6**
JUL 177	Junnagunna	1.5	1.8	0.20	<0.1	0.08	45.1	0.05	**0.062**	36	15.5	1.7	**91.5**
JU 1	Junnagunna Composite	1.2	1.2	0.29	0.01	0.04	40.8	0.02	**0.072**	42	20.3	1.5	**96.3**
JU 2	Junnagunna Composite	1.9	2.6	0.64	0.01	0.16	41.5	0.05	**0.124**	51	56.7	3.8	**97.2**
JU 3	Junnagunna Composite	1.4	2.4	0.32	0.01	0.05	41.6	0.15	**1.077**	33	54.1	5.4	**99.2**
JU 4	Junnagunna Composite	1.9	1.5	0.36	0.03	0.08	42.1	0.05	**0.062**	34	19.0	1.8	**94.4**
HU 178A	Huarabagoo	1.2	1.8	0.06	<0.1	0.04	46.9	0.03	**0.129**	39	9.3	1.3	**95.6**
HU 178B	Huarabagoo	1.4	3.2	0.09	<0.1	0.04	42.3	0.05	**0.090**	38	20.3	1.4	**97.2**
HU 173	Huarabagoo	11.1	2.5	1.02	0.31	2.50	29.3	0.57	**0.121**	70	17.6	2.1	**47.6**
HU 1	Huarabagoo Composite	1.2	1.6	0.08	0.05	0.04	41.7	0.03	**0.116**	37	9.5	1.2	**96.0**
HU 2	Huarabagoo Composite	1.7	2.1	0.14	0.01	0.06	42.6	0.05	**0.491**	37	32.7	3.0	**99.0**
HU 3	Huarabagoo Composite	0.9	0.6	0.07	0.01	0.02	46.1	0.01	**0.022**	37	8.3	1.0	**88.5**
RT 172	Redtree	2.6	1.0	0.08	<0.1	0.09	39.4	0.06	**0.114**	32	10.3	1.2	**93.6**
RT 171	Redtree	2.5	1.4	0.09	<0.1	0.10	39.9	0.06	**0.157**	37	14.4	1.9	**94.3**
RT 170	Redtree	1.4	2.0	0.05	<0.1	0.06	44.9	0.09	**0.107**	37	8.7	1.2	**95.0**
OC 175	Outcamp	2.8	2.9	0.73	<0.1	0.33	42.3	0.03	**0.040**	38	18.9	1.3	**94.5**
BH 174	Black Hills	2.3	5.2	0.38	<0.1	0.32	40.7	0.08	**0.093**	38	14.7	0.9	**77.4**

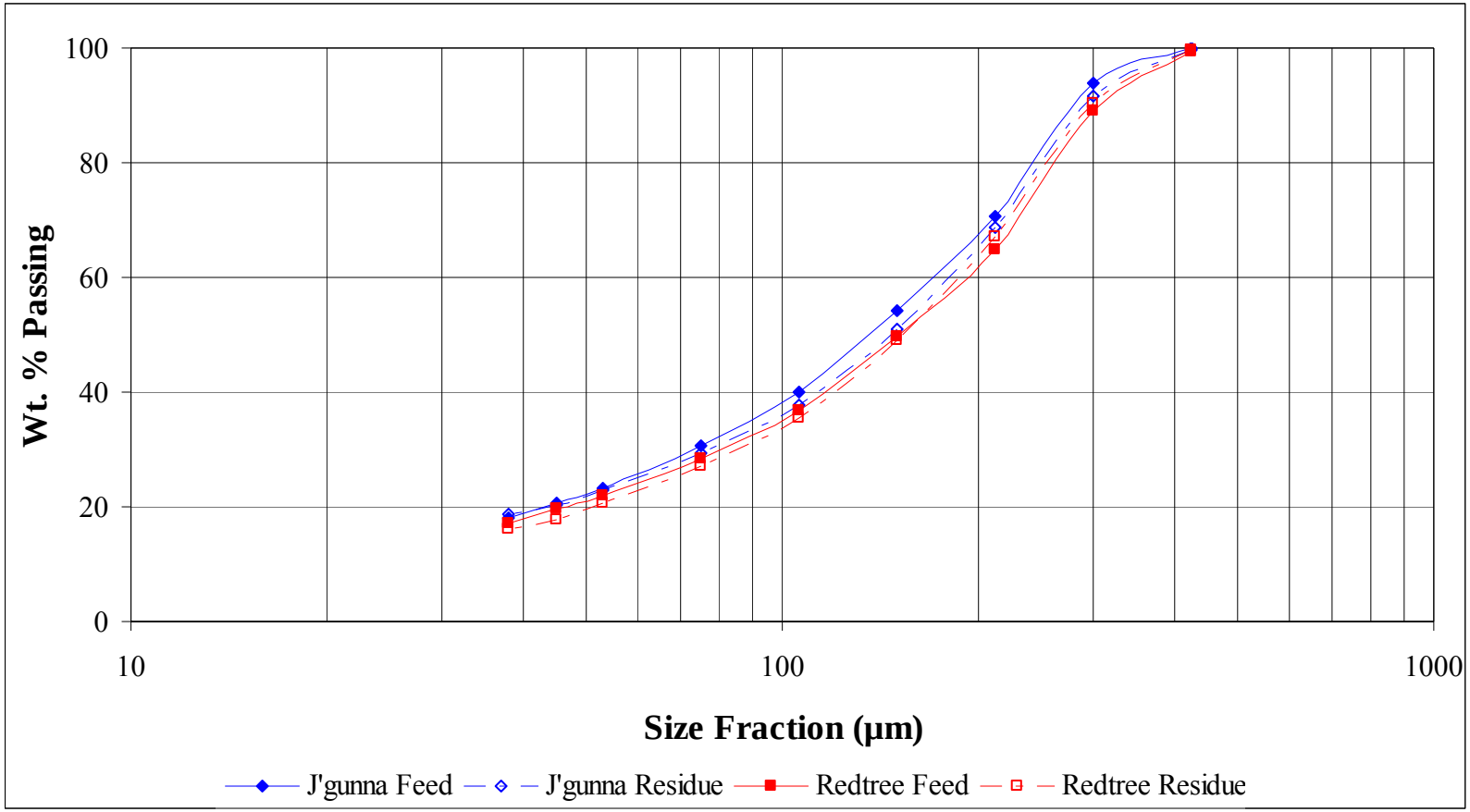
Standard Leach Conditions: pH 1.5, 475 mV vs Calomel Electrode (512 mV vs Ag/AgCl), 40°C, 55% Solids

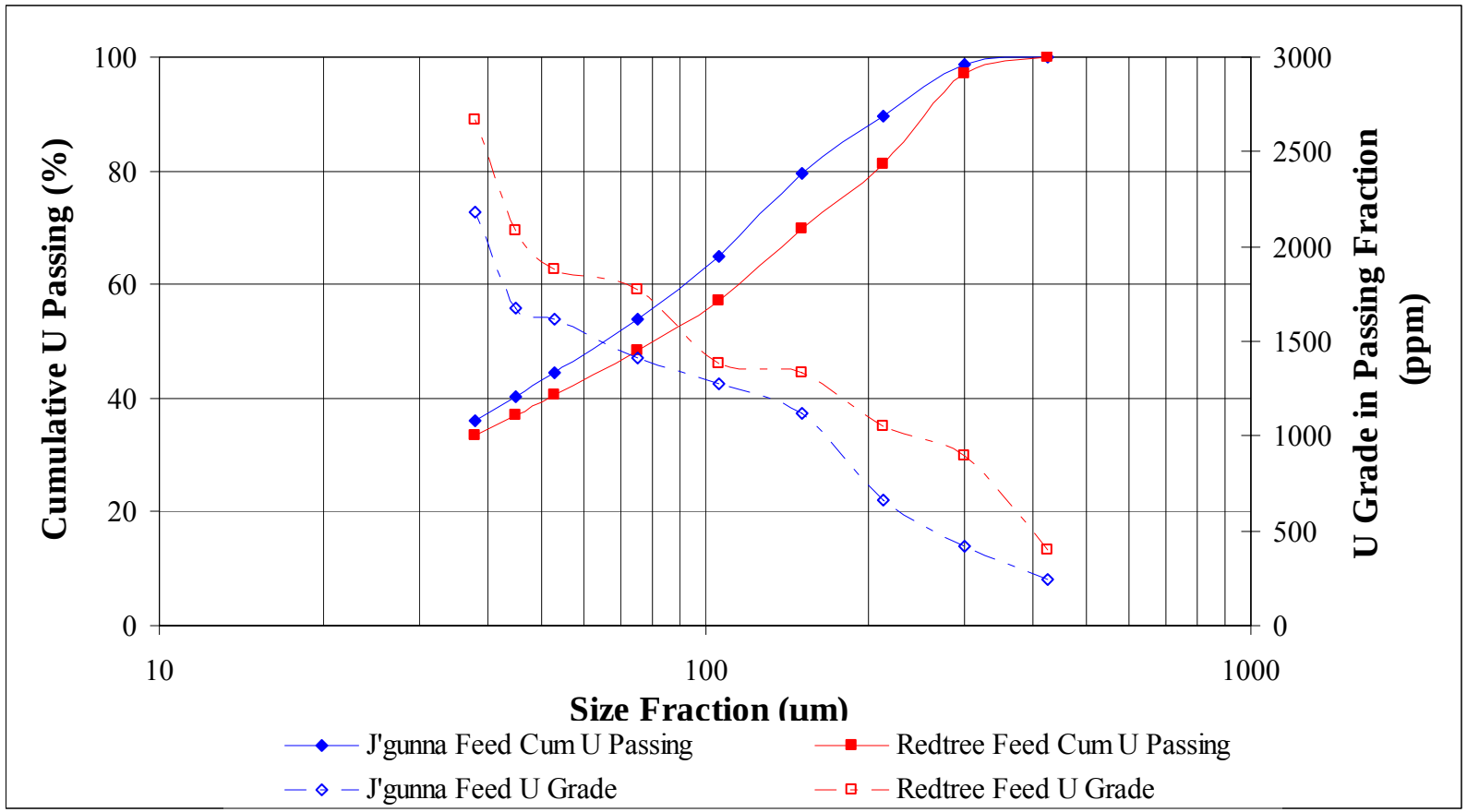
APPENDIX C

Size by Size Analyses

SIZE BY SIZE ANALYSES

Size Passing (µm)	Junnagunna						Redtree					
	Feed			Residue			Feed			Residue		
	Cumulative wt.% Passing - Leach Feed	U Grade (ppm)	Cumulative U Passing (%)	Cumulative wt.% Passing - Residue	U Grade (ppm)	Cumulative U Passing (%)	Cumulative wt.% Passing - Leach Feed	U Grade (ppm)	Cumulative U Passing (%)	Cumulative wt.% Passing - Residue	U Grade (ppm)	Cumulative U Passing (%)
425	99.9		**100**	99.7		**100.0**	99.4		**100.0**	99.7		100.0
300	94.0	248	**98.7**	91.5	13	**92.7**	89.1	398	**97.0**	90.5	34	89.3
212	70.7	415	**89.7**	68.7	13	**73.6**	64.9	901	**81.1**	67.1	27	67.7
150	54.1	666	**79.5**	51.1	12	**59.5**	49.8	1048	**69.7**	48.9	27	51.1
106	40.0	1124	**64.9**	37.7	12	**49.2**	36.9	1337	**57.1**	35.3	24	39.9
75	30.5	1271	**53.7**	29.4	12	**42.3**	28.2	1382	**48.4**	27.0	25	32.7
53	23.3	1417	**44.3**	23.0	13	**36.6**	22.1	1771	**40.4**	20.6	27	26.6
45	20.5	1620	**40.1**	20.3	17	**33.7**	19.5	1878	**37.0**	17.8	31	23.7
38	17.9	1676	**36.2**	18.7	20	**31.5**	17.1	2089	**33.3**	16.1	31	21.9
0	0	2184	**0.0**	0	25	**0**	0	2671	**0.0**	0	40	0.0


100
80
60
40
20
0
Wt. % Passing
10
100
1000
Size Fraction (µm)
J'gunna Feed
J'gunna Residue
Redtree Feed
Redtree Residue


Cumulative U Passing (%)
100
80
60
40
20
0
3000
2500
2000
1500
1000
500
0
U Grade in Passing Fraction (ppm)
10
100
1000
Size Fraction (um)
J'gunna Feed Cum U Passing
Redtree Feed Cum U Passing
J'gunna Feed U Grade
Redtree Feed U Grade

APPENDIX D

Dilute Leach Test Procedure

DILUTE LEACH TEST PROCEDURE

Dilute agitation leach tests will be carried out on pulverised samples of ore to determine the limit for extraction. Dilute tests are conducted at low slurry density to determine the maximum extraction of uranium obtainable under ideal conditions. Because of the low slurry density used, dissolution of gangue does not impact on the leach liquor composition, with the result that constant leach conditions are maintained, without the need for constant supervision.

Standard conditions to be examined are:

Slurry density	:	40 g of ore in 2 L of tap water
Temperature	:	40°C
pH	:	1.5
iron addition	:	total iron at 2 g/L by addition of iron sulphate
ORP	:	as recorded
Leach Duration	:	24 h
Samples	:	Samples will be taken after 4, 8, and 24 h for liquor assay only. After 24 h all solids will recovered, washed and assayed.

The extreme conditions to be examined are:

Temperature	:	60°C
pH	:	1.0
ORP	:	600 mV

All liquor samples will be analysed for U, P, Fe, Si, Mg, Al, S, K, Ca, Mn, As, Mo, V by ICP/OES or MS. Solids samples will be assayed for U only by DNA. ORP and pH will be monitored for the first 12 h of all tests. The pH and ORP will also be measured after 24 h.

APPENDIX E

Dilute Leach Tests Experimental Data

Run	**LC1 A**	Dilute - Base Case	**Lagoon Creek Uranium Project**	**Oxidant:**	30% Hydrogen Peroxide	**ICP/OES Request No:**	1002199
	pH 1.5		**Solids:** 40 g	Junnagunna - Pulverised	**Leach Duration:** 24 h	**ICP/MS Request No:**	1002199
			Leach Liquor Matrix: 2000 g	Sydney Water	**Temperature:** 40ºC	**XRF Request No:**	1002199
			Slurry: 2%		**ORP:** 500 mV	**DNA Request No:**	1002199
			Fe Addition: 1.5 g/L as	14.13 g Fe2(SO4)3.7H2O	**pH:** 1.5	**Date:**	15/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370					1500	1500									
LC1 A1	4	40	1.5	565	234	6.2	222				11	4	24	1578	1491	13	10	6	24	<1	2523	21	20	<1
LC1 A2	8	40	1.5	560	234	6.2	222				14	<1	25	1629	1485	14	11	6	18	<1	2515	25	20	<1
LC1 A3	12	40	1.49	557	234	6.2	222				17	4	26	1634	1489	14	12	6	18	<1	2560	28	20	<1
LC1 A4	24	40	1.5	553	234	6.2	222		14	99.0	21	2	28	1665	1491	15	13	7	19	2	2516	35	21	<1
24 h MS																							21	<1

U Accountability 85.4%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.36	<0.001	0.012	<0.01	0.045	0.014	0.034	0.64	0.563	0.085	<0.001	<0.01	0.015	0.002	0.036	43.19	0.140	0.015	0.050	12	14	0.027	0.005	0.000
Element Extractions																								
Head/liquor	6.9%	292.5%			136.5%			74.9%	12.1%	49.7%						0.4%				89.2%				
Head/residue*	10.1%	>74.7%			56.3%			41.4%	6.9%	36.4%										99.0%				
Head/residue	11.0%	>75.0%			56.7%			42.0%	7.9%	37.0%										99.0%				

* Includes mass loss

Run	**LC1 B**	Dilute - Base Case	**Lagoon Creek Uranium Project**	**Oxidant:** 30% Hydrogen Peroxide		**ICP/OES Request No:**	1002199
	pH 1.5		**Solids:** 40 g	Garee Lower Lens - Pulverised	**Leach Duration:** 24 h	**ICP/MS Request No:**	1002199
			Leach Liquor Matrix: 2000 g	Sydney Water	**Temperature:** 40ºC	**XRF Request No:**	1002199
			Slurry: 2%		**ORP:** 500 mV	**DNA Request No:**	1002199
			Fe Addition: 1.5 g/L as	14.13 g Fe2(SO4)3.7H2O	**pH:** 1.5	**Date:**	15/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1380					1500	1500									
LC1 B1	4	40	1.5	563	225	6.4	213				18	<1	63	1638	1522	15	9	7	23	<1	2598	25	21	<1
LC1 B2	8	40	1.5	558	225	6.3	213				23	2	65	1648	1503	16	10	7	17	<1	2660	31	22	<1
LC1 B3	12	40	1.5	565	225	6.1	213				27	1	67	1664	1519	16	11	7	17	<1	2645	36	22	<1
LC1 B4	24	40	1.5	558	225	6.1	213		19	98.6	33	4	70	1685	1526	16	13	7	17	<1	2614	43	21	<1
24 h MS																							21	<1

U Accountability 87.9%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.65	0.015	0.012	<0.001	0.049	0.015	0.040	1.59	0.652	0.104	0.001	0.009	0.014	0.009	0.035	41.90	0.129	0.009	0.053	1170	1380	0.022	0.008	0.030
Residue	1.46	<0.001	0.012	<0.01	0.018	0.011	0.031	1.08	0.603	0.059	<0.001	<0.01	0.008	0.003	0.031	43.10	0.141	0.017	0.057	16	19	0.019	0.005	0.000
Element Extractions																								
Head/liquor	5.5%	148.3%			718.9%			58.3%	12.6%	62.1%						0.5%				91.5%				
Head/residue*	14.0%	>93.5%			64.3%			34.0%	10.1%	44.9%										98.6%				
Head/residue	11.5%	>93.3%			63.3%			32.1%	7.5%	43.3%										98.6%				

* Includes mass loss

Run	**LC1 C**	Dilute - Base Case	**Lagoon Creek Uranium Project**	**Oxidant:**	30% Hydrogen Peroxide	**ICP/OES Request No:**	1002199
	pH 1.5		**Solids:** 40 g	Garee Upper Lens - Pulverised	**Leach Duration:**	24 h	**ICP/MS Request No:**	1002199
			Leach Liquor Matrix: 2000 g	Sydney Water	**Temperature:**	40ºC	**XRF Request No:**	1002199
			Slurry: 2%		**ORP:**	500 mV	**DNA Request No:**	1002199
			Fe Addition: 1.5 g/L as	14.13 g Fe2(SO4)3.7H2O	**pH:**	1.5	**Date:**	15/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1862					1500	1500									
LC1 C1	4	40	1.5	563	188	6.4	175				7	9	23	1607	1491	11	5	6	24	<1	2637	15	28	<1
LC1 C2	8	40	1.48	558	188	6.5	175				8	5	22	1550	1434	10	5	6	19	<1	2531	16	27	<1
LC1 C3	12	40	1.47	555	188	6.4	175				9	3	23	1545	1415	10	5	6	19	<1	2457	17	27	<1
LC1 C4	24	40	1.47	553	188	6.3	175		21	98.9	10	6	25	1546	1430	11	6	6	19	<1	2556	21	27	<1
24 h MS																							27	<1

U Accountability 81.6%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.11	0.030	0.007	<0.001	0.030	0.015	0.041	1.43	0.457	0.037	<0.001	0.009	0.011	0.013	0.015	42.99	0.150	0.010	0.038	1579	1862	0.021	0.006	0.027
Residue	1.00	0.003	0.010	<0.01	0.010	0.013	0.033	1.02	0.407	0.029	<0.001	<0.01	0.007	0.002	0.026	43.52	0.146	0.015	0.039	18	21	0.018	0.007	0.000
Element Extractions																								
Head/liquor	3.1%	98.7%			416.5%			16.1%	12.1%	77.0%						0.2%				84.2%				
Head/residue*	11.0%	90.1%			67.1%			29.5%	12.0%	22.6%										98.9%				
Head/residue	9.9%	90.0%			66.7%			28.6%	10.9%	21.6%										98.9%				

* Includes mass loss

Run	**LC1 D**	Dilute - Base Case	**Lagoon Creek Uranium Project**	**Oxidant:**	30% Hydrogen Peroxide	**ICP/OES Request No:**	1002199
	pH 1.5		**Solids:** 40 g	Jack - Pulverised	**Leach Duration:**	24 h	**ICP/MS Request No:**	1002199
			Leach Liquor Matrix: 2000 g	Sydney Water	**Temperature:**	40ºC	**XRF Request No:**	1002199
			Slurry: 2%		**ORP:**	500 mV	**DNA Request No:**	1002199
			Fe Addition: 1.5 g/L as	14.13 g Fe2(SO4)3.7H2O	**pH:**	1.5	**Date:**	15/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929					1500	1500									
LC1 D1	4	40	1.5	585	397	6.1	384				4	<1	20	1495	1408	<10	4	5	22	<1	2320	8	12	<1
LC1 D2	8	40	1.46	581	403	6.8	389				4	2	21	1515	1442	<10	4	5	17	<1	2551	9	13	<1
LC1 D3	12	40	1.45	576	403	6.7	389				4	<1	22	1508	1421	<10	4	6	17	2	2526	10	13	<1
LC1 D4	24	40	1.45	574	403	6.7	390		22	97.6	6	3	23	1515	1428	<10	4	6	17	<1	2532	13	13	<1
24 h MS																							13	<1

U Accountability 80.0%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	0.98	<0.001	0.009	<0.01	0.009	0.013	0.029	0.63	0.396	0.017	<0.001	<0.01	0.010	0.003	0.038	43.98	0.148	0.016	0.037	19	22	0.031	0.007	0.000
Element Extractions																								
Head/liquor	1.7%	285.0%			353.3%			10.2%		111.7%						0.1%				83.6%				
Head/residue*	7.4%	>83.5%			73.0%			16.5%	10.9%	6.5%										97.7%				
Head/residue	6.5%	>83.3%			72.7%			15.7%	10.0%	5.6%										97.6%				

* Includes mass loss

Run	**LC2 A**	Dilute - Extreme Case	**Lagoon Creek Uranium Project**		**Oxidant:** 30% Hydrogen Peroxide		**ICP/OES Request No:**	1E+06
	pH 1		**Solids:** 40 g	Junnagunna - Pulverised	**Leach Duration:** 24 h		**ICP/MS Request No:**	1E+06
			Leach Liquor Matrix: 2000 g	Sydney Water	**Temperature:** 60ºC		**XRF Request No:**	1E+06
			Slurry: 2%		**ORP:** 550 mV		**DNA Request No:**	1E+06
			Fe Addition: 1.5 g/L as	14.13 g Fe2(SO4)3.7H2O	**pH:** 1.0		**Date:**	######

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370					1500	1500									
LC2 A1	4	60	1	569	724	16.6	691				37	3	32	1500	1297	36	14	7	18	9	6014	47	21	<1
LC2 A2	8	60	1	564	753	17.1	719				45	<1	33	1563	1364	39	16	7	19	6	6370	60	22	1
LC2 A3	12	60	0.97	563	753	17.1	719				49	4	34	1583	1383	41	17	7	19	7	6351	66	22	1
LC2 A4	24	60	1	560	753	18.5	716		9	99.3	56	3	34	1607	1373	44	18	7	19	10	6538	80	21	1
24 h MS																							22	1

U Accountability 92.2%

Comments:

Sample ID	**Element Concentration (wt.%)**																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.28	<0.001	0.014	<0.01	0.010	0.010	0.025	0.35	0.555	0.055	<0.001	<0.01	0.002	0.002	0.031	43.71	0.146	0.016	0.049	8	9	0.023	0.007	0.034
Element Extractions																								
Head/liquor	12.2%	375.0%			161.1%			48.7%	35.6%	68.1%						0.9%				96.1%				
Head/residue*	16.4%	>75.0			90.4%			68.4%	9.3%	59.3%										99.3%				
Head/residue	16.3%	>75.0			90.4%			68.3%	9.2%	59.3%										99.3%				

* Includes mass loss

Run	**LC2 B**	Dilute - Extreme Case	**Lagoon Creek Uranium Project**		**Oxidant:**	30% Hydrogen Peroxide		**ICP/OES Request No:**	1002236
	pH 1		**Solids:**	40 g	**Leach Duration:**	24 h		**ICP/MS Request No:**	1002236
			Leach Liquor Matrix:	2000 g	**Temperature:**	60ºC		**XRF Request No:**	1002274
			Slurry:	2%	**ORP:**	550 mV		**DNA Request No:**	1002274
			Fe Addition:	1.5 g/L as	**pH:**	1.0		**Date:**	20/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1380					1500	1500									
LC2 B1	4	60	1	564	715	16.1	682				52	2	22	1576	1330	26	13	7	17	3	6023	61	22	<1
LC2 B2	8	60	0.98	563	727	16.5	694				60	7	22	1603	1378	29	15	7	18	6	6108	73	23	<1
LC2 B3	12	60	1	561	727	16.6	694				65	2	24	1609	1374	30	16	7	18	3	6160	81	23	<1
LC2 B4	24	60	1	557	727	17.2	693		12	99.1	72	10	23	1621	1375	33	17	7	18	3	6192	95	23	<1
24 h MS																							24	<1
																							U Accountability	97.6%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.65	0.015	0.012	<0.001	0.049	0.015	0.040	1.59	0.652	0.104	0.001	0.009	0.014	0.009	0.035	41.90	0.129	0.009	0.053	1170	1380	0.022	0.008	0.030
Residue	1.32	<0.001	0.013	<0.01	0.008	0.009	0.027	0.67	0.583	0.031	<0.001	0.010	0.004	0.001	0.027	43.13	0.143	0.015	0.057	10	12	0.017	0.006	0.033
Element Extractions																								
Head/liquor	15.8%	319.0%			232.9%			38.1%	25.0%	80.0%						1.1%				101.6%				
Head/residue*	22.7%	>93.5%			84.1%			59.0%	13.1%	71.0%										99.1%				
Head/residue	20.4%	>93.3%			83.7%			57.7%	10.6%	70.2%										99.1%				

* Includes mass loss

Run **LC2 C** **pH 1**	Dilute - Extreme Case	**Lagoon Creek Uranium Project**	**Oxidant:** 30% Hydrogen Peroxide	**ICP/OES Request No:** 1002236
		Solids: 40 g — Garee Upper Lens - Pulverised	**Leach Duration:** 24 h	**ICP/MS Request No:** 1002236
		Leach Liquor Matrix: 2000 g — Sydney Water	**Temperature:** 60ºC	**XRF Request No:** 1002274
		Slurry: 2%	**ORP:** 550 mV	**DNA Request No:** 1002274
		Fe Addition: 1.5 g/L as — 14.13 g Fe2(SO4)3.7H2O	**pH:** 1.0	**Date:** 20/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1862					1500	1500									
LC2 C1	4	60	1	573	688	16.4	656				23	8	19	1551	1377	24	5	7	17	2	5914	29	30	<1
LC2 C2	8	60	0.97	570	697	17.1	663				27	<1	19	1573	1403	27	6	7	18	3	6175	36	30	<1
LC2 C3	12	60	0.97	571	697	17.4	662				29	2	20	1559	1382	28	6	7	18	3	6356	41	30	<1
LC2 C4	24	60	0.97	569	697	18.4	660		14	99.2	34	6	19	1558	1370	30	6	7	17	2	6473	52	30	<1
24 h MS																							32	<1

U Accountability 97.4%

Comments:

Sample ID	**Element Concentration (wt.%)**																						
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.11	0.030	0.007	<0.001	0.030	0.015	0.041	1.43	0.457	0.037	<0.001	0.009	0.011	0.013	0.015	42.99	0.150	0.010	0.038	1579	1862	0.021	0.006	0.027
Residue	0.95	0.001	0.006	<0.01	0.008	0.010	0.025	0.84	0.399	0.020	<0.001	<0.01	0.007	0.002	0.012	43.73	0.152	0.016	0.037	12	14	0.018	0.007	0.029
	Element Extractions																							
Head/liquor	10.3%	102.2%			309.5%			20.4%	33.3%	83.6%						0.6%				100.4%				
Head/residue*	15.5%	96.7%			73.8%			42.6%	14.2%	46.9%										99.3%				
Head/residue	14.0%	96.7%			73.3%			41.6%	12.7%	45.9%										99.2%				

* Includes mass loss

Run	**LC2 D**	Dilute - Extreme Case	**Lagoon Creek Uranium Project**		**Oxidant:** 30% Hydrogen Peroxide		**ICP/OES Request No:**	1002236
	pH 1		**Solids:** 40 g	Jack - Pulverised	**Leach Duration:** 24 h		**ICP/MS Request No:**	1002236
			Leach Liquor Matrix: 2000 g	Sydney Tap Water	**Temperature:** 60ºC		**XRF Request No:**	1002274
			Slurry: 2%		**ORP:** 550 mV		**DNA Request No:**	1002274
			Fe Addition: 1.5 g/L as	14.13 g Fe2(SO4)3.7H2O	**pH:** 1.0		**Date:**	20/07/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929					1500	1500									
LC2 D1	4	60	1	580	678	16.5	645				16	2	20	1506	1390	26	4	6	17	6	6000	18	14	<1
LC2 D2	8	60	0.97	575	680	17.0	646				18	7	20	1498	1393	28	4	6	18	5	5951	23	14	1
LC2 D3	12	60	0.99	575	680	17.1	646				20	8	20	1506	1393	28	5	6	17	3	6065	27	15	1
LC2 D4	24	60	1	575	680	17.5	645		14	98.5	24	1	20	1533	1409	31	5	6	18	3	6252	35	14	2
24 h MS																							15	2

U Accountability 89.3%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	0.94	<0.001	0.008	<0.01	0.009	0.007	0.026	0.49	0.387	0.014	<0.001	<0.01	0.010	0.002	0.030	43.97	0.155	0.016	0.036	12	14	0.028	0.007	0.034
Element Extractions																								
Head/liquor	7.5%	122.5%			302.9%			22.0%	35.0%	142.5%						0.4%				94.2%				
Head/residue*	11.3%	>83.5%			73.0%			35.7%	12.9%	22.9%										98.5%				
Head/residue	10.4%	>83.3%			72.7%			35.1%	12.0%	22.2%										98.5%				

* Includes mass loss

APPENDIX F

Conventional Leach Tests Experimental Data

Run	**LC3 A**	Base Case	**Lagoon Creek Uranium Project**	10% Sodium Permanganate	**ICP/OES Request No:**	1002363
	pH 1.5	P_{80} of 250 µm	**Solids:** 1000 g	Junnagunna	24 h	**ICP/MS Request No:** 1002363
			Leach Liquor Matrix: 818 g	Sydney Tap Water	40ºC	**XRF Request No:** 1002385
			Slurry: 55%		500 mV	**DNA Request No:** 1002385
			Fe Addition: none		1.5	**Date:** 3/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head			7.56						1370															
LC3 A1	2	40	1.5	500	12.7	5.2	8	0.86	220	83.9	340	29	371	1870	1363	98	191	340	240	38	4730	467	1160	17
LC3 A2	4	40	1.5	500	14.3	5.6	10	1.09	104	92.4	402	35	383	2193	1620	108	206	434	231	40	4640	459	1250	19
LC3 A3	8	40	1.49	500	16.2	4.2	13	1.37	57	95.9	497	34	399	2930	2177	135	255	545	325	44	6110	545	1330	22
LC3 A4	12	40	1.52	500	17.5	4.6	14	1.57	42	96.9	613	37	417	3310	2528	180	301	622	372	47	6740	595	1330	26
LC3 A5	24	40	1.5	485	20.6	4.8	17	1.64	34	97.5	804	39	427	4020	2499	272	369	657	380	47	7870	681	1320	31
24 h MS																							1417	29

U Accountability 105.4%

Comments: Oxidant wasn't stopped until ~ 14h

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.48	0.001	0.012	0.000	0.069	0.011	0.022	0.69	0.627	0.109	<0.001	0.011	0.025	0.007	0.044	43.03	0.144	0.013	0.054	29	34	0.031	0.006	0.046
Element Extractions																								
Head/liquor	4.3%	79.2%			33.6%			29.9%	3.6%	22.4%						0.1%				99.8%				
Head/residue*	2.2%	74.7%			32.7%			36.4%	-4.0%	18.1%										97.5%				
Head/residue	3.5%	75.0%			33.7%			37.2%	-2.6%	19.3%										97.5%				

* Includes mass loss

Run **LC3 B** Base Case **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002363
pH 1.5 P_{80} of 250 µm **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002363
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002385
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002385
Fe Addition: none **pH:** 1.5 **Date:** 3/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704																
LC3 B1	2	40	1.52	500	8.9	4.9	5	0.84	363	78.7	257	176	185	1200	896	105	76	318	177	33	3410	301	1140	7
LC3 B2	4	40	1.5	500	10.3	5.8	6	1.05	206	87.9	317	194	191	1510	1162	106	90	387	202	37	3950	369	1320	8
LC3 B3	8	40	1.51	500	12.0	4.4	8	1.32	97	94.3	412	204	195	2040	1598	134	117	469	244	40	4610	461	1410	9
LC3 B4	12	40	1.53	500	13.1	4.5	9	1.53	80	95.3	509	212	198	2420	1920	165	145	555	283	42	5280	534	1390	9
LC3 B5	24	40	1.5	477	17.1	4.8	13	1.62	59	96.5	698	219	204	3090	1902	248	195	579	291	43	6260	580	1340	11
24 h MS																							1473	11

U Accountability 80.3%

Comments: Oxidant wasn't stopped until ~ 14h

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.49	0.005	0.009	0.000	0.024	0.012	0.041	1.23	0.607	0.069	<0.001	0.012	0.013	0.008	0.040	42.79	0.148	0.015	0.053	50	59	0.021	0.005	0.039
Element Extractions																								
Head/liquor	4.2%	74.7%			40.7%			16.7%	3.7%	21.9%						0.1%				83.4%				
Head/residue*	-7.8%	79.2%			41.7%			19.5%	-10.0%	5.8%										96.6%				
Head/residue	-8.2%	79.2%			41.5%			19.2%	-10.4%	5.5%										96.5%				

* Includes mass loss

Run **LC4 A** High Acid **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002388
pH 1.3 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 1002389
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002461
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002461
Fe Addition: none **pH:** 1.3 **Date:** 5/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC4 A1	2	40	1.33	500	13.6	6.1	9	0.90	345	74.8	386	31	449	2050	1500	120	201	372	236	77	5250	514	1107	19
LC4 A2	4	40	1.3	500	16.1	8.3	9	1.16	95	93.1	491	34	463	2580	1899	148	245	468	278	82	6720	579	1219	23
LC4 A3	8	40	1.3	500	20.2	8.3	13	1.49	57	95.8	635	36	478	3200	2374	179	296	572	321	83	8110	672	1250	27
LC4 A4	12	40	1.31	500	20.9	9.4	13	1.72	41	97.0	765	37	472	3610	2748	209	347	639	358	84	8480	775	1270	31
LC4 A5	24	40	1.27	481	25.0	8.0	18	1.72	28	97.9	954	36	452	4060	2546	268	409	605	337	80	9470	856	1199	34
24 h MS																							1096	29

U Accountability 89.5%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.48	0.003	0.002	<0.01	0.069	0.014	0.039	0.62	0.589	0.097	<0.01	0.011	0.028	0.010	0.036	44.56	0.167	0.009	0.051	24	28	0.022	0.007	0.124
Element Extractions																								
Head/liquor	5.1%	73.8%			35.6%			30.2%	3.6%	24.8%						0.2%				77.2%				
Head/residue*	5.7%	26.6%			35.0%			44.7%	5.6%	29.7%										98.0%				
Head/residue	3.7%	25.0%			33.7%			43.5%	3.6%	28.1%										97.9%				

* Includes mass loss

Run	**LC4 B** Low Acid	**Lagoon Creek Uranium Project**	**Oxidant:** 10% Sodium Permanganate	**ICP/OES Request No:** 1002388
	pH 1.7	**Solids:** 1000 g Junnagunna	**Leach Duration:** 24 h	**ICP/MS Request No:** 1002389
		Leach Liquor Matrix: 868 g Sydney Tap Water	**Temperature:** 40ºC	**XRF Request No:** 1002461
		Slurry: 54%	**ORP:** 500 mV	**DNA Request No:** 1002461
		Fe Addition: none	**pH:** 1.7	**Date:** 5/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC4 B1	2	40	1.7	500	7.3	2.3	5	0.77	223	83.7	256	26	318	1360	1049	120	185	313	217	19	3230	413	1148	15
LC4 B2	4	40	1.71	500	9.2	4.3	6	1.00	103	92.5	320	31	334	1800	1402	137	197	402	247	23	3730	466	1260	17
LC4 B3	8	40	1.72	500	11.3	2.4	9	1.28	71	94.8	412	35	350	2290	1805	179	226	501	292	26	4630	501	1301	21
LC4 B4	12	40	1.71	500	12.7	4.7	9	1.47	44	96.8	446	36	348	2610	2096	206	228	543	307	25	4760	543	1332	21
LC4 B5	24	40	1.69	474	14.7	2.2	13	1.47	36	97.3	595	37	355	3080	1936	302	284	550	314	26	5710	605	1291	26
24 h MS																							1221	21

U Accountability 97.1%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.35	0.003	0.003	<0.01	0.074	0.014	0.139	0.65	0.520	0.101	<0.01	0.010	0.031	0.008	0.033	45.37	0.163	0.008	0.050	31	36	0.022	0.007	0.120
Element Extractions																								
Head/liquor	3.4%	80.1%			29.6%			24.3%	4.3%	18.3%						0.1%				91.2%				
Head/residue*	15.3%	27.9%			31.6%			43.0%	18.2%	28.1%										97.5%				
Head/residue	11.9%	25.0%			28.8%			40.7%	14.9%	25.2%										97.3%				

* Includes mass loss

Run **LC5 A** High Acid **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002460
pH 1.3 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002460
Leach Liquor Matrix: 825 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002483
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002483
Fe Addition: none **pH:** 1.3 **Date:** 10/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC5 A1	2	40	1.33	499	11.3	7.9	5	0.86	394	76.9	308	176	244	1566	1146	93	84	307	159	74	4215	341	1085	7
LC5 A2	4	40	1.27	499	13.7	8.3	7	1.11	205	88.0	405	200	253	2045	1514	109	116	402	201	77	5334	440	1285	8
LC5 A3	8	40	1.31	500	15.6	6.9	10	1.41	86	94.9	534	201	246	2657	2000	125	152	481	232	82	5774	553	1325	9
LC5 A4	12	40	1.33	500	17.3	6.6	12	1.62	65	96.2	648	205	256	3164	2401	152	185	565	268	85	6867	634	1385	11
LC5 A5	24	40	1.27	471	20.4	6.7	15	1.62	31	98.2	846	208	254	3909	2344	201	232	557	263	84	7733	731	1379	12
24 h MS																							1420	13

U Accountability 76.9%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.51	0.001	0.005	<0.01	0.070	0.006	0.028	0.66	0.597	0.105	<0.01	0.009	0.030	0.006	0.037	42.16	0.158	0.012	0.049	27	31	0.024	0.004	0.123
Element Extractions																								
Head/liquor	5.1%	71.5%			51.1%			21.2%	3.0%	26.2%						0.1%				81.1%				
Head/residue*	-11.3%	95.8%			-72.7%			55.9%	-9.8%	-45.5%										98.1%				
Head/residue	-10.0%	95.8%			-70.7%			56.4%	-8.5%	-43.8%										98.2%				

* Includes mass loss

Run **LC5 B** Low Acid **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002460
pH 1.7 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002460
Leach Liquor Matrix: 822 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002483
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002483
Fe Addition: none **pH:** 1.7 **Date:** 10/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC5 B1	2	40	1.74	500	6.0	4.0	3	0.69	511	70.0	213	125	169	944	693	90	65	275	142	25	2337	239	1080	5
LC5 B2	4	40	1.67	500	6.3	3.7	3	0.88	300	82.4	264	154	174	1286	977	101	76	348	172	34	2973	303	1290	7
LC5 B3	8	40	1.73	500	7.6	2.4	6	1.09	160	90.6	314	155	171	1530	1192	112	87	413	197	35	3221	357	1365	7
LC5 B4	12	40	1.82	500	9.3	2.2	7	1.22	113	93.4	381	165	182	1882	1505	125	105	482	226	39	3564	398	1456	8
LC5 B5	24	40	1.65	459	11.4	2.3	9	1.22	73	95.7	572	192	190	2819	1573	151	160	491	226	45	4687	540	1515	10
24 h MS																							1549	9

U Accountability 85.0%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.30	0.007	0.001	<0.01	0.028	0.004	0.021	1.08	0.511	0.053	<0.01	0.007	0.014	0.003	0.023	42.50	0.159	0.011	0.042	62	73	0.016	0.004	0.119
Element Extractions																								
Head/liquor	3.4%	65.7%			38.1%			15.3%	2.3%	18.0%						0.1%				88.1%				
Head/residue*	5.1%	70.7%			31.5%			28.6%	6.8%	27.2%										95.7%				
Head/residue	5.4%	70.8%			31.7%			28.8%	7.1%	27.4%										95.7%				

* Includes mass loss

Run **LC5 C** High ORP **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002460
pH 1.5 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 1002460
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002483
Slurry: 55% **ORP:** 550 mV **DNA Request No:** 1002483
Fe Addition: none **pH:** 1.5 **Date:** 12/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370																
LC5 C1	2	40	1.52	550	11.2	6.4	6	1.04	157	88.5	314	28	359	1758	1695	118	175	394	246	57	4320	417	1113	16
LC5 C2	4	40	1.48	550	12.7	5.9	8	1.31	75	94.6	368	33	371	2177	2052	128	194	495	283	62	4824	446	1213	17
LC5 C3	8	40	1.54	550	13.9	4.3	10	1.63	48	96.5	425	35	364	2576	2455	136	212	579	313	61	5008	480	1167	18
LC5 C4	12	40	1.59	550	14.7	4.0	11	1.82	39	97.2	506	40	388	3017	2882	152	247	680	359	66	5786	538	1254	21
LC5 C5	24	40	1.47	492	18.3	4.8	14	1.82	28	97.9	657	39	388	3509	2654	170	313	674	351	63	6700	592	1169	26
24 h MS																							1233	32

U Accountability 82.6%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.38	0.004	0.004	<0.01	0.016	0.003	0.032	1.05	0.550	0.049	<0.01	<0.01	0.010	0.006	0.022	42.76	0.161	0.014	0.046	24	28	0.014	0.006	0.121
Element Extractions																								
Head/liquor	3.5%	79.0%			30.5%			26.1%	2.3%	18.9%						0.1%				86.8%				
Head/residue*	8.3%	-2.0%			84.3%			2.9%	8.2%	63.0%										97.9%				
Head/residue	10.1%	0.0%			84.6%			4.8%	10.0%	63.7%										97.9%				

* Includes mass loss

Run **LC6 A** Low ORP **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002491
pH 1.5 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 1002491
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002572
Slurry: 55% **ORP:** 450 mV **DNA Request No:** 1002572
Fe Addition: none **pH:** 1.5 **Date:** 12/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC6 A1	2	40	1.52	450	10.0	5.8	5	0.28	521	62.0	345	21	336	1720	532	99	184	112	125	33	3770	364	808	15
LC6 A2	4	40	1.51	450	11.7	5.8	7	0.39	316	76.9	398	22	346	2090	641	106	206	155	141	33	4370	423	1050	18
LC6 A3	8	40	1.5	450	14.1	5.1	10	0.53	161	88.3	529	25	373	2730	847	130	251	214	170	38	5540	498	1210	22
LC6 A4	12	40	1.5	450	15.5	6.3	10	0.63	97	92.9	614	25	377	3160	1045	141	297	250	180	39	6130	568	1280	24
LC6 A5	24	40	1.47	439	18.0	5.2	14	0.63	61	95.5	859	27	394	4070	1144	184	384	262	184	42	7410	707	1310	31
24 h MS																							1238	37

U Accountability 88.9%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.30	0.002	0.003	<0.01	0.058	0.002	0.019	0.56	0.582	0.085	<0.005	0.007	0.022	0.006	0.036	42.75	0.160	0.011	0.044	52	61	0.020	0.005	0.118
Element Extractions																								
Head/liquor	4.6%	54.8%			31.0%			30.2%	2.5%	23.3%						0.1%				87.2%				
Head/residue*	13.3%	49.0%			43.1%			48.2%	2.8%	35.8%										95.4%				
Head/residue	15.0%	50.0%			44.2%			49.2%	4.7%	37.0%										95.5%				

* Includes mass loss

Run **LC6 B** High ORP **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002491
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002491
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002572
Slurry: 55% **ORP:** 550 mV **DNA Request No:** 1002572
Fe Addition: none **pH:** 1.5 **Date:** 10/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC6 B1	2	40	1.5	550	8.1	6.4	3	0.95	244	85.7	253	146	175	1130	1058	104	71	365	182	30	3260	274	1390	6
LC6 B2	4	40	1.51	551	8.5	6.4	3	1.19	127	92.6	322	171	180	1470	1398	117	87	447	222	34	3810	348	1500	7
LC6 B3	8	40	1.5	551	11.7	6.2	7	1.48	72	95.8	440	192	189	2030	1914	133	124	569	266	37	4840	443	1550	9
LC6 B4	12	40	1.35	550	15.1	9.5	7	1.77	53	96.9	568	203	193	2620	2461	160	162	662	317	42	6330	515	1550	10
LC6 B5	24	40	1.51	491	17.5	5.4	13	1.77	44	97.4	741	201	201	3470	2485	215	216	658	313	41	6630	632	1520	12
24 h MS																							1351	10

U Accountability 73.3%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.35	0.005	0.002	<0.01	0.021	0.005	0.019	1.08	0.531	0.050	<0.005	0.007	0.013	0.004	0.023	42.81	0.163	0.012	0.048	37	44	0.015	0.006	0.118
Element Extractions																								
Head/liquor	4.4%	68.5%			40.1%			18.7%	3.2%	24.2%						0.1%				76.5%				
Head/residue*	2.4%	79.3%			49.0%			29.0%	3.9%	31.8%										97.4%				
Head/residue	2.0%	79.2%			48.8%			28.7%	3.5%	31.5%										97.4%				

* Includes mass loss

Run **LC6 C** Low ORP **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002491
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002491
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002572
Slurry: 55% **ORP:** 450 mV **DNA Request No:** 1002572
Fe Addition: none **pH:** 1.5 **Date:** 10/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC6 C1	2	40	1.5	450	8.1	6.2	3	0.40	539	68.4	283	152	208	1240	443	105	73	152	90	41	3090	280	1020	6
LC6 C2	4	40	1.5	451	9.3	6.4	4	0.50	404	76.3	353	169	214	1540	540	119	94	192	108	42	3640	349	1180	7
LC6 C3	8	40	1.49	451	11.4	5.3	7	0.68	281	83.5	493	175	224	2060	742	142	136	251	134	48	4480	479	1310	9
LC6 C4	12	40	1.46	451	13.2	7.2	7	0.78	192	88.7	585	182	227	2470	934	152	168	287	146	49	5210	552	1410	10
LC6 C5	24	40	1.52	436	15.0	5.0	11	0.78	106	93.8	745	172	222	3060	873	172	209	280	141	48	5740	625	1430	11
24 h MS																							1455	11

U Accountability 89.7%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.21	0.005	<0.005	<0.01	0.017	0.006	0.014	1.00	0.479	0.042	<0.005	0.008	0.010	0.004	0.021	43.03	0.168	0.012	0.045	90	106	0.014	0.007	0.117
Element Extractions																								
Head/liquor	4.4%	58.6%			44.3%			16.5%	2.6%	23.4%						0.1%				82.4%				
Head/residue*	12.6%	79.4%			58.9%			34.9%	13.7%	43.0%										93.8%				
Head/residue	11.8%	79.2%			58.5%			34.3%	12.9%	42.5%										93.8%				

* Includes mass loss

Run **LC7 A** Low Temperature **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002668
pH 1.5 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 1002668
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 30ºC **XRF Request No:** 1002704
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002704
Fe Addition: none **pH:** 1.5 **Date:** 2/09/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC7 A1	2	30	1.51	499	7.9	4.6	4	0.50	500	63.5	242	22	320	1100	583	87	178	181	144	26	2850	252	849	11
LC7 A2	4	30	1.52	500	9.6	6.1	5	0.71	283	79.4	321	27	334	1520	897	93	206	273	172	30	3400	334	1040	14
LC7 A3	8	30	1.5	500	11.2	6.4	6	0.94	137	90.0	401	30	356	1970	1224	117	220	383	209	33	4060	397	1270	17
LC7 A4	12	30	1.5	500	12.3	6.6	7	1.09	87	93.6	454	33	369	2460	1475	122	240	471	230	36	4490	430	1290	18
LC7 A5	24	30	1.5	480	14.3	5.5	10	1.09	55	96.0	608	34	382	3070	1426	147	288	492	227	36	5180	508	1280	22
24 h MS																							1296	0

U Accountability 87.6%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.54	0.001	0.003	<0.01	0.069	0.002	0.026	0.73	0.630	0.116	<0.005	0.011	0.029	0.006	0.035	42.51	0.156	0.010	0.051	46	55	0.025	0.005	0.117
Element Extractions																								
Head/liquor	3.2%	69.5%			30.1%			22.8%	2.0%	17.5%						0.1%				91.3%				
Head/residue*	-3.2%	74.3%			31.9%			32.2%	-5.8%	11.8%										95.9%				
Head/residue	-0.5%	75.0%			33.7%			34.0%	-3.1%	14.1%										96.0%				

* Includes mass loss

Run **LC7 B** Low Temperature **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002668
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002668
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 30ºC **XRF Request No:** 1002704
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002704
Fe Addition: none **pH:** 1.5 **Date:** 2/09/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC7 B1	2	30	1.51	500	6.5	4.3	3	0.57	579	66.0	192	136	183	736	381	80	67	220	100	28	2360	165	983	5
LC7 B2	4	30	1.53	500	7.6	5.9	3	0.77	415	75.7	256	165	190	1040	634	92	77	310	134	32	2810	227	1170	6
LC7 B3	8	30	1.49	500	9.0	6.6	4	0.97	218	87.2	342	183	198	1390	868	109	92	420	163	37	3180	291	1370	7
LC7 B4	12	30	1.50	501	9.9	6.8	4	1.10	156	90.9	406	192	202	1630	956	122	117	480	182	41	3470	328	1450	8
LC7 B5	24	30	1.47	470	12.4	5.7	8	1.10	98	94.2	592	201	206	2290	660	154	165	487	181	43	4420	481	1640	9
24 h MS																							1477	0

U Accountability 91.1%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.30	0.005	0.002	<0.01	0.021	0.004	0.018	1.14	0.519	0.054	<0.005	<0.01	0.011	0.004	0.020	42.67	0.163	0.010	0.041	83	98	0.015	0.005	0.118
Element Extractions																								
Head/liquor	3.5%	68.5%			41.1%			12.3%	2.3%	18.5%						0.1%				83.6%				
Head/residue*	5.5%	79.2%			48.8%			25.1%	5.7%	26.1%										94.2%				
Head/residue	5.5%	79.2%			48.8%			25.0%	5.6%	26.0%										94.2%				

* Includes mass loss

Run **LC7 C** Fine Grind (150 µm) **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002668
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002668
Leach Liquor Matrix: 820 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002704
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002704
Fe Addition: none **pH:** 1.5 **Date:** 2/09/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC7 C1	2	40	1.51	500	8.0	4.7	4	0.80	345	79.7	295	187	201	1260	818	108	88	358	151	30	3070	264	1240	7
LC7 C2	4	40	1.5	500	9.7	6.6	4	1.01	122	92.8	347	191	190	1520	977	114	98	415	167	33	3360	305	1390	7
LC7 C3	8	40	1.42	500	12.7	6.9	7	1.29	102	94.0	481	210	201	2100	1354	134	147	595	207	38	4420	410	1560	9
LC7 C4	12	40	1.5	500	13.6	6.6	8	1.50	74	95.7	593	220	204	2770	2002	147	183	789	241	41	4790	491	1550	9
LC7 C5	24	40	1.48	474	16.4	5.7	12	1.50	56	96.7	825	229	216	3580	1885	172	243	827	246	43	5800	628	1510	11
24 h MS																							1545	0

U Accountability 84.1%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.28	0.004	0.003	<0.01	0.021	0.003	0.045	1.08	0.527	0.046	<0.005	0.009	0.013	0.003	0.019	41.43	0.165	0.008	0.044	47	56	0.015	0.005	0.122
Element Extractions																								
Head/liquor	4.9%	78.2%			43.2%			19.3%	2.6%	27.3%						0.1%				87.7%				
Head/residue*	4.3%	82.8%			47.3%			26.7%	1.4%	35.2%										96.6%				
Head/residue	7.1%	83.3%			48.8%			28.8%	4.2%	37.0%										96.7%				

* Includes mass loss

Run **LC8 A** Low Temperature **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002540
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002541
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 30ºC **XRF Request No:** 1002585
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002585
Fe Addition: none **pH:** 1.5 **Date:** 19/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC8 A1	2	30	1.5	501	6.5	4.1	3	0.62	549	67.8	181	116	164	697	530	110	60	219	126	25	2370	185	961	5
LC8 A2	4	30	1.5	500	8.3	5.5	4	0.82	400	76.5	216	118	152	851	597	117	61	253	140	25	2560	227	998	5
LC8 A3	8	30	1.49	501	9.7	6.6	4	1.03	216	87.3	330	145	171	1290	1000	162	81	349	181	33	3460	355	1210	7
LC8 A4	12	30	1.39	501	11.9	5.0	8	1.19	129	92.4	455	170	188	1720	1328	199	105	414	217	41	4460	473	1410	9
LC8 A5	24	30	1.66	468	13.9	3.5	11	1.19	83	95.1	654	162	190	2290	1187	258	146	402	206	41	4770	575	1510	11
24 h MS																							1280	10

U Accountability 71.2%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.18	0.006	0.004	<0.01	0.024	0.003	0.031	1.06	0.452	0.049	<0.005	<0.01	0.014	0.003	0.026	42.64	0.161	0.011	0.044	70	83	0.014	0.004	0.117
Element Extractions																								
Head/liquor	3.9%	55.2%			37.9%			12.3%	3.8%	16.4%						0.1%				72.5%				
Head/residue*	14.2%	75.0%			41.5%			30.1%	17.8%	32.9%										95.1%				
Head/residue	14.2%	75.0%			41.5%			30.1%	17.8%	32.9%										95.1%				

* Includes mass loss

Run	**LC8 B**	Ferric Addition	**Lagoon Creek Uranium Project**	**Oxidant:**	10% Sodium Permanganate	**ICP/OES Request No:**	1002540
	pH 1.5	**Solids:**	1000 g Junnagunna	**Leach Duration:**	24 h	**ICP/MS Request No:**	1002541
		Leach Liquor Matrix:	818 g Sydney Tap Water	**Temperature:**	40ºC	**XRF Request No:**	1002585
		Slurry:	55%	**ORP:**	500 mV	**DNA Request No:**	1002585
		Fe Addition:	1.0 g/L as 3.85 g Fe2(SO4)3.7H2O	**pH:**	1.5	**Date:**	19/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370																
LC8 B1	2	40	1.5	500	9.2	4.6	5	0.56	146	89.4	280	26	265	3380	2691	118	169	240	173	9	6160	352	1690	15
LC8 B2	4	40	1.5	500	11.3	6.0	6	0.82	71	94.8	318	24	255	3660	2971	121	169	297	191	10	6420	357	1590	16
LC8 B3	8	40	1.5	500	13.3	7.4	7	1.08	43	96.8	435	29	284	3830	3003	150	216	417	242	12	6670	448	1450	19
LC8 B4	12	40	1.49	500	14.4	4.3	11	1.28	36	97.4	556	31	306	3840	2882	173	253	519	294	14	6440	521	1290	23
LC8 B5	24	40	1.52	481	16.6	3.6	14	1.28	31	97.7	768	32	318	4500	2845	214	317	535	292	16	7440	629	1300	28
24 h MS																							1249	23

U Accountability 86.5%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.37	0.001	0.003	<0.01	0.074	<0.01	0.021	0.63	0.540	0.095	<0.005	<0.01	0.033	0.006	0.036	42.71	0.159	0.011	0.048	26	31	0.021	0.007	0.118
Element Extractions																								
Head/liquor	4.1%	64.8%			25.0%			33.4%	2.9%	19.2%						0.1%				87.9%				
Head/residue*	8.3%	74.5%			27.3%			41.7%	9.7%	28.1%										97.7%				
Head/residue	10.3%	75.0%			28.8%			43.0%	11.6%	29.6%										97.7%				

* Includes mass loss

Run **LC8 C** Ferric Addition **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002540

pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002541

Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002585

Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002585

Fe Addition: 1.0 g/L as 3.85 g Fe2(SO4)3.7H2O **pH:** 1.5 **Date:** 19/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC8 C1	2	40	1.5	500	7.3	4.5	4	0.59	269	84.2	252	147	107	1940	1338	113	70	253	130	15	3600	269	1160	6
LC8 C2	4	40	1.5	500	8.9	5.8	4	0.81	149	91.3	300	217	162	2630	2086	140	89	307	159	18	4960	323	1390	8
LC8 C3	8	40	1.48	500	11.0	7.4	5	1.10	73	95.7	429	191	138	2850	2095	174	109	411	199	21	5010	430	1430	9
LC8 C4	12	40	1.5	500	12.8	4.3	9	1.31	56	96.7	533	201	145	3340	2455	200	140	491	227	23	5700	513	1500	10
LC8 C5	24	40	1.56	478	15.0	3.0	13	1.31	45	97.3	763	198	154	4140	2369	258	189	486	227	25	6690	689	1470	13
24 h MS																							1438	11

U Accountability 77.6%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.18	0.004	<0.005	<0.01	0.027	0.004	0.017	0.99	0.467	0.045	<0.005	<0.01	0.014	0.005	0.024	42.79	0.152	0.011	0.041	38	45	0.013	0.006	0.114
Element Extractions																								
Head/liquor	4.5%	67.5%			30.7%			22.3%	3.8%	21.2%						0.1%				81.5%				
Head/residue*	14.7%	83.4%			34.4%			35.0%	15.4%	38.6%										97.4%				
Head/residue	14.4%	83.3%			34.1%			34.7%	15.1%	38.4%										97.3%				

* Includes mass loss

Run **LC9 A** Very Low Acid **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002581
pH 2 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 1002581
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002662
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002662
Fe Addition: none **pH:** 2.0 **Date:** 24/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370																
LC9 A1	2	40	2.01	501	5.3	2.2	4	0.65	299	78.2	170	17	282	788	585	105	155	249	143	8	2160	286	1110	9
LC9 A2	4	40	1.99	500	6.5	1.6	5	0.83	148	89.2	216	21	286	1090	800	116	158	324	165	16	2620	341	1210	11
LC9 A3	8	40	2	501	8.0	1.6	7	1.05	89	93.5	283	27	314	1570	1222	141	184	443	202	6	3250	406	1290	14
LC9 A4	12	40	2	501	8.8	1.6	8	1.19	71	94.8	318	30	319	1850	1458	151	192	503	223	16	3560	420	1310	15
LC9 A5	24	40	2.01	474	9.8	1.0	9	1.19	52	96.2	394	29	339	2360	1388	149	219	529	225	8	4060	456	1400	18
24 h MS																							1194	18

U Accountability 80.8%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.44	0.002	0.003	0.014	0.077	0.005	0.048	0.80	0.556	0.110	<0.005	<0.01	0.033	0.007	0.042	42.68	0.160	0.011	0.044	44	52	0.024	0.007	0.124
Element Extractions																								
Head/liquor	2.1%	59.3%			26.7%			17.5%	2.0%	13.3%						0.1%				84.1%				
Head/residue*	4.1%	48.9%			24.3%			26.1%	7.0%	16.7%										96.1%				
Head/residue	6.1%	50.0%			26.0%			27.7%	9.0%	18.5%										96.2%				

* Includes mass loss

Run **LC9 B** Very Low Acid **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002581
pH 2 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002581
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002662
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002662
Fe Addition: none **pH:** 2.0 **Date:** 24/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC9 B1	2	40	2	500	8.8	2.2	7	0.56	499	70.7	120	46	125	381	250	82	52	226	91	3	1420	155	1030	3
LC9 B2	4	40	2	501	9.5	1.6	8	0.73	371	78.2	147	51	121	510	365	89	52	275	99	3	1630	195	1110	4
LC9 B3	8	40	2	500	10.3	1.7	9	0.90	215	87.4	215	68	142	799	596	115	70	386	136	8	2120	276	1350	5
LC9 B4	12	40	2	500	10.8	1.8	9	0.99	176	89.6	245	76	144	949	717	123	74	431	143	5	2420	305	1370	6
LC9 B5	24	40	1.99	469	11.8	1.5	11	0.99	130	92.4	340	83	156	1340	687	149	97	448	154	13	2940	381	1430	7
24 h MS																							1227	7

U Accountability 71.1%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.27	0.014	0.002	0.008	0.026	0.002	0.024	1.12	0.489	0.060	<0.005	<0.01	0.015	0.002	0.021	41.92	0.154	0.010	0.042	110	130	0.015	0.005	0.116
Element Extractions																								
Head/liquor	2.0%	28.4%			31.1%			7.2%	2.2%	10.8%						0.1%				69.5%				
Head/residue*	5.8%	40.7%			35.5%			24.7%	9.6%	16.4%										92.2%				
Head/residue	7.3%	41.7%			36.6%			26.0%	11.1%	17.8%										92.4%				

* Includes mass loss

Run	**LC9 C**	Fine Grind (150 µm)	**Lagoon Creek Uranium Project**	**Oxidant:** 10% Sodium Permanganate		**ICP/OES Request No:**	1002581
	pH 1.5		**Solids:** 1000 g Junnagunna	**Leach Duration:** 24 h		**ICP/MS Request No:**	1002581
			Leach Liquor Matrix: 818 g Sydney Tap Water	**Temperature:** 40ºC		**XRF Request No:**	1002662
			Slurry: 55%	**ORP:** 500 mV		**DNA Request No:**	1002662
			Fe Addition: none	**pH:** 1.5		**Date:**	24/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC9 C1	2	40	1.52	500	10.7	4.9	7	0.78	252	81.6	312	26	355	1630	1586	128	188	351	172	25	4250	428	1160	16
LC9 C2	4	40	1.56	500	12.1	4.1	9	1.02	100	92.7	356	26	343	1980	1487	137	193	426	187	27	4540	451	1170	17
LC9 C3	8	40	1.5	500	14.6	4.7	11	1.29	59	95.7	466	32	376	2720	2081	178	241	587	236	28	5560	534	1270	21
LC9 C4	12	40	1.48	500	16.2	4.9	12	1.48	43	96.9	549	31	372	2930	2161	190	270	654	255	34	6010	564	1230	23
LC9 C5	24	40	1.45	480	19.4	5.0	15	1.48	41	97.0	767	32	385	3630	2179	227	353	666	258	36	7170	671	1240	29
24 h MS																							1128	29

U Accountability 76.5%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.39	<0.001	0.004	0.009	0.072	0.010	0.023	0.64	0.546	0.095	<0.005	<0.01	0.030	0.007	0.034	42.88	0.159	0.006	0.045	35	41	0.021	0.008	0.122
Element Extractions																								
Head/liquor	4.1%	66.1%			30.3%			27.0%	3.0%	21.4%						0.1%				79.5%				
Head/residue*	7.5%	>74.6%			29.6%			40.6%	9.1%	28.4%										97.0%				
Head/residue	9.1%	>75.0%			30.8%			41.6%	10.6%	29.6%										97.0%				

* Includes mass loss

Run	**LC10 A**	High Temperature	**Lagoon Creek Uranium Project**	**Oxidant:** 10% Sodium Permanganate		**ICP/OES Request No:**	1002604
	pH 1.5		**Solids:** 1000 g Junnagunna	**Leach Duration:** 24 h		**ICP/MS Request No:**	1002604
			Leach Liquor Matrix: 818 g Sydney Tap Water	**Temperature:** 50ºC		**XRF Request No:**	1002682
			Slurry: 55%	**ORP:** 500 mV		**DNA Request No:**	1002682
			Fe Addition: none	**pH:** 1.5		**Date:**	26/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370																
LC10 A1	2	50	1.5	500	12.7	5.0	9	1.02	96	93.0	435	30	341	2470	1701	165	233	408	275	31	5350	463	1350	18
LC10 A2	4	50	1.5	500	14.5	3.6	12	1.29	55	96.0	486	30	307	2680	1896	165	239	454	292	29	5670	458	1220	18
LC10 A3	8	50	1.5	500	17.3	4.4	14	1.60	38	97.2	683	35	342	3460	2531	207	323	595	352	32	6860	549	1280	25
LC10 A4	12	50	1.5	500	19.1	4.8	15	1.79	34	97.5	889	40	369	4110	2905	240	403	712	409	36	8500	683	1420	30
LC10 A5	24	50	1.5	479	24.1	4.4	20	1.79	27	98.0	1220	40	384	4970	2924	297	526	714	426	41	9750	771	1410	38
24 h MS																							1406	36

U Accountability 94.2%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.32	<0.001	0.002	<0.01	0.072	0.004	0.017	0.55	0.538	0.081	<0.005	0.007	0.030	0.006	0.034	42.72	0.159	0.010	0.041	23	27	0.020	0.005	0.120
Element Extractions																								
Head/liquor	6.5%	82.6%			30.2%			36.9%	4.0%	31.9%						0.1%				99.0%				
Head/residue*	11.8%	>74.5%			29.3%			49.4%	10.1%	38.7%										98.0%				
Head/residue	13.7%	>75.0%			30.8%			50.5%	11.9%	40.0%										98.0%				

* Includes mass loss

Run **LC10 B** High Temperature **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002604
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002604
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 50ºC **XRF Request No:** 1002682
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002682
Fe Addition: none **pH:** 1.5 **Date:** 26/08/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC10 B1	2	50	1.5	500	10.0	5.3	6	0.93	221	87.0	325	185	155	1590	1082	133	94	360	189	30	3860	313	1320	7
LC10 B2	4	50	1.5	501	12.6	4.0	9	1.21	106	93.8	419	187	148	1990	1453	151	125	429	221	32	4530	381	1340	8
LC10 B3	8	50	1.44	501	15.9	5.3	12	1.57	61	96.4	631	220	167	2980	2182	207	185	591	289	39	6450	570	1470	10
LC10 B4	12	50	1.37	500	19.0	6.7	14	1.82	50	97.0	822	237	176	3660	2571	240	235	694	339	41	7720	652	1420	11
LC10 B5	24	50	1.53	476	19.0	3.5	16	1.82	41	97.6	1060	227	177	4410	2364	289	285	694	336	42	8120	613	1480	13
24 h MS																							1521	14

U Accountability 82.3%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.28	0.005	0.001	<0.01	0.024	0.004	0.020	0.95	0.509	0.042	<0.005	<0.01	0.014	0.003	0.020	42.13	0.164	0.009	0.043	35	41	0.015	0.005	0.121
Element Extractions																								
Head/liquor	6.3%	77.4%			35.3%			23.8%	4.3%	31.9%						0.1%				86.1%				
Head/residue*	5.7%	78.9%			40.8%			36.7%	6.4%	41.8%										97.6%				
Head/residue	6.8%	79.2%			41.5%			37.5%	7.5%	42.5%										97.6%				

* Includes mass loss

Run **LC11 A** Very Fine Grind (75 µm) **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002725
pH 1.5 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 1002725
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002789
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002789
Fe Addition: none **pH:** 1.5 **Date:** 7/09/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC11 A1	2	40	1.49	499	12.1	4.3	9	0.99	150	89.1	351	31	345	2000	1390	136	204	377	229	35	4560	458	1020	18
LC11 A2	4	40	1.51	500	13.9	4.1	11	1.27	76	94.5	397	32	343	2390	1708	146	221	449	253	36	4950	492	1030	19
LC11 A3	8	40	1.5	500	15.4	4.3	12	1.46	51	96.3	545	39	390	3160	2391	180	282	616	321	41	6480	604	1150	24
LC11 A4	12	40	1.5	500	17.0	4.4	13	1.60	38	97.2	633	42	408	3720	2762	200	312	691	348	44	7240	614	1200	28
LC11 A5	24	40	1.46	486	19.8	4.3	16	1.60	27	98.1	830	43	409	4360	2734	214	387	677	342	47	8080	756	1190	33
24 h MS																							1245	29

U Accountability 83.3%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.32	<0.001	0.002	<0.01	0.072	0.004	0.017	0.55	0.538	0.081	<0.005	0.007	0.030	0.006	0.034	42.72	0.159	0.010	0.041	23	27	0.020	0.005	0.120
Element Extractions																								
Head/liquor	4.4%	86.9%			32.2%			32.4%	2.9%	23.5%						0.1%				87.7%				
Head/residue*	11.8%	>74.5%			29.3%			49.4%	10.1%	38.7%										98.0%				
Head/residue	13.7%	>75.0%			30.8%			50.5%	11.9%	40.0%										98.1%				

* Includes mass loss

Run **LC11 B** Very Fine Grind (75 µm) **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 1002725
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 1002725
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 1002789
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 1002789
Fe Addition: none **pH:** 1.5 **Date:** 7/09/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC11 B1	2	40	1.51	500	9.7	4.2	6	0.98	286	83.2	286	190	184	1460	1068	114	82	399	181	35	3810	320	1180	7
LC11 B2	4	40	1.49	500	11.2	4.2	8	1.18	150	91.2	339	200	179	1790	1369	116	95	459	204	39	4120	374	1260	8
LC11 B3	8	40	1.5	500	13.1	4.2	10	1.45	81	95.2	461	229	202	2530	1833	136	141	591	250	46	5110	494	1400	10
LC11 B4	12	40	1.5	500	14.7	4.1	11	1.68	61	96.4	549	240	202	2970	2244	140	170	702	290	48	5750	548	1430	11
LC11 B5	24	40	1.5	477	17.3	3.7	14	1.68	54	96.8	709	238	210	3790	2266	147	216	697	288	49	6610	630	1320	13
24 h MS																							1411	11

U Accountability 77.0%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.28	0.005	0.001	<0.01	0.024	0.004	0.020	0.95	0.509	0.042	<0.005	<0.01	0.014	0.003	0.020	42.13	0.164	0.009	0.043	46	54	0.015	0.005	0.121
Element Extractions																								
Head/liquor	4.2%	81.1%			41.9%			20.4%	2.2%	24.2%						0.1%				79.9%				
Head/residue*	5.7%	78.9%			40.8%			36.7%	6.4%	41.8%										96.8%				
Head/residue	6.8%	79.2%			41.5%			37.5%	7.5%	42.5%										96.8%				

* Includes mass loss

Run	**LC11 C**	Base Case with Pyrolusite	**Lagoon Creek Uranium Project**	**Oxidant:** Pyrolusite	**ICP/OES Request No:** 1002725
	pH 1.5		**Solids:** 1000 g Junnagunna	**Leach Duration:** 24 h	**ICP/MS Request No:** 1002725
			Leach Liquor Matrix: 818 g Sydney Tap Water	**Temperature:** 40ºC	**XRF Request No:** 1002789
			Slurry: 55%	**ORP:** 500 mV	**DNA Request No:** 1002789
			Fe Addition: none	**pH:** 1.5	**Date:** 7/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC11 C1	2	40	1.49	499	12	4.4	8	1.32	204	85.1	314	26	351	1680	1230	121	189	852	86	41	4270	393	1040	17
LC11 C2	4	40	1.48	499	13.9	4.2	10	1.77	89	93.5	380	28	361	2130	1651	139	209	1010	83	44	4840	439	1080	19
LC11 C3	8	40	1.56	674	16.4	4.0	13	3.58	46	96.7	508	32	386	2760	2716	185	263	1700	90	50	6320	535	1180	23
LC11 C4	12	40	1.5	578	18.5	4.8	15	3.58	29	97.9	598	40	400	3120	3047	210	286	1990	91	53	7200	573	1220	25
LC11 C5	24	40	1.51	503	20.7	4.3	17	3.58	28	97.9	762	39	393	3650	2939	244	344	1880	89	53	7770	652	1130	31
24 h MS																							1121	26

U Accountability 74.2%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.24	0.002	0.002	<0.01	0.013	0.006	0.020	0.51	0.494	0.071	<0.005	0.008	0.006	0.005	0.042	42.76	0.166	0.009	0.045	24	28	0.019	0.005	0.121
Element Extractions																								
Head/liquor	4.1%	79.2%			30.9%			27.1%	3.3%	20.8%						0.1%				79.0%				
Head/residue*	17.4%	49.0%			87.2%			52.9%	17.5%	46.3%										97.9%				
Head/residue	19.0%	50.0%			87.5%			53.9%	19.1%	47.4%										97.9%				

* Includes mass loss

Run	**LC12 A**	Base Case with Pyrolusite	**Lagoon Creek Uranium Project**	**Oxidant:** Pyrolusite	**ICP/OES Request No:**	1002752
	pH 1.5		**Solids:** 1028 g Junnagunna	**Leach Duration:** 24 h	**ICP/MS Request No:**	1002752
			Leach Liquor Matrix: 841 g Sydney Tap Water	**Temperature:** 40ºC	**XRF Request No:**	1002809
			Slurry: 55%	**ORP:** 500 mV	**DNA Request No:**	1002809
			Fe Addition: none	**pH:** 1.5	**Date:**	9/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC12 A1	2	40	1.52	496	11.0	4.3	7	1.45	296	78.4	303	24	363	1730	1184	99	185	711	85	38	4160	416	1091	16
LC12 A2	4	40	1.5	499	13.2	4.5	9	1.95	116	91.6	356	27	379	2220	1587	111	207	915	84	41	4960	464	1250	18
LC12 A3	8	40	1.5	501	15.7	4.5	12	2.57	64	95.3	453	27	395	2790	2056	130	245	1270	84	44	6330	520	1292	21
LC12 A4	12	40	1.5	501	17.4	4.7	14	2.93	39	97.2	543	30	405	3210	2403	150	284	1370	88	45	7080	551	1292	24
LC12 A5	24	40	1.48	481	20.0	4.3	16	2.93	38	97.2	718	30	406	3660	2185	182	355	1330	86	45	7760	652	1229	29
24 h MS																							1259	28

U Accountability 83.9%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	1.42	0.001	0.011	<0.01	0.066	0.007	0.019	0.63	0.556	0.098	<0.005	0.015	0.027	0.005	0.046	42.12	0.153	<0.01	0.050	32	38	0.022	0.005	0.120
Element Extractions																								
Head/liquor	3.8%	61.2%			31.9%			27.2%	2.4%	21.5%						0.1%				88.7%				
Head/residue*	4.2%	74.1%			34.3%			40.8%	5.7%	24.8%										97.1%				
Head/residue	7.5%	75.0%			36.5%			42.9%	9.0%	27.4%										97.2%				

* Includes mass loss

Run	**LC12 B**	Base Case with Pyrolusite	**Lagoon Creek Uranium Project**		**Oxidant:** Pyrolusite		**ICP/OES Request No:**	1E+06
	pH 1.5		**Solids:** 1016 g	Garee (Redtree) Composite	**Leach Duration:** 24 h		**ICP/MS Request No:**	1E+06
			Leach Liquor Matrix: 831 g	Sydney Tap Water	**Temperature:** 40ºC		**XRF Request No:**	1E+06
			Slurry: 55%		**ORP:** 500 mV		**DNA Request No:**	1E+06
			Fe Addition: none		**pH:** 1.5		**Date:**	#####

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC12 B1	2	40	1.5	502	9.5	4.3	6	1.41	376	77.9	234	183	214	1200	901	92	75	682	29	39	3420	280	1218	7
LC12 B2	4	40	1.5	499	11.0	4.4	7	1.79	204	88.0	289	200	219	1570	1126	105	91	829	28	43	4060	347	1419	8
LC12 B3	8	40	1.5	500	12.9	4.4	9	2.37	101	94.1	404	211	232	2230	1684	129	122	1200	29	48	4740	447	1578	9
LC12 B4	12	40	1.5	500	14.5	4.6	11	2.76	76	95.6	491	221	241	2640	2007	150	152	1330	30	51	6060	523	1525	10
LC12 B5	24	40	1.5	472	17.0	4.2	14	2.76	53	96.9	672	214	241	3330	1855	189	201	1300	31	51	6830	616	1494	12
24 h MS																							1434	12

U Accountability 76.9%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.34	0.005	0.010	<0.01	0.019	0.006	0.028	1.06	0.514	0.064	<0.005	<0.01	0.011	0.005	0.031	42.07	0.170	<0.01	0.047	45	53	0.015	0.007	0.120
Element Extractions																								
Head/liquor	4.0%	72.9%			48.1%			17.9%	2.8%	22.5%						0.1%				81.2%				
Head/residue*	0.9%	78.9%			53.0%			29.2%	5.3%	11.1%										96.8%				
Head/residue	2.3%	79.2%			53.7%			30.2%	6.5%	12.3%										96.9%				

***** Includes mass loss

Run	**LC12 C** Optimised	**Lagoon Creek Uranium Project**		**Oxidant:** 10% Sodium Permanganate		**ICP/OES Request No:**	1002752
	pH 1.5	**Solids:** 1021 g	Jack	**Leach Duration:** 24 h		**ICP/MS Request No:**	1002752
		Leach Liquor Matrix: 835 g	Sydney Tap Water	**Temperature:** 40ºC		**XRF Request No:**	1002809
		Slurry: 55%		**ORP:** 500 mV		**DNA Request No:**	1002809
		Fe Addition: none		**pH:** 1.5		**Date:**	9/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929															
LC12 C1	2	40	1.52	505	4.4	4.1	1	0.22	216	76.8	79	36	219	167	100	58	18	95	56	82	1630	59	715	13
LC12 C2	4	40	1.48	500	4.7	4.2	1	0.26	203	78.2	102	39	254	201	178	76	20	115	63	96	1850	86	754	15
LC12 C3	8	40	1.47	500	5.0	4.4	1	0.32	164	82.3	131	40	279	252	214	107	22	138	73	105	2050	129	792	18
LC12 C4	12	40	1.5	500	5.0	4.5	1	0.37	149	84.0	163	40	285	290	238	131	25	148	80	105	2120	167	789	20
LC12 C5	24	40	1.5	449	5.5	4.4	2	0.37	119	87.2	239	39	284	380	139	190	29	147	77	103	2360	264	796	24
24 h MS																							785	22

U Accountability 94.4%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	1.05	0.002	<0.005	<0.01	0.013	0.008	0.032	0.56	0.402		<0.005	<0.01	0.016	0.003	0.030	43.60	0.172	0.011	0.035	101	119	0.026	0.007	0.122
Element Extractions																								
Head/liquor	1.9%	53.2%			70.4%			4.1%	3.5%	13.4%						0.0%				81.5%				
Head/residue*	-0.8%	66.7%			60.6%			25.1%	8.7%											87.2%				
Head/residue	-0.9%	66.7%			60.6%			25.0%	8.6%											87.2%				

* Includes mass loss

Run **LC13 A** Coarse Grind (350 µm) **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 0
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 0
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 0
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 0
Fe Addition: none **pH:** 1.5 **Date:** 12/10/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC13 A1	2	40	2.01	499	3.2	0.0	3	0.50	519	69.5	127	39	148	351	177	89	59	200	122	<1	1470	164	1210	4
LC13 A2	4	40	1.58	499	7.0	4.3	4	0.71	347	79.6	245	142	151	1040	692	107	74	285	163	13	3210	276	1540	7
LC13 A3	8	40	1.5	500	10.3	5.0	6	1.01	157	90.8	366	179	161	1730	1382	123	108	406	206	21	4380	389	1730	9
LC13 A4	12	40	1.5	508	12.2	5.3	8	1.36	80	95.3	521	215	178	2410	2033	163	149	551	271	27	5610	509	1860	11
LC13 A5	24	40	1.5	470	16.4	4.1	13	1.36	56	96.7	725	244	176	3970	2649	223	200	504	253	28	7790	657	2070	13
24 h MS																							1427	12

U Accountability 77.7%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.21	0.006	<0.005	<0.01	0.026	<0.01	0.010	1.00	0.470	0.052	<0.005	<0.01	0.014	0.003	0.024	42.70	0.155	0.010	0.042	47	56	0.016	0.007	0.119
Element Extractions																								
Head/liquor	4.3%	83.1%			35.1%			21.4%	3.3%	22.4%						0.1%				80.8%				
Head/residue*	12.3%	75.0%			36.7%			34.3%	14.7%	28.9%										96.7%				
Head/residue	12.1%	75.0%			36.6%			34.2%	14.5%	28.8%										96.7%				

* Includes mass loss

Run **LC13 B** Base Case Duplicate **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 0
pH 1.5 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 0
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 0
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 0
Fe Addition: none **pH:** 1.5 **Date:** 12/10/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC13 B1	2	40	1.51	498	8.8	5.5	4	0.71	344	79.8	316	165	229	1390	1013	123	87	304	165	42	4050	345	1470	8
LC13 B2	4	40	1.5	498	10.1	5.2	6	0.91	220	87.1	390	187	232	1760	1281	135	110	382	196	47	4470	411	1650	9
LC13 B3	8	40	1.5	500	12.3	4.6	9	1.16	101	94.1	471	192	228	2230	1707	147	140	478	229	48	5170	478	1650	10
LC13 B4	12	40	1.5	500	13.8	5.5	9	1.37	79	95.3	598	209	245	2840	2158	171	177	565	270	53	6210	563	1760	12
LC13 B5	24	40	1.5	473	16.7	4.6	13	1.38	55	96.8	739	197	241	3510	2131	200	223	528	262	52	6730	667	1630	13
24 h MS																							1485	12

U Accountability 80.8%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	1.29	0.004	0.002	<0.01	0.019	0.002	0.015	1.03	0.506	0.050	<0.005	<0.01	0.010	0.002	0.022	42.51	0.157	0.010	0.040	47	55	0.014	0.006	0.118
Element Extractions																								
Head/liquor	4.4%	67.3%			48.1%			18.9%	3.0%	25.0%						0.1%				84.1%				
Head/residue*	6.1%	83.3%			53.5%			31.8%	7.7%	31.3%										96.7%				
Head/residue	6.4%	83.3%			53.7%			32.0%	8.0%	31.5%										96.8%				

* Includes mass loss

Run **LC14 A** Very Low Acid Repeat **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 0
pH 2 **Solids:** 1000 g Garee (Redtree) Composite **Leach Duration:** 24 h **ICP/MS Request No:** 0
Leach Liquor Matrix: 824 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 0
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 0
Fe Addition: none **pH:** 2.0 **Date:** 14/10/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1704															
LC14 A1	2	40	1.98	500	5.4	0.0	5	0.60	428	74.9	162	53	141	480	393	82	63	251	740	2	2110	150	1160	4
LC14 A2	4	40	2.05	499	5.5	0.0	6	0.78	333	80.5	192	46	137	576	474	79	64	299	720	2	2130	181	1200	4
LC14 A3	8	40	2.11	499	6.0	2.1	4	0.92	197	88.4	261	59	154	829	655	102	77	379	789	4	2660	240	1400	5
LC14 A4	12	40	1.96	500	7.3	2.5	5	1.03	136	92.0	320	90	159	1160	957	114	88	430	812	10	3130	279	1490	6
LC14 A5	24	40	2	467	9.5	2.4	7	1.03	116	93.2	403	81	156	1530	819	130	114	409	777	10	3420	333	1390	7
24 h MS																							1316	7
																							U Accountability	75.2%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.38	0.024	0.009	<0.001	0.041	0.016	0.042	1.52	0.550	0.073	<0.001	0.011	0.013	0.012	0.027	42.63	0.135	0.010	0.045	1445	1704	0.021	0.007	0.031
Residue	0.02	0.003	0.003	<0.01	0.027	0.004	0.024	1.20	0.537	0.066	<0.005	0.008	0.015	0.004	0.026	42.46	0.159	0.012	0.042	98	116	0.016	0.005	0.120
Element Extractions																								
Head/liquor	2.4%	27.8%			31.4%			8.3%	1.9%	12.9%						0.1%				75.0%				
Head/residue*	98.9%	87.4%			33.9%			20.8%	2.0%	9.2%										93.2%				
Head/residue	98.9%	87.5%			34.1%			21.1%	2.4%	9.6%										93.2%				

* Includes mass loss

Run **LC14 B** Coarse Grind (350 µm) **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 0
pH 1.5 **Solids:** 1000 g Junnagunna **Leach Duration:** 24 h **ICP/MS Request No:** 0
Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 0
Slurry: 55% **ORP:** 500 mV **DNA Request No:** 0
Fe Addition: none **pH:** 1.5 **Date:** 14/10/10

Sample ID	Leach Conditions								Uranium		Solution Assays (mg/L)														
									ppm U_3O_8	Ext'n (%)															
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1370															
LC14 B1	2	40	1.5	500	10.5	5.5	6	0.65	266	80.6	333	22	346	1750	1242	92	200	310	215	22	4310	352	1120	16
LC14 B2	4	40	1.49	498	12.6	5.1	8	0.93	114	91.7	389	23	345	2180	1541	99	218	398	237	23	4800	385	1240	17
LC14 B3	8	40	1.48	498	14.1	4.9	10	1.20	61	95.6	497	27	381	2860	2149	119	269	536	302	26	5770	446	1410	21
LC14 B4	12	40	1.5	500	16.3	5.5	12	1.43	49	96.5	623	30	399	3390	2635	143	312	650	358	29	6730	506	1420	24
LC14 B5	24	40	1.5	480	18.8	5.3	14	1.43	40	97.1	830	30	398	4230	2750	181	393	633	334	30	7850	576	1450	29
24 h MS																							1253	27

U Accountability 84.5%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	As	Ba	Bi	Ca	Ce	Cr	Fe	K	Mg	Mn	Mo	P	Pb	S	Si	Sr	Th	Ti	U (ppm)	U_3O_8 (ppm)	V	Y	Zr
Head	1.53	0.004	0.012	<0.001	0.104	0.018	0.048	1.10	0.611	0.135	0.001	0.015	0.027	0.013	0.042	43.63	0.140	0.011	0.050	1162	1370	0.033	0.007	0.038
Residue	0.00	0.005	0.005	<0.01	0.081	0.006	0.020	0.63	0.585	0.103	<0.005	<0.012	0.035	0.006	0.052	42.43	0.158	0.010	0.047	34	40	0.022	0.005	0.118
Element Extractions																								
Head/liquor	4.4%	61.8%			31.3%			31.4%	2.4%	23.8%						0.1%				88.3%				
Head/residue*	99.9%	-28.5%			19.9%			40.9%	1.6%	21.6%										97.0%				
Head/residue	99.9%	-25.0%			22.1%			42.5%	4.3%	23.7%										97.1%				

* Includes mass loss

Run **LC15 A** High Acid **Lagoon Creek Uranium Project** **Oxidant:** 10% Sodium Permanganate **ICP/OES Request No:** 0

pH 1.5 **Solids:** 1000 g Jack **Leach Duration:** 24 h **ICP/MS Request No:** 0

Leach Liquor Matrix: 818 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 0

Slurry: 55% **ORP:** 500 mV **DNA Request No:** 0

Fe Addition: none **pH:** 1.5 **Date:** 9/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929															
LC15 A1	2	40	1.21	501	8.2	8.9	1	0.16	169	81.8	94	42	258	247	145	68	25	63	51	114	3250	80	705	15
LC15 A2	4	40	1.2	501	8.3	9.1	1	0.20	134	85.6	112	43	260	306	219	85	28	82	57	115	3500	108	756	18
LC15 A3	8	40	1.2	500	8.6	9.3	1	0.25	99	89.4	152	45	272	385	269	112	33	103	71	120	3620	151	791	20
LC15 A4	12	40	1.21	499	8.6	8.4	2	0.28	89	90.4	182	46	271	441	296	134	36	114	77	120	3710	182	794	22
LC15 A5	24	40	1.2	468	9.8	8.6	3	0.28	79	91.5	266	47	279	578	346	197	43	117	78	126	4130	261	850	28
24 h MS																							967	29

U Accountability 111.5%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	0.84	0.003	<0.005	<0.01	0.013	<0.01	0.136	0.49	0.331	<0.005	<0.005	0.010	0.011	<0.001	0.028	38.08	0.140	<0.01	0.026	67	79	0.019	0.001	0.110
Element Extractions																								
Head/liquor	2.1%	64.4%			69.2%			6.3%	3.7%	19.7%						0.0%				100.4%				
Head/residue*	7.7%	42.8%			54.9%			26.2%	14.0%	68.2%										90.3%				
Head/residue	19.3%	50.0%			60.6%			35.5%	24.8%	72.2%										91.5%				

* Includes mass loss

Run **LC16 A** Ferric Addition
pH 1.5

Lagoon Creek Uranium Project
Solids: 1000 g Jack
Leach Liquor Matrix: 818 g Sydney Tap Water
Slurry: 55%
Fe Addition: 1.0 g/L as 3.85 g Fe2(SO4)3.7H2O

Oxidant: 10% Sodium Permanganate
Leach Duration: 24 h
Temperature: 40ºC
ORP: 500 mV
pH: 1.5

ICP/OES Request No: 0
ICP/MS Request No: 0
XRF Request No: 0
DNA Request No: 0
Date: 10/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929															
LC16 A1	2	40	1.51	505	3.4	2.9	1	0.00	148	84.1	86	31	93	1117	747	57	22	16	28	31	2087	54	789	12
LC16 A2	4	40	1.51	497	3.4	2.9	1	0.00	128	86.2	101	35	98	1187	729	69	26	19	28	34	2237	76	818	13
LC16 A3	8	40	1.5	495	3.9	3.2	1	0.03	97	89.5	129	36	100	1256	719	90	25	34	35	37	2433	110	842	16
LC16 A4	12	40	1.51	495	4.0	3.2	1	0.10	99	89.4	158	36	107	1310	759	112	34	58	49	41	2523	139	828	18
LC16 A5	24	40	1.53	495	4.0	3.2	1	0.14	83	91.0	228	36	120	1427	846	172	32	98	65	47	2788	231	871	22
24 h MS																							803	0

U Accountability 92.5%

Comments:

Sample ID	**Element Concentration (wt.%)**																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	1.07	0.003	<0.005	<0.01	0.030	0.011	0.028	0.58	0.427	0.020	<0.005	<0.01	0.025	0.005	0.030	44.76	0.166	0.008	0.034	71	83	0.027	0.006	0.121
	Element Extractions																							
Head/liquor	1.8%	48.8%			29.7%			15.5%	3.2%	14.7%						0.0%				83.4%				
Head/residue*	0.0%	51.3%			11.5%			25.5%	5.6%	-8.1%										91.3%				
Head/residue	-2.8%	50.0%			9.1%			23.4%	3.0%	-11.1%										91.0%				

* Includes mass loss

Run	**LC16 B**	Ferric Addition, High Acid	**Lagoon Creek Uranium Project**	**Oxidant:**	10% Sodium Permanganate	**ICP/OES Request No:**	0
	pH 1.2	**Solids:**	1000 g Jack	**Leach Duration:**	24 h	**ICP/MS Request No:**	0
		Leach Liquor Matrix:	818 g Sydney Tap Water	**Temperature:**	40ºC	**XRF Request No:**	0
		Slurry:	55%	**ORP:**	500 mV	**DNA Request No:**	0
		Fe Addition:	1.0 g/L as 3.85 g Fe2(SO4)3.7H2O	**pH:**	1.2	**Date:**	11/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929															
LC16 B1	2	40	1.22	511	6.7	6.2	2	0.00	161	82.7	90	42	243	1180	788	70	25	16	30	113	3332	57	808	13
LC16 B2	4	40	1.21	493	7.2	6.7	2	0.00	120	87.1	110	43	288	1238	730	87	25	18	27	138	3618	81	843	15
LC16 B3	8	40	1.2	496	8.3	7.4	2	0.05	98	89.5	143	45	298	1324	801	111	29	41	39	145	4053	119	880	18
LC16 B4	12	40	1.19	495	8.8	7.7	2	0.08	91	90.2	165	44	294	1344	822	125	30	60	47	142	4206	146	880	20
LC16 B5	24	40	1.18	495	8.9	7.7	3	0.11	81	91.3	235	43	295	1445	937	164	36	94	63	142	4428	224	863	25
24 h MS																							793	0

U Accountability 91.3%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	0.94	0.002	<0.005	<0.01	0.012	0.006	0.035	0.52	0.374	0.011	<0.005	0.008	0.015	<0.001	0.030	42.07	0.158	0.001	0.039	69	81	0.025	0.007	0.118
Element Extractions																								
Head/liquor	1.8%	58.2%			73.1%			15.7%	3.0%	16.4%						0.0%				82.4%				
Head/residue*	7.0%	65.5%			62.3%			28.4%	12.0%	36.7%										91.0%				
Head/residue	10.1%	66.7%			63.6%			30.9%	15.0%	38.9%										91.3%				

* Includes mass loss

Run	**LC16 C**	Ferric Addition, Fine Grind (P80 - 150 µm)	**Lagoon Creek Uranium Project**	**Oxidant:**	10% Sodium Permanganate	**ICP/OES Request No:**	0
	pH 1.5	**Solids:**	1000 g Jack	**Leach Duration:**	24 h	**ICP/MS Request No:**	0
		Leach Liquor Matrix:	818 g Sydney Tap Water	**Temperature:**	40ºC	**XRF Request No:**	0
		Slurry:	55%	**ORP:**	500 mV	**DNA Request No:**	0
		Fe Addition:	1.0 g/L as 3.85 g Fe2(SO4)3.7H2O	**pH:**	1.5	**Date:**	12/09/2010

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									929															
LC16 C1	2	40	1.51	512	3.5	3.1	1	0.16	143	84.6	88	37	75	1211	790	62	27	22	35	33	2272	64	839	13
LC16 C2	4	40	1.51	504	3.5	3.2	1	0.20	125	86.5	104	41	80	1271	756	71	28	25	34	36	2366	85	877	15
LC16 C3	8	40	1.51	496	3.7	3.3	1	0.25	97	89.5	133	42	92	1376	680	90	31	30	37	40	2544	121	908	17
LC16 C4	12	40	1.5	495	3.8	3.3	1	0.28	91	90.2	156	43	99	1433	736	104	33	47	45	44	2631	153	922	19
LC16 C5	24	40	1.5	495	4.3	3.5	1	0.28	82	91.2	217	41	118	1550	896	143	38	95	68	51	2911	246	930	23
24 h MS																							857	0
																							U Accountability	98.3%

Comments:

Sample ID	**Element Concentration (wt.%)**																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.05	0.006	0.009	<0.001	0.033	0.014	0.061	0.75	0.440	0.018	<0.001	0.009	0.021	0.007	0.037	43.56	0.152	0.009	0.036	788	929	0.037	0.007	0.032
Residue	0.97	0.002	<0.005	<0.01	0.030	0.003	0.051	0.59	0.382	0.015	<0.005	0.010	0.022	<0.001	0.027	41.34	0.161	0.003	0.034	69	82	0.023	0.006	0.117
Element Extractions																								
Head/liquor	1.8%	168.8%			32.2%			21.6%	3.1%	20.5%						0.0%				89.0%				
Head/residue*	2.5%	64.9%			4.2%			17.9%	8.5%	12.2%										90.8%				
Head/residue	7.5%	66.7%			9.1%			22.1%	13.2%	16.7%										91.2%				

* Includes mass loss

Run **LC17 A** Bulk Leach **Lagoon Creek Uranium Project** **Oxidant:** Pyrolusite **ICP/OES Request No:** 0
pH 1.5 **Solids:** 60600 g Composite **Leach Duration:** 12 h **ICP/MS Request No:** 0
Leach Liquor Matrix: 49600 g Sydney Tap Water **Temperature:** 40ºC **XRF Request No:** 0
Slurry: 55% **ORP:** 550 mV **DNA Request No:** 0
Fe Addition: none **pH:** 1.5 **Date:** 28/03/2011

Sample ID	Leach Conditions								Uranium Assay (ppm U_3O_8)	U Extraction (%)	Solution Assays (mg/L)													
	Time (h)	Temp. (°C)	pH	ORP (mV)	Acid Addition (kg/t)	Free Acidity (g/L H_2SO_4)	Acid Cons. (kg/t)	Oxidant Addition (kg/t)	DNA	DNA	Al	As	Ca	Fe	Fe^{3+}	K	Mg	Mn	Na	P	S	Si	U	V
Head									1361		0		21.5	0	0	41.4	13.7	0	59.8	0	75.9	5	0	0
	0									0														
LC17 A1	2	40	1.54	540	17.9	3.3	15.1	5.29	218	84.0	429	84	287	4420	4420	213	117	3230	83	65	8130	469	1140	17
LC17 A2	4	40	1.50	550	21.5	3.7	18.5	5.93	84	93.8	477	96	298	4670	4420	220	130	3470	84	72	8800	515	1300	18
LC17 A3	8	40	1.50	548	22.8	3.7	19.7	6.24	53	96.1	551	100	307	5010	4690	228	152	3600	84	76	9420	553	1330	20
LC17 A4	12	40	1.50	550	23.7	3.3	21.0	6.44	52	96.2	609	100	312	5350	5016	236	170	3750	86	79	9910	589	1360	21
24 h MS																							1208	19

U Accountability 91.4%

Comments:

Sample ID	Element Concentration (wt.%)																							
	Al	**As**	**Ba**	**Bi**	**Ca**	**Ce**	**Cr**	**Fe**	**K**	**Mg**	**Mn**	**Mo**	**P**	**Pb**	**S**	**Si**	**Sr**	**Th**	**Ti**	**U (ppm)**	**U_3O_8 (ppm)**	**V**	**Y**	**Zr**
Head	1.30	0.012	0.006	<0.01	0.063	0.001	0.001	1.22	0.502	0.078	<0.005	0.007	0.028	0.006	0.026	42.92	0.167	0.013	0.045	1154	1361	0.022	0.007	0.127
Residue	1.25	0.004	0.013	<0.01	0.044	0.003	0.001	0.86	0.485	0.065	<0.005	0.008	0.024	0.007	0.031	43.48	0.171	0.014	0.044	44	52	0.020	0.004	0.130
Element Extractions																								
Head/liquor	3.8%	68.2%			37.7%			36.0%	3.2%	16.4%						0.1%				85.7%				
Head/residue*	5.6%	67.1%			31.1%			30.5%	4.6%	17.8%										96.2%				
Head/residue	4.4%	66.7%			30.2%			29.5%	3.4%	16.7%										96.2%				

* Includes mass loss

APPENDIX G

Composition of Final Leach Liquors by ICP/MS (mg/L)

	As	Ba	Cd	Ce	Co	Cr	Cu	Eu	Hg	Ho	La	Mo	Nb	Nd	Ni	Pb	Pr	Sb	Sc	Sm	Sn	Sr	Ta	Th	Ti	Tl	U	V	Y	Yb	Zn	Zr
LC13 A5	181	<1	<1	5	10	8	6	<1	<1	<1	1	6	<1	3	18	3	<1	<2	<1	<1	<1	<1	<1	1	<1	<1	1338	11	4	<1	1	<1
LC14 B5	38	<1	<1	7	13	6	5	<1	<1	<1	2	28	<1	5	8	5	1	<2	<1	2	<1	<1	<1	2	<1	<1	1340	30	8	<1	2	<1
LC15 A5	51	<1	<1	<1	14	14	13	<1	<1	<1	<1	3	<1	<1	14	2	<1	<2	<1	<1	<1	<1	<1	<1	<1	<1	834	26	4	<1	1	<1

REPORT NUMBER: ICPMS REPORT 1003455
Job Description:
REPORT DATE: 24 November 2010

APPENDIX H

Mineralogy Report

The Uranium Processing and Radioactivity Specialists

TECHNICAL MEMORANDUM: AM_TN_2010_12

Submitted To: LAGOON CREEK RESOURCES

Subject: MINERALOGY OF WESTMORELAND ORES AND THEIR RESIDUES

Prepared By: M. Grigore

Checked By:

Date: December 2010

Commercial-in-Confidence

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H1. INTRODUCTION

Five Westmoreland uranium ores and two selected residues were provided for mineralogical characterisation. The mineralogy of these samples was investigated using X-ray diffraction (XRD). Scanning electron microscopy (SEM) analysis was carried out only on the residues. The following ore and residue samples have been investigated:

- Junnagunna Lens
- Garee Lower Lens
- Garee Upper Lens
- Garee (Redtree) Lens Composite
- Jack Lens
- Junnagunna - residue (LC 3 A)
- Garee (Redtree) Composite - residue (LC 3 B)
- Jack - residue (LC 12 C)

H2. SCOPE OF WORK

The aim of this study was to identify the relative concentration of the gangue minerals detected by XRD, and identification of the factors that limit uranium extraction during leaching.

H3. ANALYSIS

H3.1 X-Ray Diffraction

Method

The X-ray diffraction analyses of the pulverised samples were run on an X'pert Pro PANalytical X-ray diffractometer using Cu Kα radiation. Step scans were undertaken from 2 – 80º 2θ, with a step interval of 0.05º 2θ and 5 seconds count time per step. Bruker Eva search/match software was used for minerals identification. A quantitative XRD analysis software package, SIROQUANT^{TM}, was used to determine the relative concentrations of the identified minerals.

Results

Ores: Quartz (SiO_2) is the dominant gangue mineral in these ores (**Appendix A – Figures A1-A5**). Its relative concentrations vary from 88 to 92.3 wt% (**Table H1**). The minor constituents of these ores (less than 10% each) are illite ($(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$), chamosite ($(Fe^{2+},Mg,Fe^{3+})_5Al(Si_3Al)O_{10}(OH,O)_8$), hematite ($Fe_2O_3$), jarosite ($(K,H_3O)Fe_3(SO_4)_2(OH)_6$), and hydroxylapatite ($Ca_5(PO_4)_3(OH)$). Illite, hematite and jarosite are present in all ores. Chamosite was found in four ores, whereas hydroxylapatite was detected only in Junnagunna ore. The uranium-bearing minerals were not abundant enough to be detectable by XRD.

Residues: The mineralogy of the selected ores (Junnagunna, Garee (Redtree) Composite and Jack) have not changed significantly after leaching (**Table H1** and **Appendix A – Figures A6** and **A7**). Hydroxylapatite was not detected by XRD in the Junnagunna residue. It most likely dissolved during leaching.

Table H1 The relative concentrations (wt%) of the minerals identified in the ores and their residues, determined by SIROQUANT™ using the XRD patterns

Ores	Junnagunna	Garee Upper	Garee Lower	Redtree Composite	Jack
Chlorite	1.8	0.5	2.8	1.7	
Hematite	0.5	1.4	0.8	1.1	0.8
Jarosite	0.9	0.8	0.7	0.9	0.6
Hydroxylapatite	0.8				
Illite	8.0	6.6	6.8	6.6	6.4
Quartz	88.0	90.6	88.8	89.7	92.3

Residues	Junnagunna LC 3A	Redtree LC 3B	Jack LC 12C
Chlorite	2.6	2.2	
Hematite	0.4	1.5	0.7
Jarosite	0.9	1.2	0.6
Hydroxylapatite			
Illite	11.3	11.5	3.7
Quartz	84.7	83.7	95.0

H3.2 Scanning Electron Microscopy

Method

The samples were mounted in epoxy resin and polished to a 1-micron diamond finish. Approximately 5 nm of carbon was evaporated onto the surfaces under vacuum to prevent charging. The SEM was a Zeiss Ultra Plus with an attached Oxford Instruments X-Max 80mm^2 SDD X-ray microanalysis system. The SEM was operated at an accelerating voltage of 15 kV. The X-ray microanalysis system enables microchemical characterisation of the sample. The images were acquired in backscattered electron imaging mode (BSE). This mode can enable compositional differences between/within grains to be observed. Images obtained from backscattered electrons are mean atomic number contrast images. Elements with high atomic number give brighter contrast (light grey) than those with low atomic number (dark grey).

Results

Junnagunna - residue (LC 3A): In addition to the gangue minerals identified by XRD, SEM analysis shows that other gangue minerals such as rutile/anatase (TiO_2), zircon ($ZrSiO_4$), pyrite (FeS_2), monazite ($(Ce,La,Nd,Th)PO_4$), florencite ($(Ce,La)Al_3(PO_4)_2(OH)_6$), galena (PbS), iron copper sulfide, copper sulfide and barite ($BaSO_4$) were also present in this sample. Their abundance was too low to be detected by XRD.

The residual uranium minerals consist of coffinite ($U(SiO_4)_{1-x}(OH)_{4x}$), uranium phosphate, probably phosphuranylite ($KCa(H_3O)3(UO_2)_7(PO_4)_4O_4{\cdot}8(H_2O)$), and uraniferous zircon, where coffinite was the most common uranium mineral. They were enclosed in the quartz

particles. Various amounts of arsenic were detected in most uranium minerals. Lead was found only in coffinite.

Figure A9 shows inclusions of coffinite in quartz. Occasionally, coffinite is intergrown with illite (**Figure A10**) and rutile/anatase (**Figure A11**).

The uraniferous zircons has high uranium content (26 and 42 wt.%) (**Figures A12 and A13**). This suggests that uranium may occur as impurity within the zircon crystal or as uraninite/pitchblende finely intergrown with zircon.

Uranium phosphate was found in only one occurrence (**Figure A14**). EDS data suggests that the uranium phosphate is probably phosphuranylite.

Garee (Redtree) Composite - residue (LC 3 B): Ilmenite ($FeTiO_3$), rutile/anatase, pyrite, monazite and goethite (FeO(OH)) occurred in accessory amounts. They were confirmed only by SEM/EDS since they were not abundant enough to be detected by XRD.

Uraninite/pitchblende, coffinite and two forms of uranium phosphate were the residual uranium minerals. The compositions of the uranium phosphates (EDS data) suggest that the minerals are most likely to be autunite ($Ca(UO_2)_2(PO_4)_2 \cdot 10\text{-}12(H_2O)$) and phosphuranylite. Arsenic and lead were present in the uranium minerals. Arsenic was detected mainly in the uranium phosphates, whereas lead was present only in uraninite/pitchblende and coffinite. Most of the uranium minerals were enclosed in quartz. Only two quartz particles displayed zirconium-rich coffinite partially enclosed in quartz.

Figures A15 and **A16** show uraninite/pitchblende and coffinite inclusions within quartz. Occasionally, coffinite is intergrown rutile/anatase (**Figure A17**). Most autunite and phosphuranylite contain various amounts of arsenic (up to 10 wt%) (**Figures A18** and **A19**).

The zirconium-rich coffinite does not give any visible indication that it has begun to dissolve (**Figure A20**). The zirconium-rich coffinite may also be coffinite intimately intergrown with zircon.

Jack - residue (LC 12 C): Zircon, rutile/anatase, pyrite, monazite, galena, barite, iron copper sulphide and copper sulfide are the additional gangue minerals identified by SEM/EDS (their concentration is below XRD detection limit).

The uranium bearing minerals detected in this residue were uraninite/pitchblende, coffinite, two uranium phosphate minerals, most likely autunite and phosphuranylite (EDS spectra) and uraniferous zircon. Autunite was the dominant uranium phosphate. Lead was often present in uraninite/pitchblende and coffinite, where its concentration was up to 20 wt%. Phosphuranylite contains small amounts of arsenic. Uraninite/pitchblende and coffinite were found as inclusions within quartz, whereas the uranium phosphates were either completely or partially enclosed in quartz or liberated. The uraniferous zircon was found in only two occurrences.

Generally, uraninite/pitchblende and coffinite did not show any sign of alteration, which indicate lack of access of the leach liquor to them (**Figures A21** and **A23**). A uraninite/pitchblende grain displayed acid attack around the grain margins and small solution

pits (**Figure A22**). Although the uraninite/pitchblende was enclosed within quartz, it was not impermeable enough to prevent it.

The dissolution of the uranium phosphates was incomplete although they were exposed to the leach liquor (**Figures A24-A26**). The morphology of the residual uranium phosphates indicates that the main reason for their incomplete dissolution was insufficient leaching time. More severe leaching conditions would increase their solubility.

Zircon appears to be finely inter-grown with uranium phosphate (**Figure A27**). The ratio U:P observed in the EDS spectrum is similar to that of phosphuranylite. Iron, aluminium and arsenic detected in zircon are probably impurities. Although zircon is enclosed within quartz, it is partially dissolved.

H4. CONCLUSIONS

The major findings from this study include the following:

- Coffinite and the uranium phosphate similar in composition to phosphuranylite were found in all residues. Uraninite/pitchblende, uraniferous zircon and the uranium phosphate similar in composition to autunite were detected only in the residues of Garee (Redtree) Composite and Jack ores.
- The uranium bearing minerals in the residues of Junnagunna and Garee (Redtree) Composite were enclosed within quartz, with one exception, the coffinite intimately intergrown with zircon in Garee (Redtree) Composite. They did not appear altered by leaching. It is likely that the acid solution could not penetrate the enclosing quartz, since no liberated or partially exposed uranium minerals were found. The coffinite intimately intergrown with zircon appears to be refractory to the leaching conditions employed in the leaching test.
- The uranium phosphates in the residue of Jack ore were partially dissolved although they were exposed to the leach liquor. Their solubility is reduced under the test conditions. The other uranium minerals in this residue appear to be soluble under the test conditions, since they were detected only as inclusions in quartz. Moreover, a uraninite/pitchblende grain and an uraniferous zircon grain, which were enclosed in quartz, were partially dissolved. Their dissolution was limited by the reduced permeability of the quartz particles.

Appendix H1: XRD Analyses

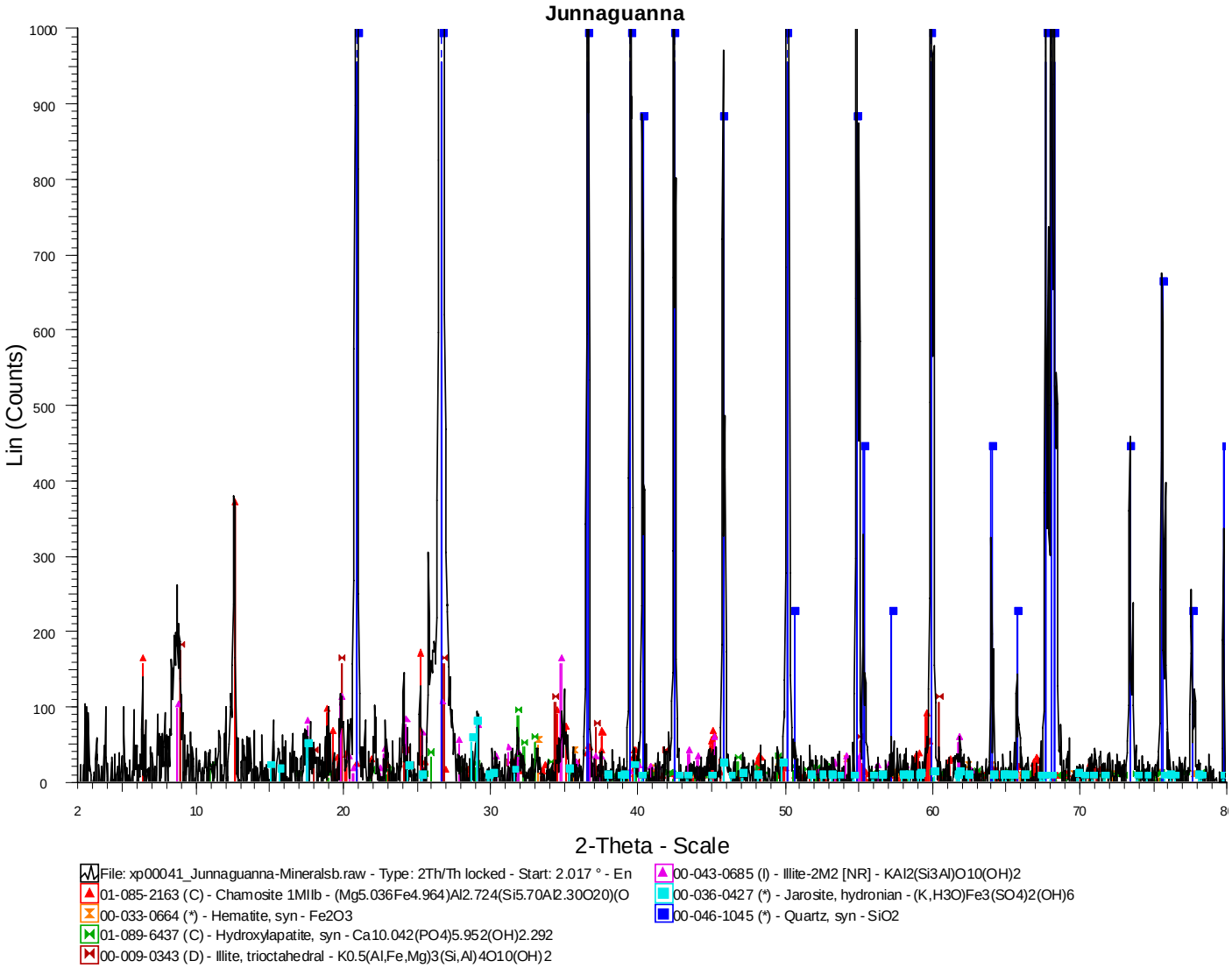


FIGURE A1 Truncated XRD Pattern of Junnaguanna ore (background removed).

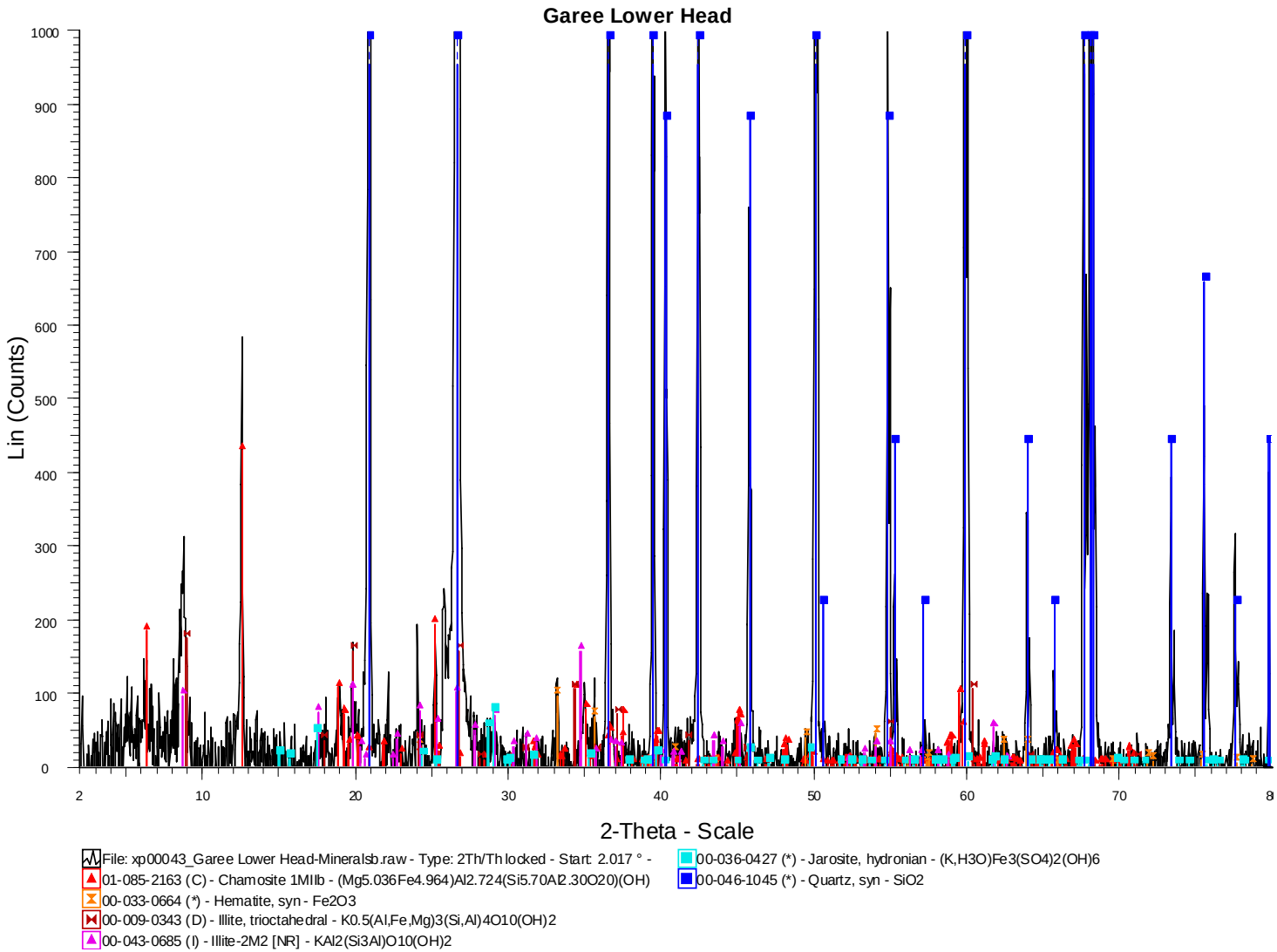


FIGURE A2 Truncated XRD Pattern of Garee Lower ore (background removed).

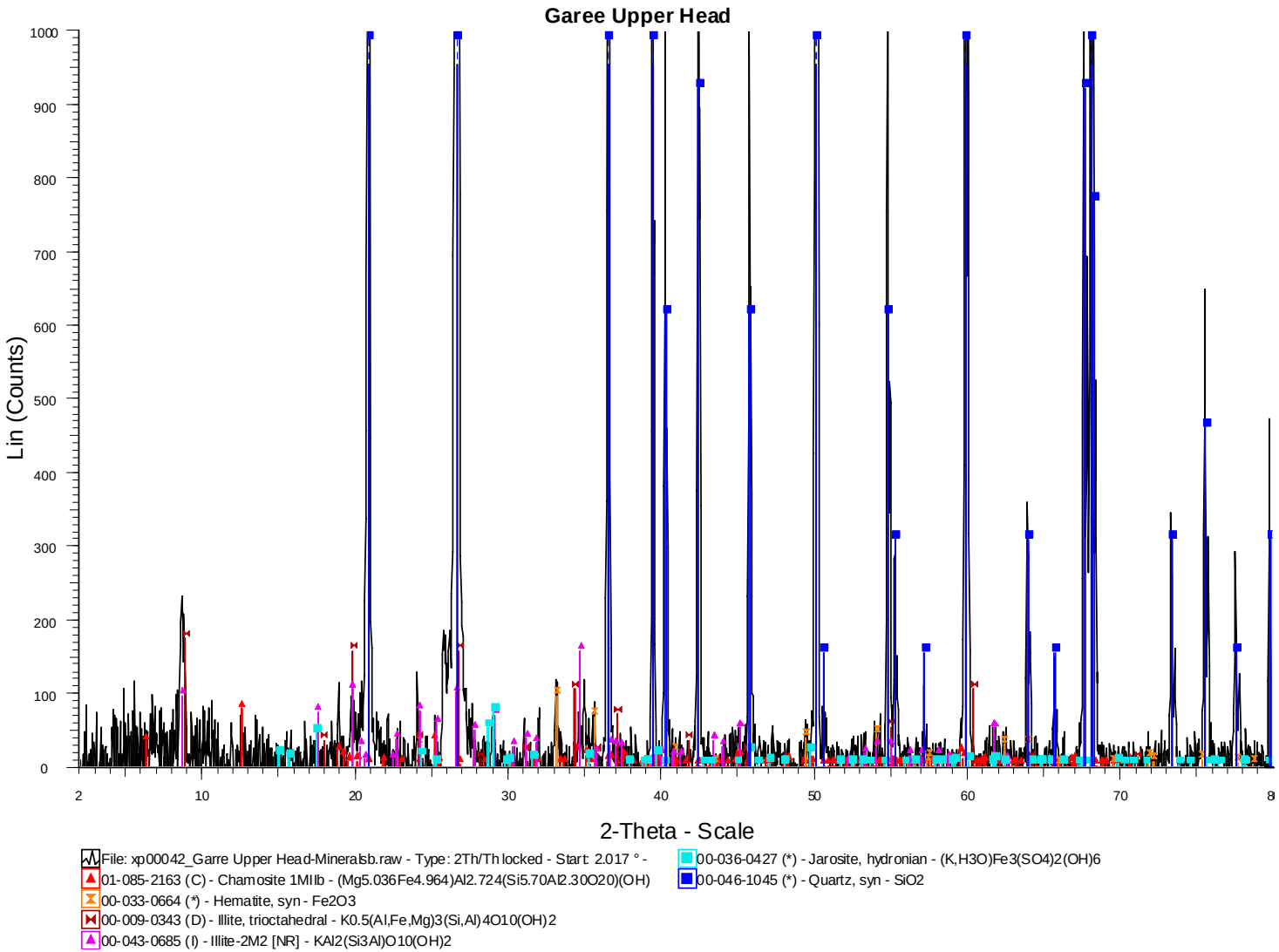


FIGURE A3 Truncated XRD pattern of Garee Upper ore (background removed).

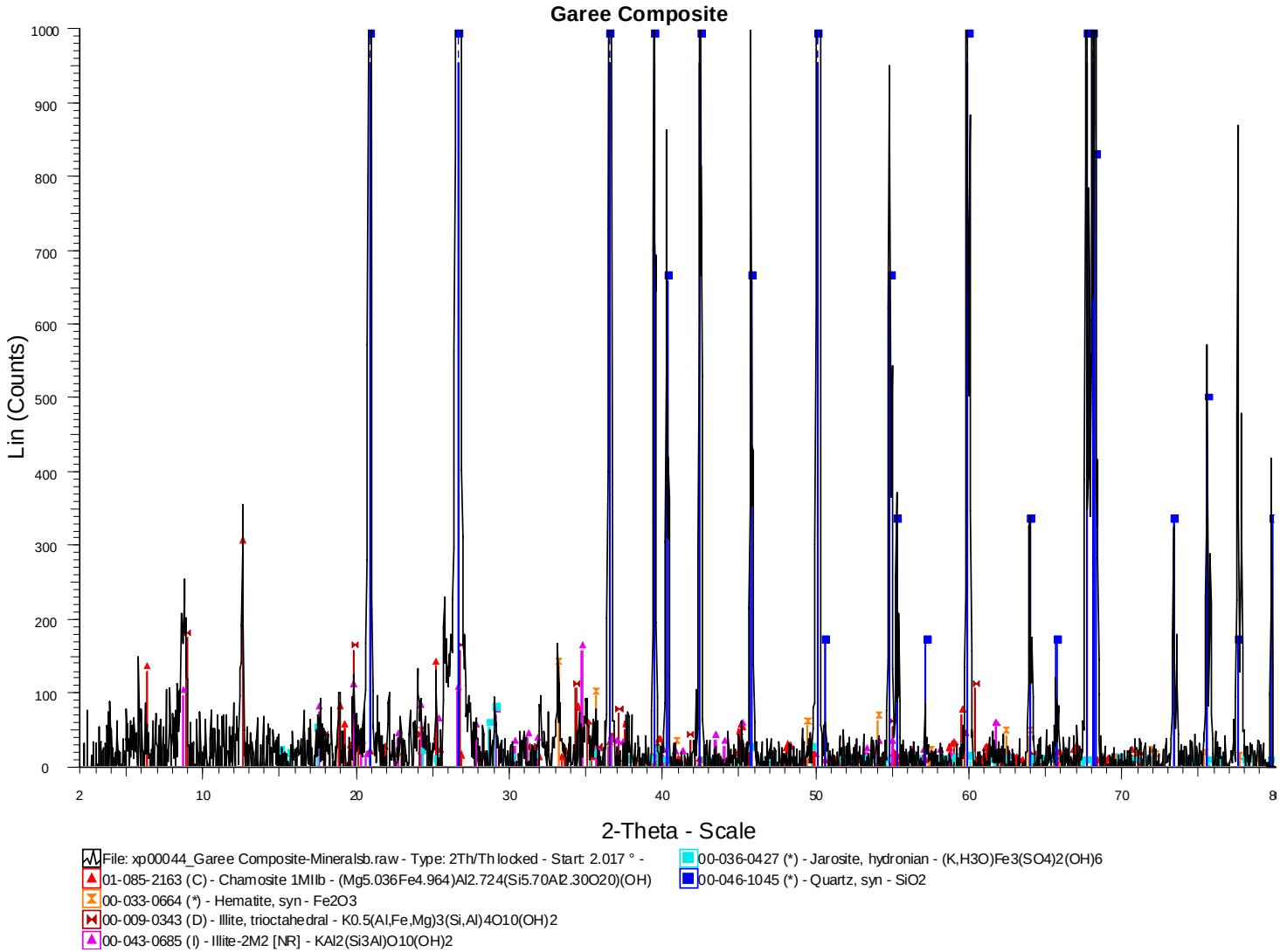


FIGURE A4 Truncated XRD pattern of Garee (Redtree) Composite (background removed).

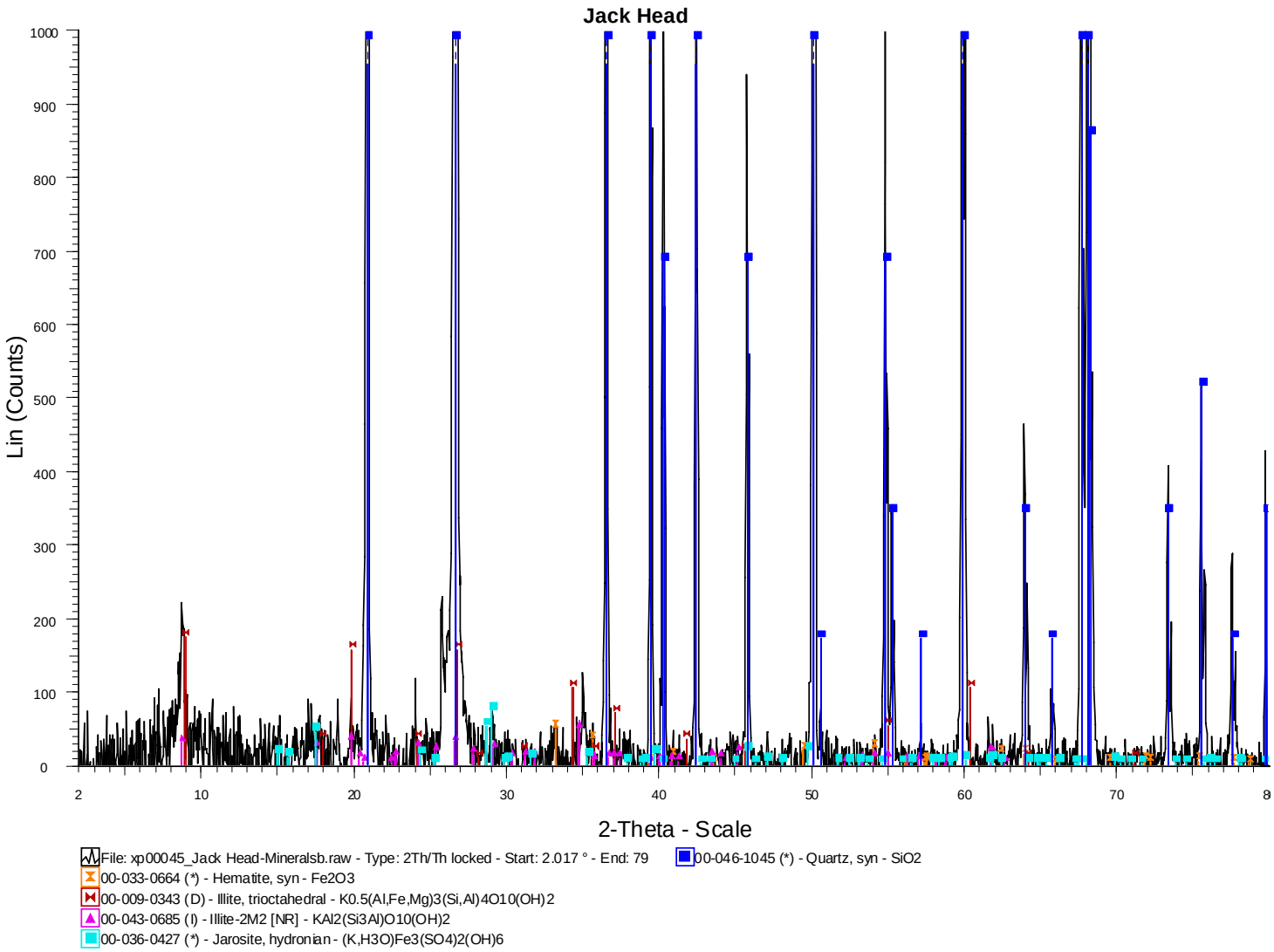


FIGURE A5 Truncated XRD pattern of Jack ore (background removed).

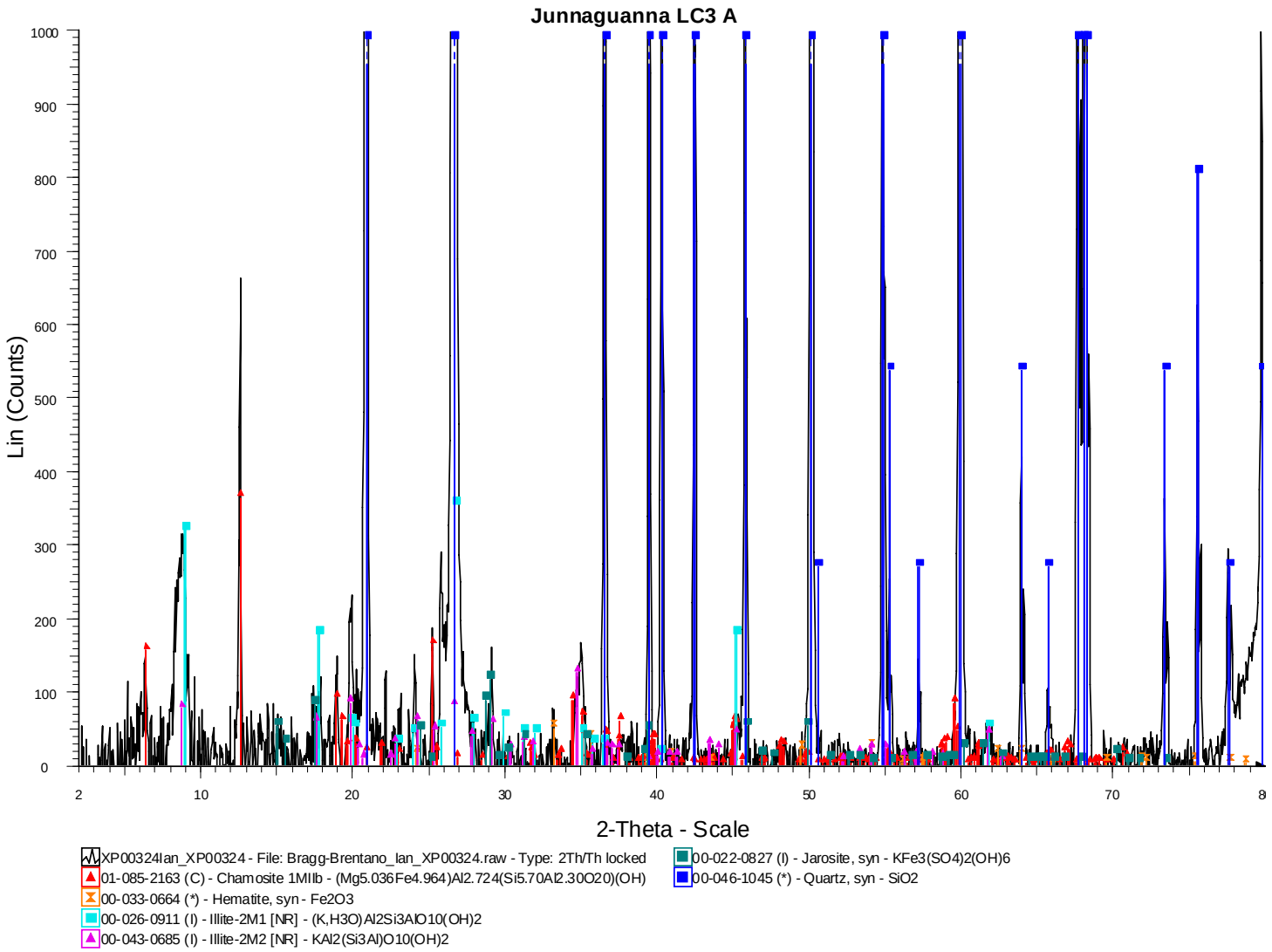


FIGURE A6 Truncated XRD pattern of Junnagunna - residue (LC 3 A) (background removed).

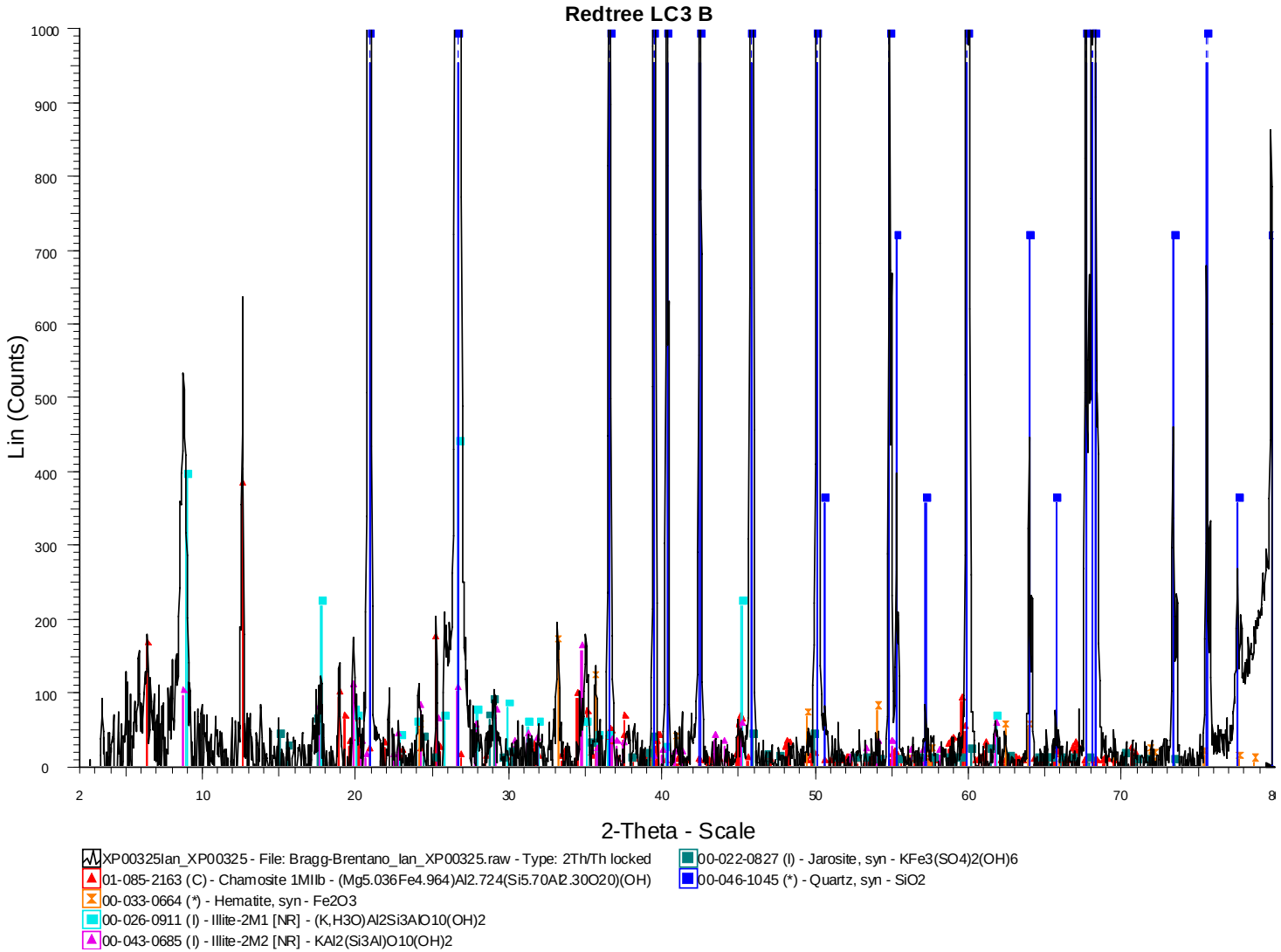


FIGURE A7 Truncated XRD pattern of Garee (Redtree) Composite - residue (LC 3 B) (background removed).

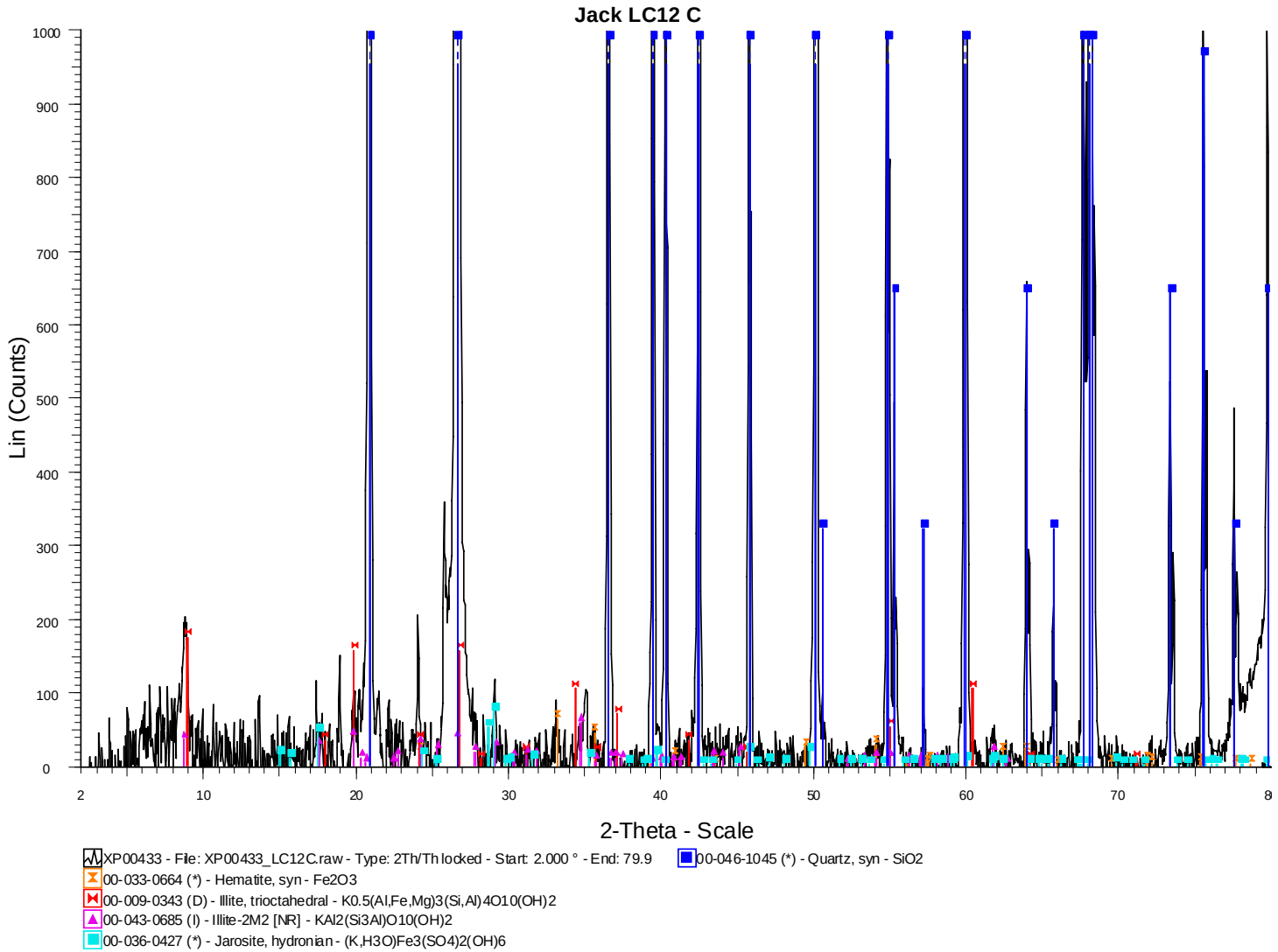


FIGURE A8 Truncated XRD pattern of Jack - residue (LC 12 C) (background removed).

Appendix H2: SEM Images and EDS spectra

FIGURE A9 JUNNAGUNNA - RESIDUE (LC 3A): (a) Backscattered electron (BSE) micrograph showing a coffinite inclusion in quartz; (b) magnified view of coffinite. Small amounts of lead were detected in coffinite.

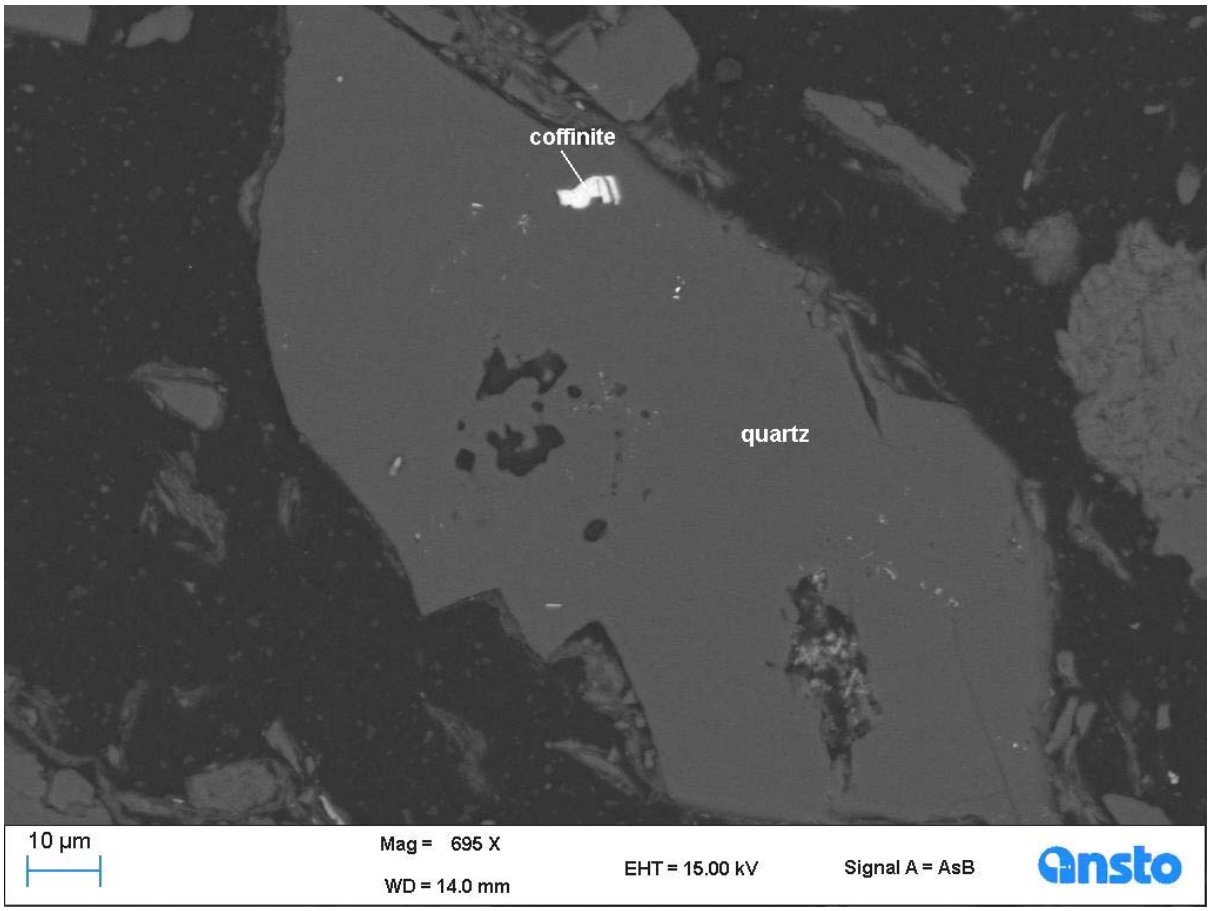
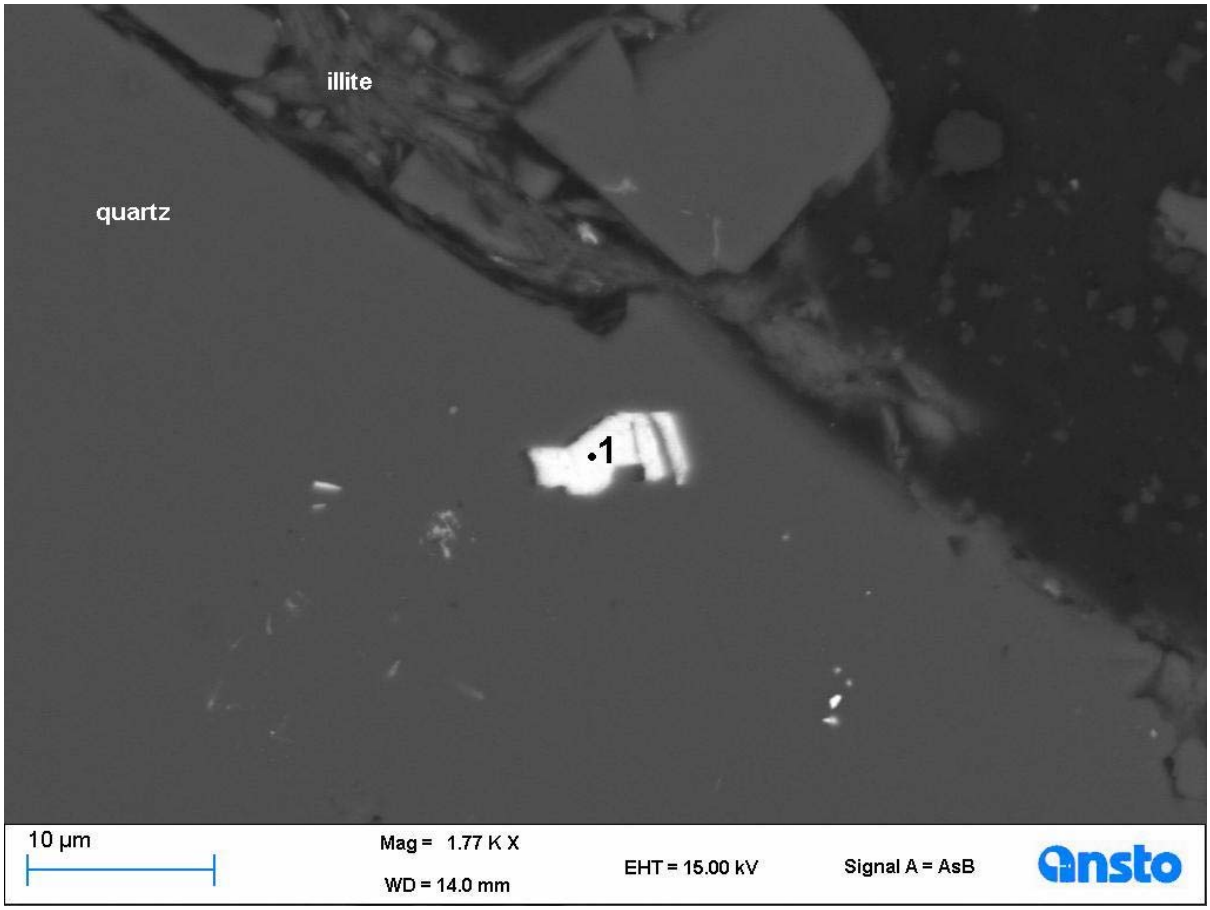
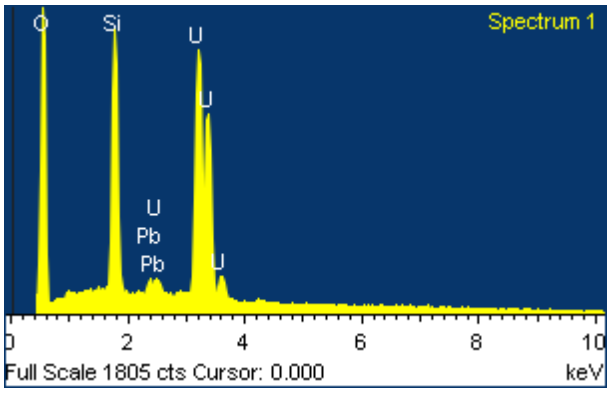


FIGURE A9 – (a)



The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

FIGURE A9 – (b)



S1 – coffinite

FIGURE A10 JUNNAGUNNA - RESIDUE (LC 3A): (a) BSE micrograph illustrating coffinite intergrown with illite, hosted by quartz; (b) coffinite intergrown with illite in more detail. Coffinite contains relative high amounts of arsenic. Arsenic and zirconium may substitute for silicon and uranium, respectively, in coffinite. Also, zircon may be intimately intergrown with coffinite.

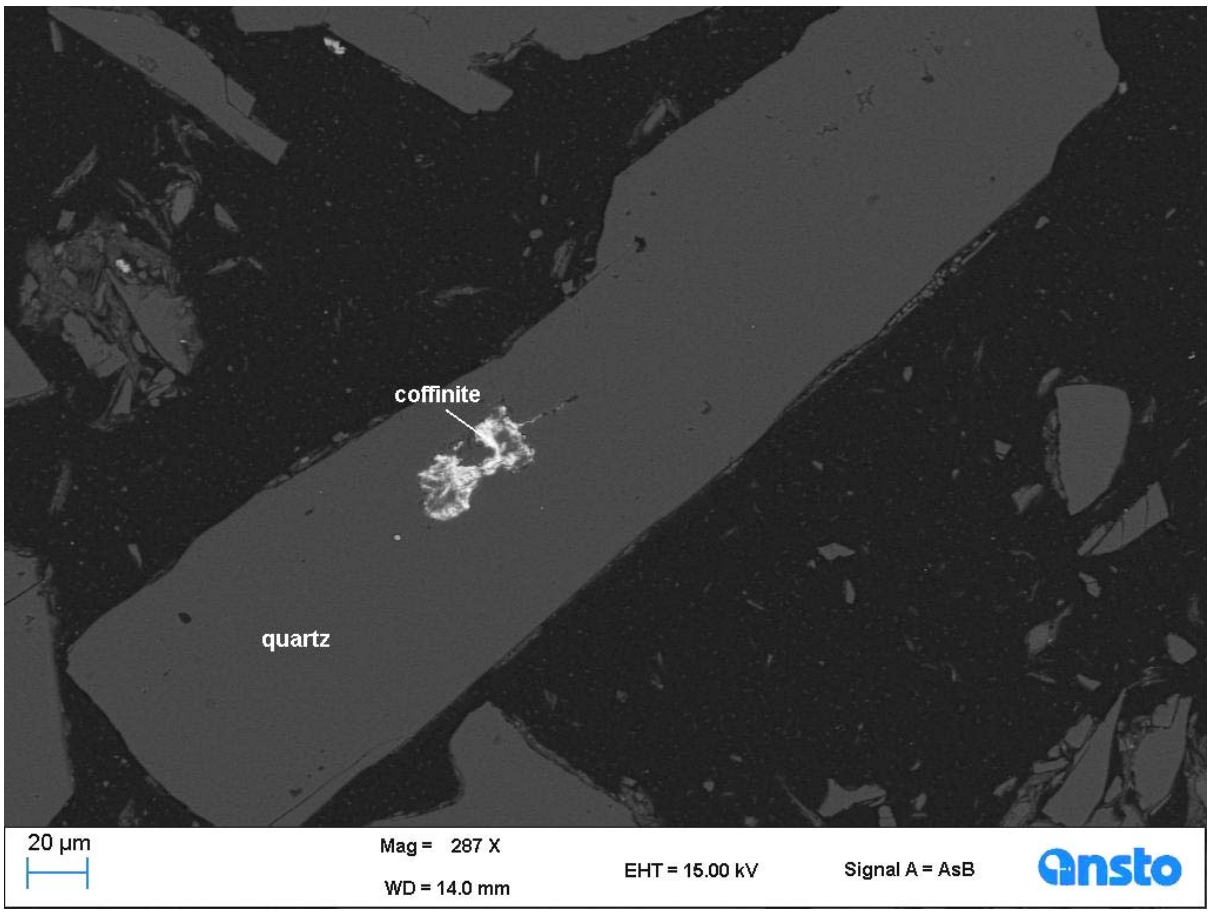
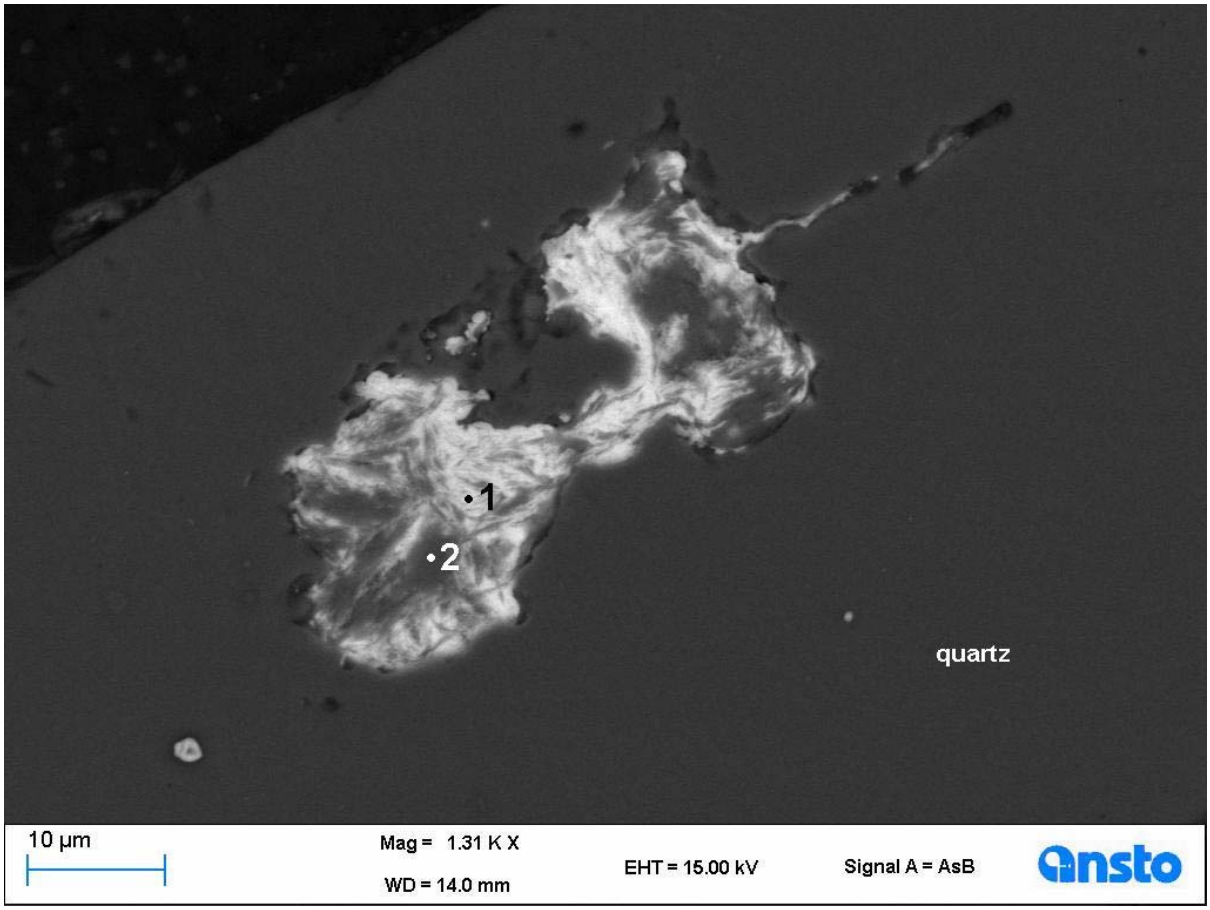
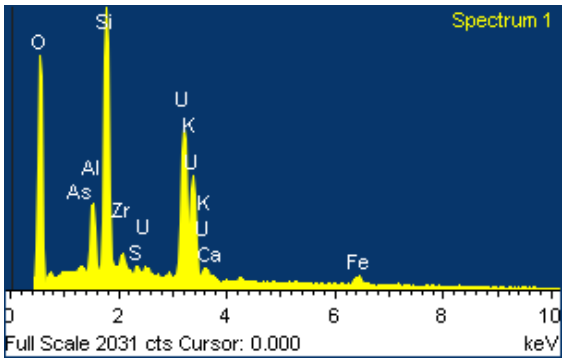


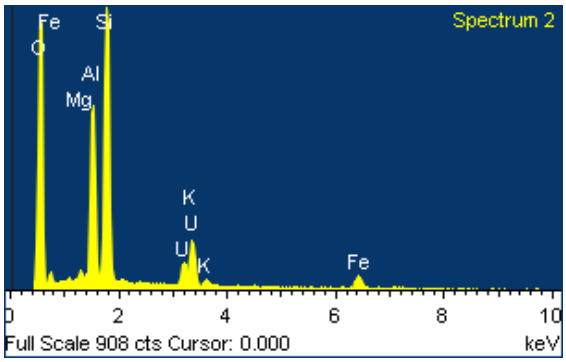
FIGURE A10 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A10 – (b)





S1 – coffinite (X-rays from illite)

S2 – illite (X-rays from coffinite)

FIGURE A11 JUNNAGUNNA - RESIDUE (LC 3A): (a) BSE micrograph illustrating coffinite intergrown with rutile/anatase hosted by quartz; (b) magnified view of coffinite intergrown with rutile/anatase. Coffinite contains small amounts of yttrium and lead.

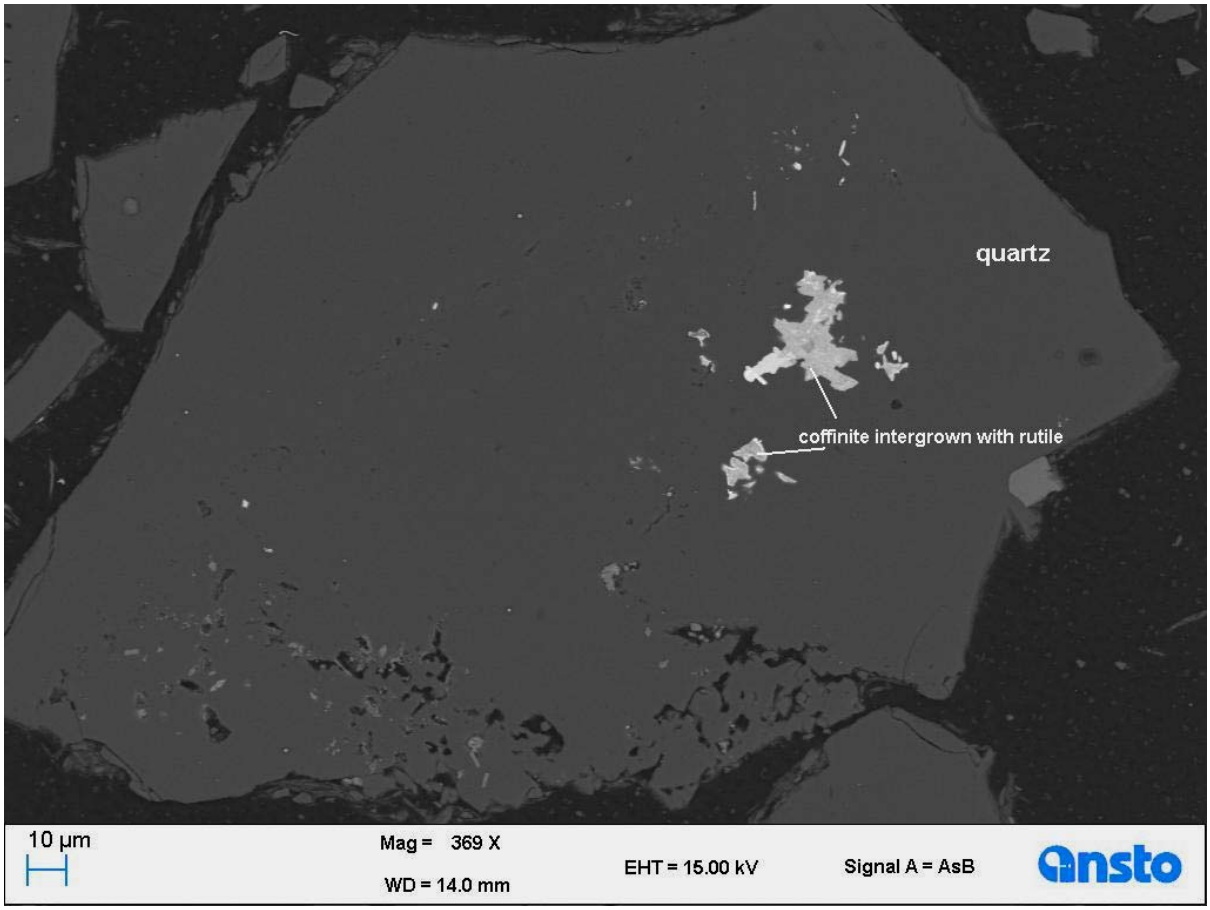
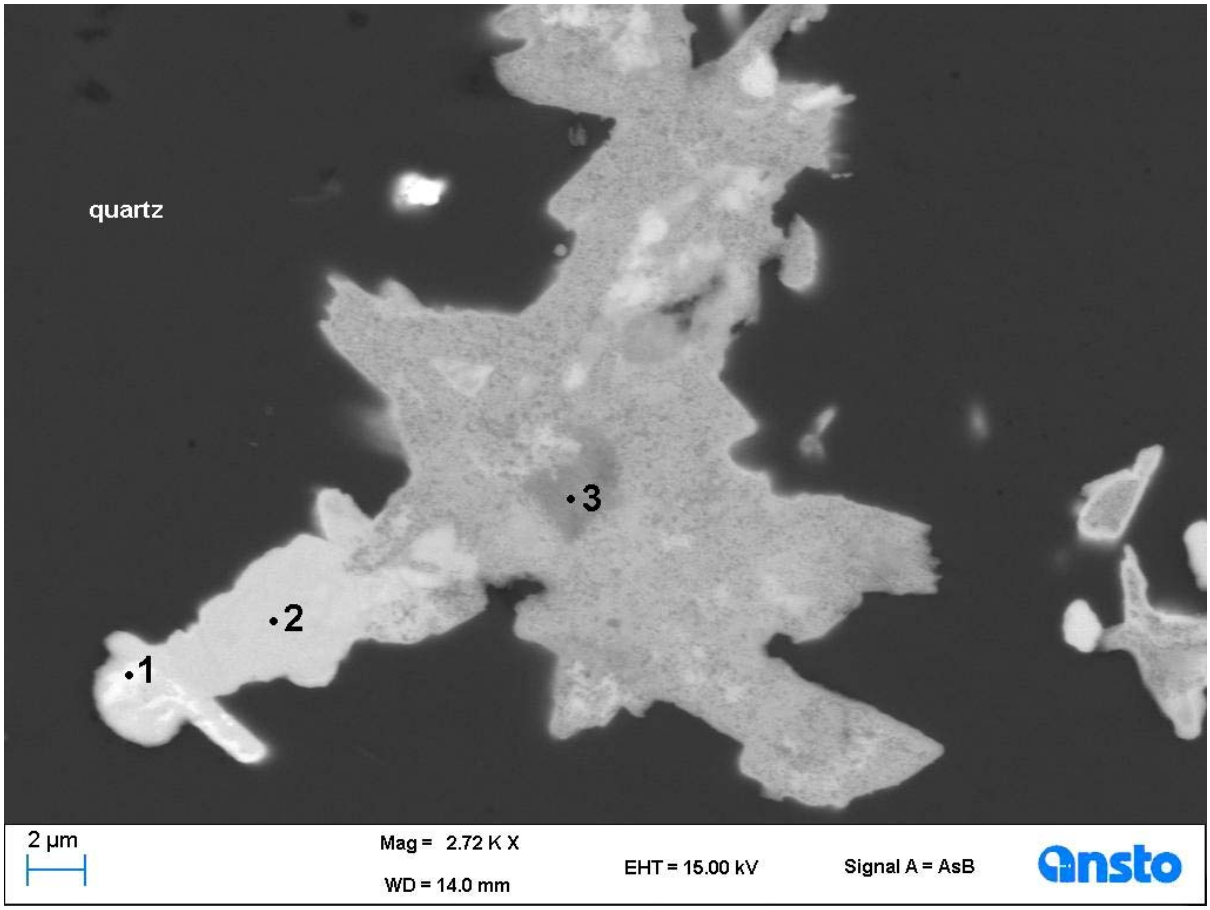
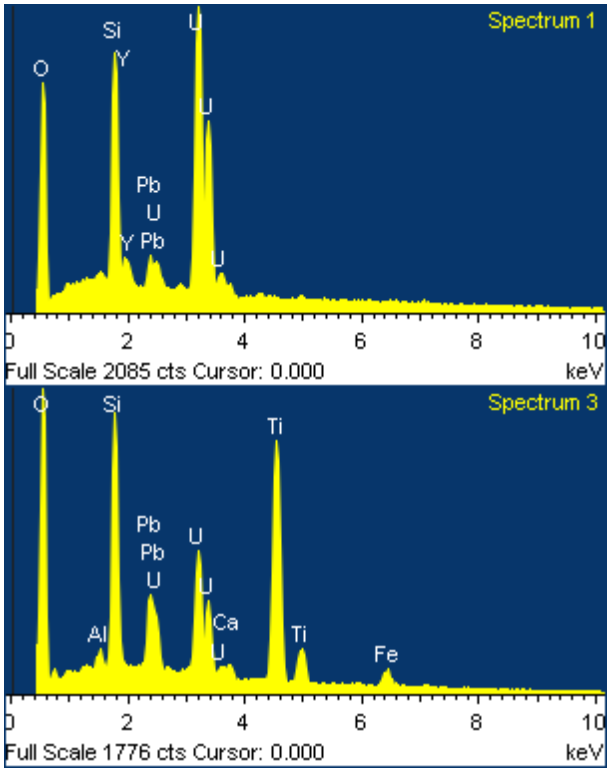


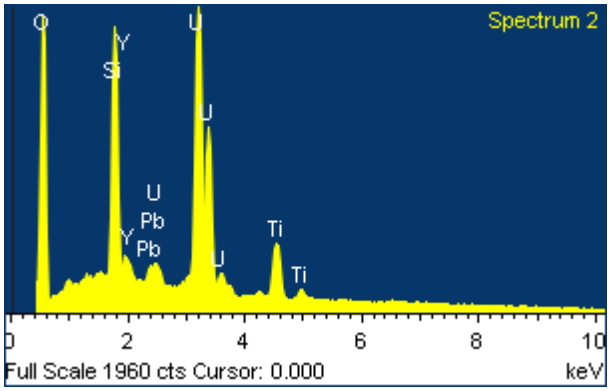
FIGURE A11 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A11 – (b)



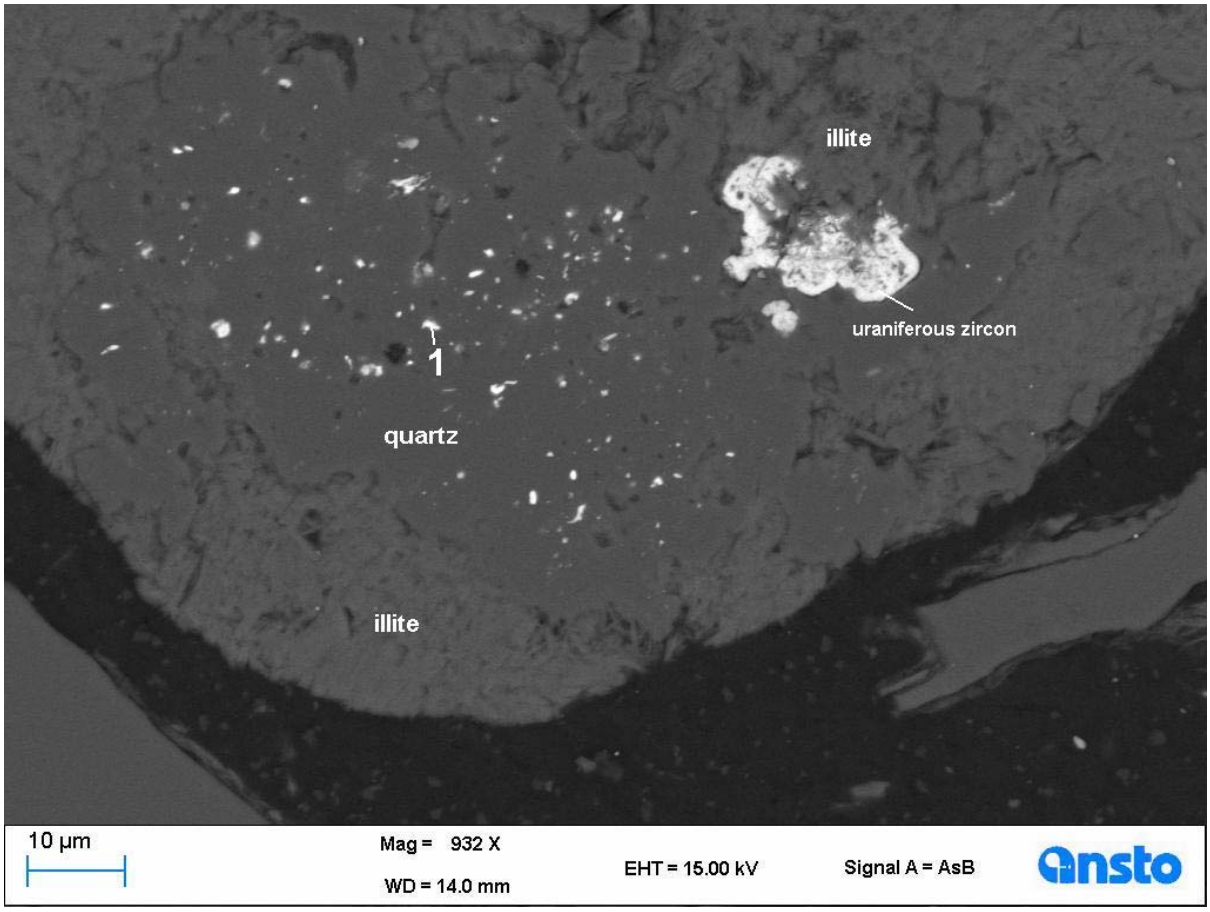


S1 – coffinite

S2 – coffinite intergrown with rutile/anatase

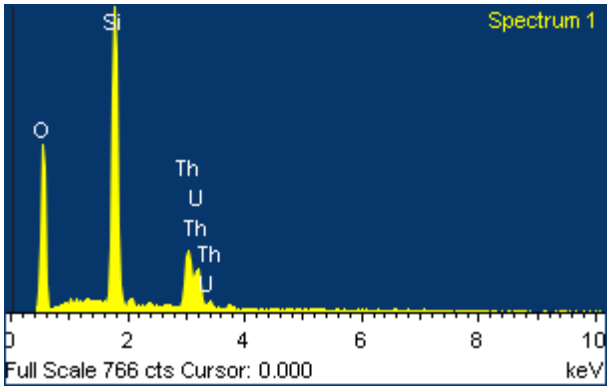
S3 – coffinite intergrown with rutile/anatase and chlorite?

FIGURE A12 JUNNAGUNNA - RESIDUE (LC 3A): (a) BSE micrograph illustrating uraniferous zircon interstitial to quartz and illite. The white bright grains dispersed throughout quartz is thorite; (b) the uraniferous zircon in more detail. Uranium is present either as impurity within the zircon crystal or as uraninite/pitchblende intimately intergrown with zircon.

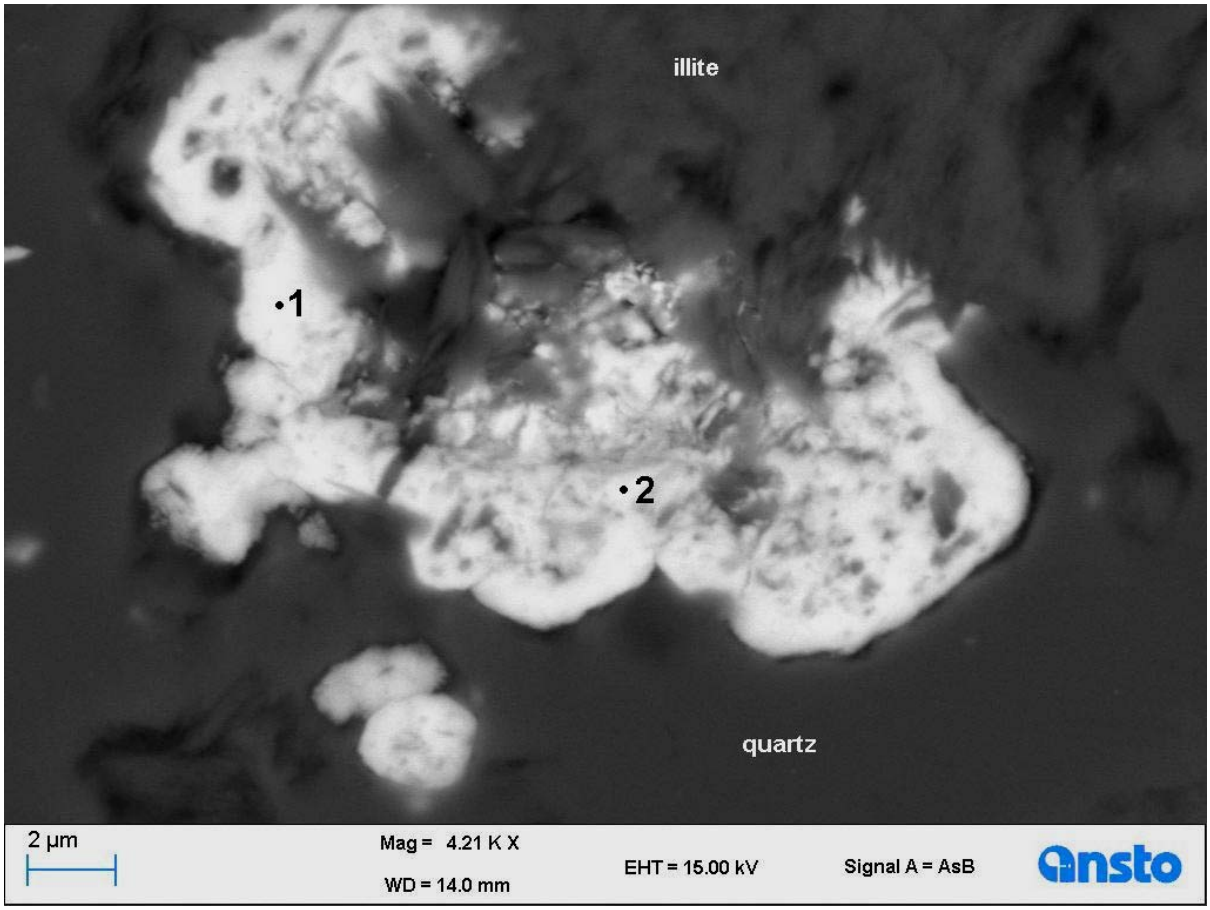


The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

FIGURE A12 – (a)

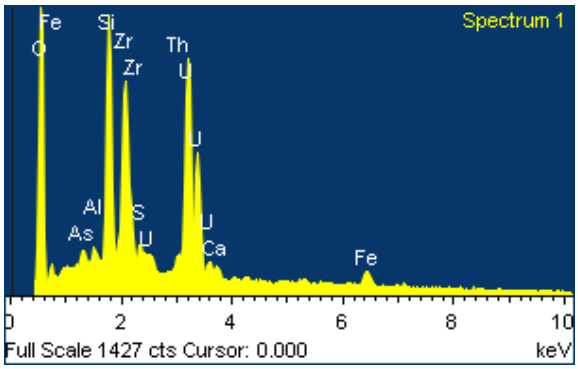


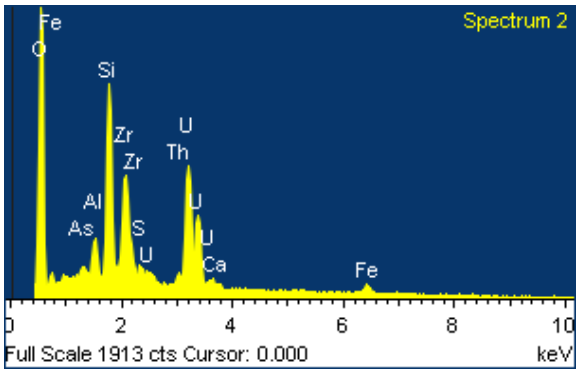
S1 – thorite



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A12 – (b)

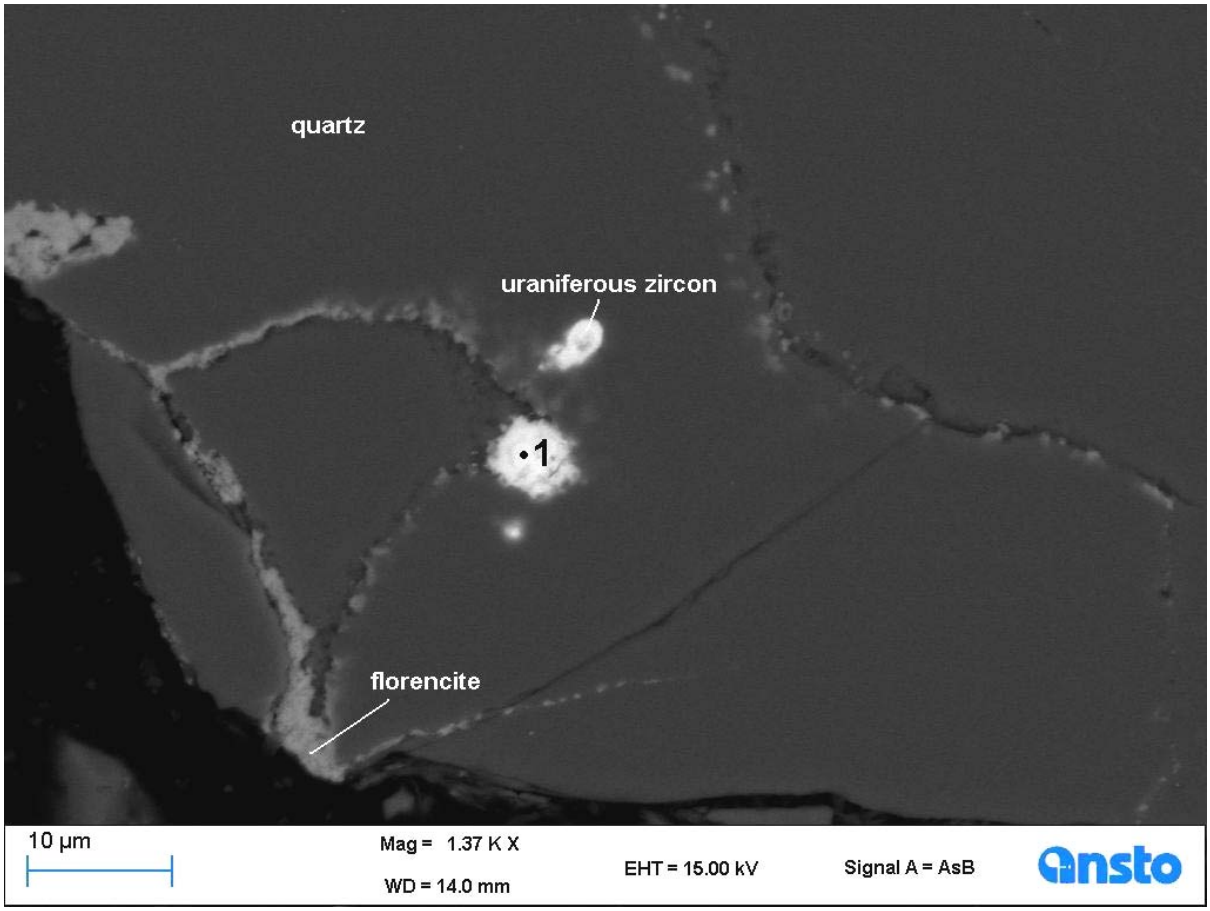




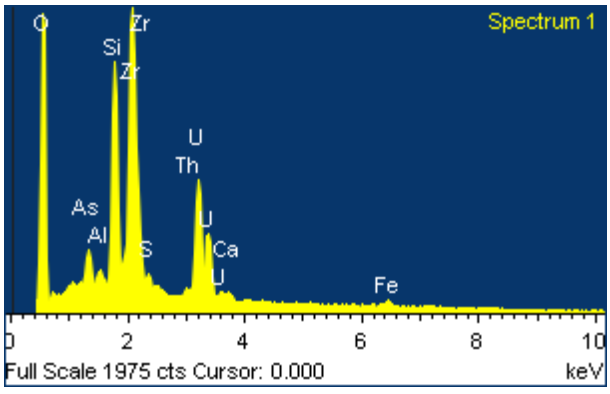
S1 – uraniferous zircon

S2 – uraniferous zircon (X-rays from illite)

FIGURE A13 JUNNAGUNNA - RESIDUE (LC 3A): BSE micrograph illustrating inclusions of uraniferous zircon and florencite veins within quartz. Uranium is present either as impurity within the zircon crystal or as uraninite/pitchblende intimately intergrown with zircon. The concentration of uranium is high (26wt.%).

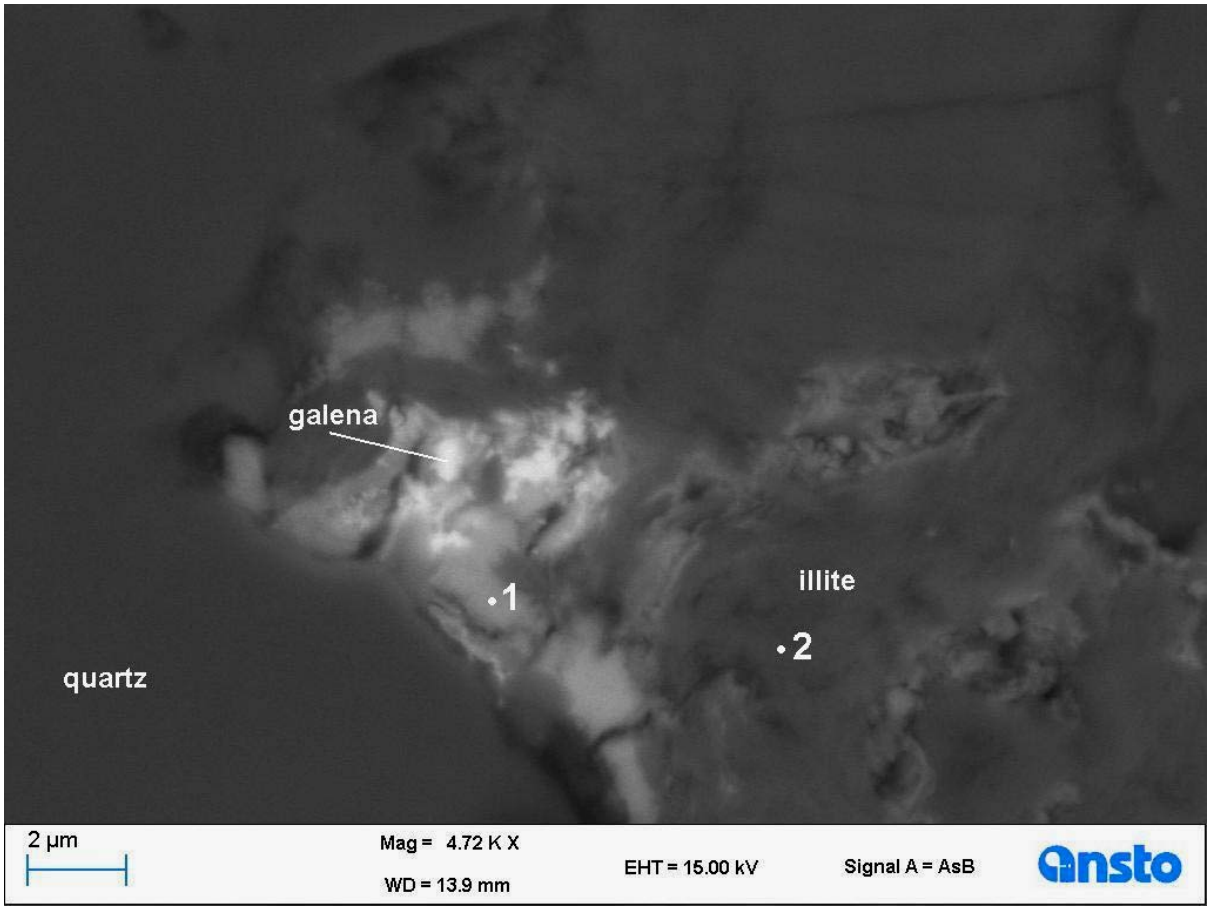


The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

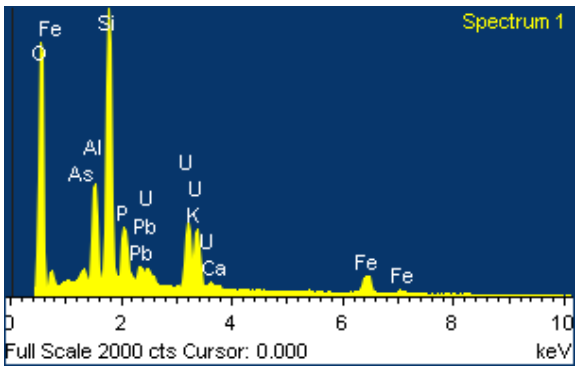


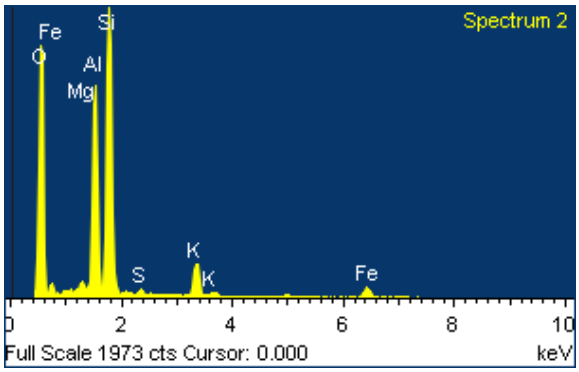
S1 – uraniferous zircon

FIGURE A4 JUNNAGUNNA - RESIDUE (LC 3A): BSE micrograph showing uranium phosphate hosted by illite within a quartz particle. The composition of the uranium phosphate is indicative of phosphuranylite. Low levels of arsenic were detected in the uranium phosphate.



The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.





S1 – uranium phosphate (X-rays from illite and quartz)

S2 – illite

FIGURE A15 GAREE (REDTREE) COMPOSITE - RESIDUE (LC 3 B): (a) BSE micrograph illustrating uraninite/pitchblende inclusions within quartz; (b) the uraninite/pitchblende inclusions in more detail. Uraninite/pitchblende contains high amounts of lead.

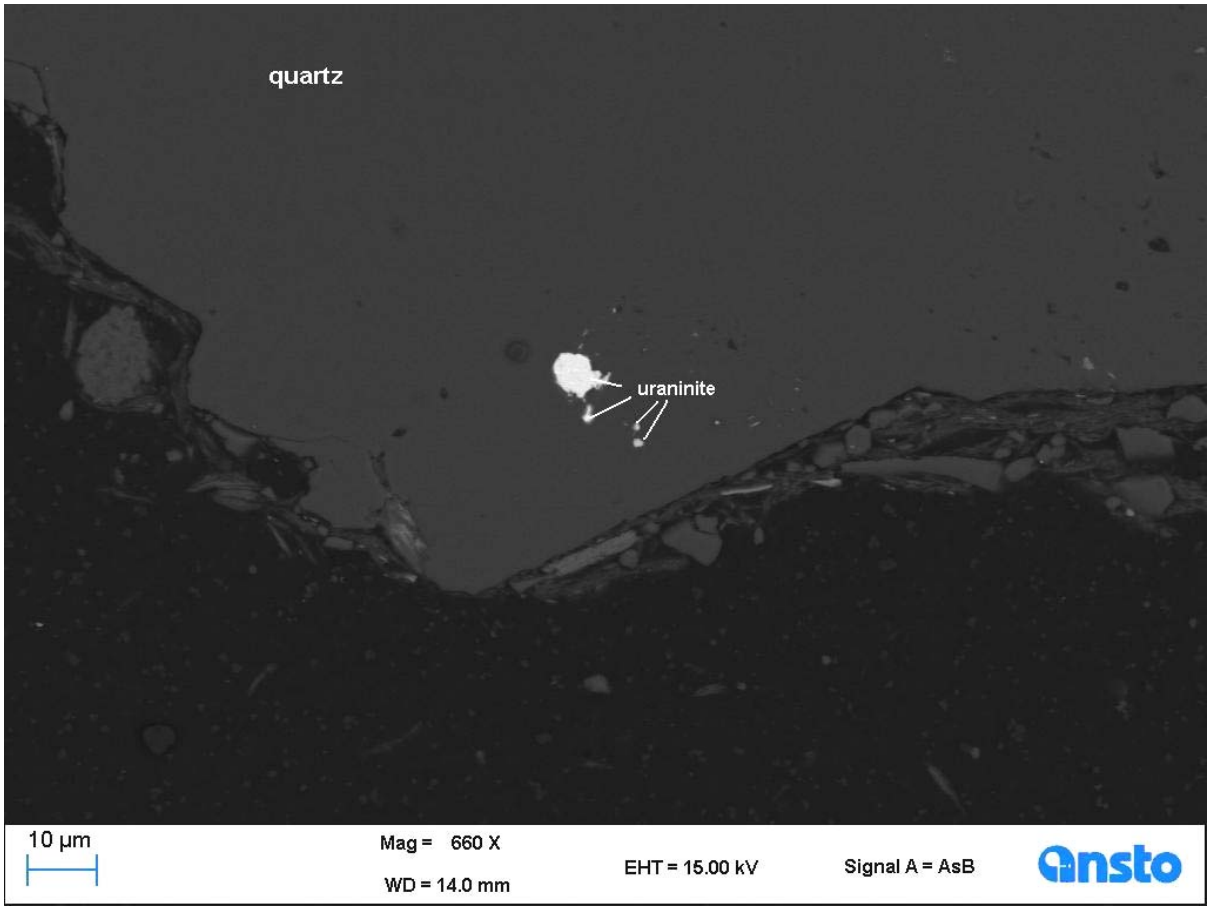
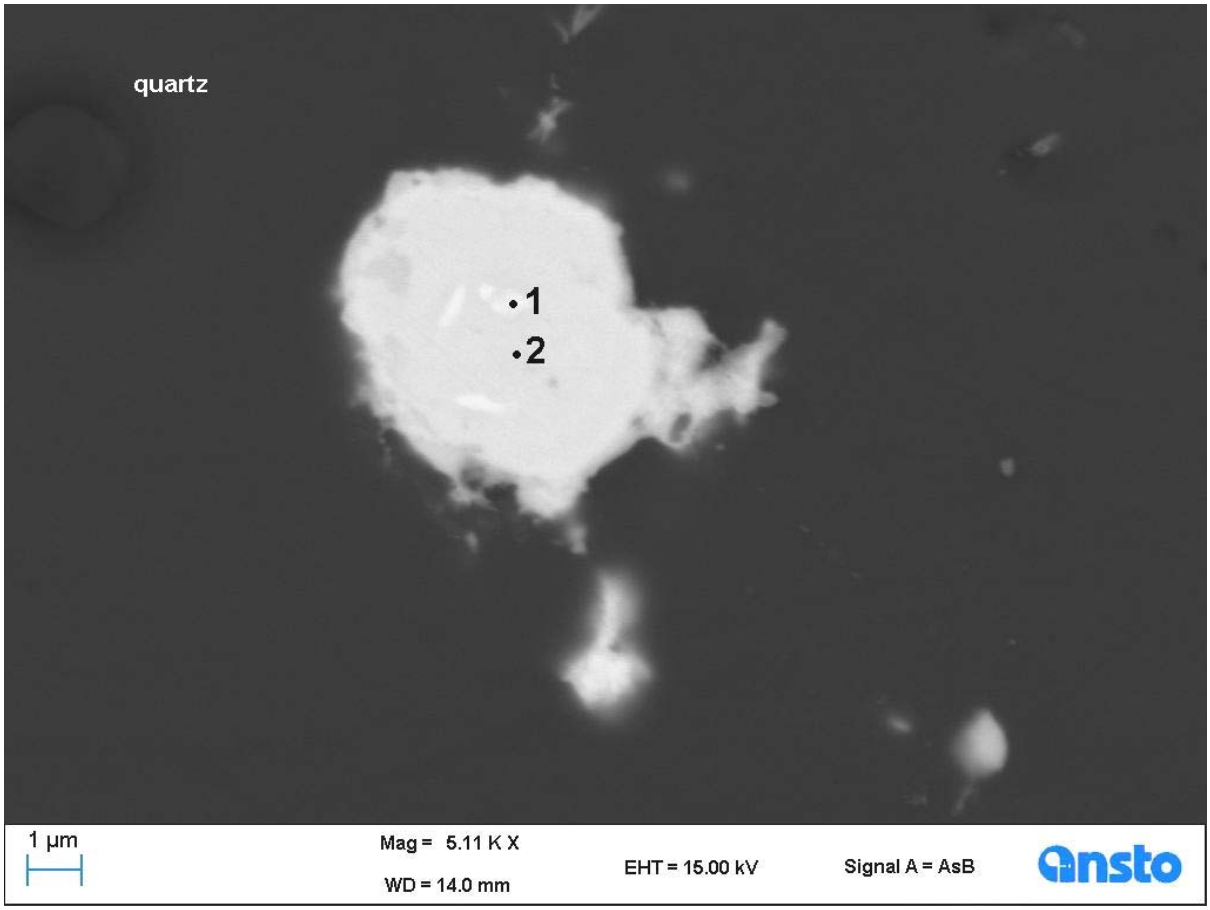
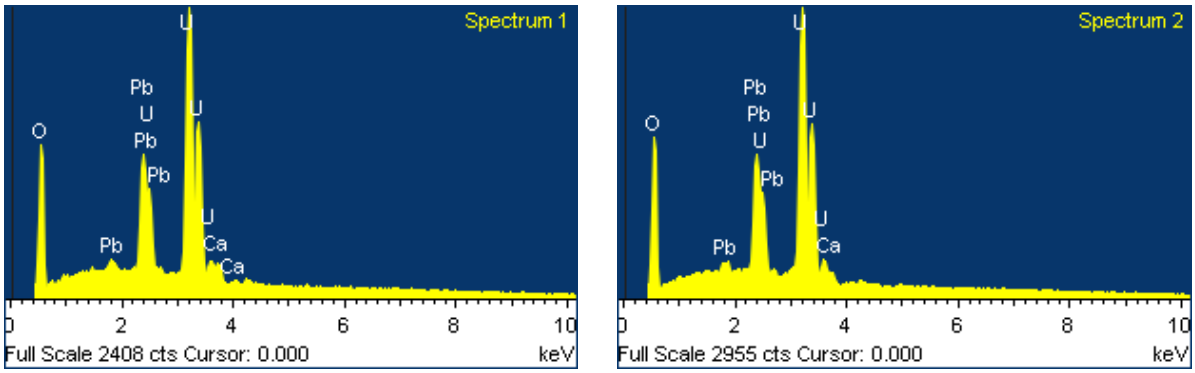


FIGURE A15 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A15 – (b)



S1and S2 – uraninite

FIGURE A16 GAREE (REDTREE) COMPOSITE - RESIDUE (LC 3 B): (a) BSE micrograph illustrating an altered uraninite/pitchblende grain hosted by quartz. Uraninite/pitchblende is completely surrounded by coffinite; (b) the altered uraninite/pitchblende grain in more detail. Lead was detected in both uraninite/pitchblende and coffinite.

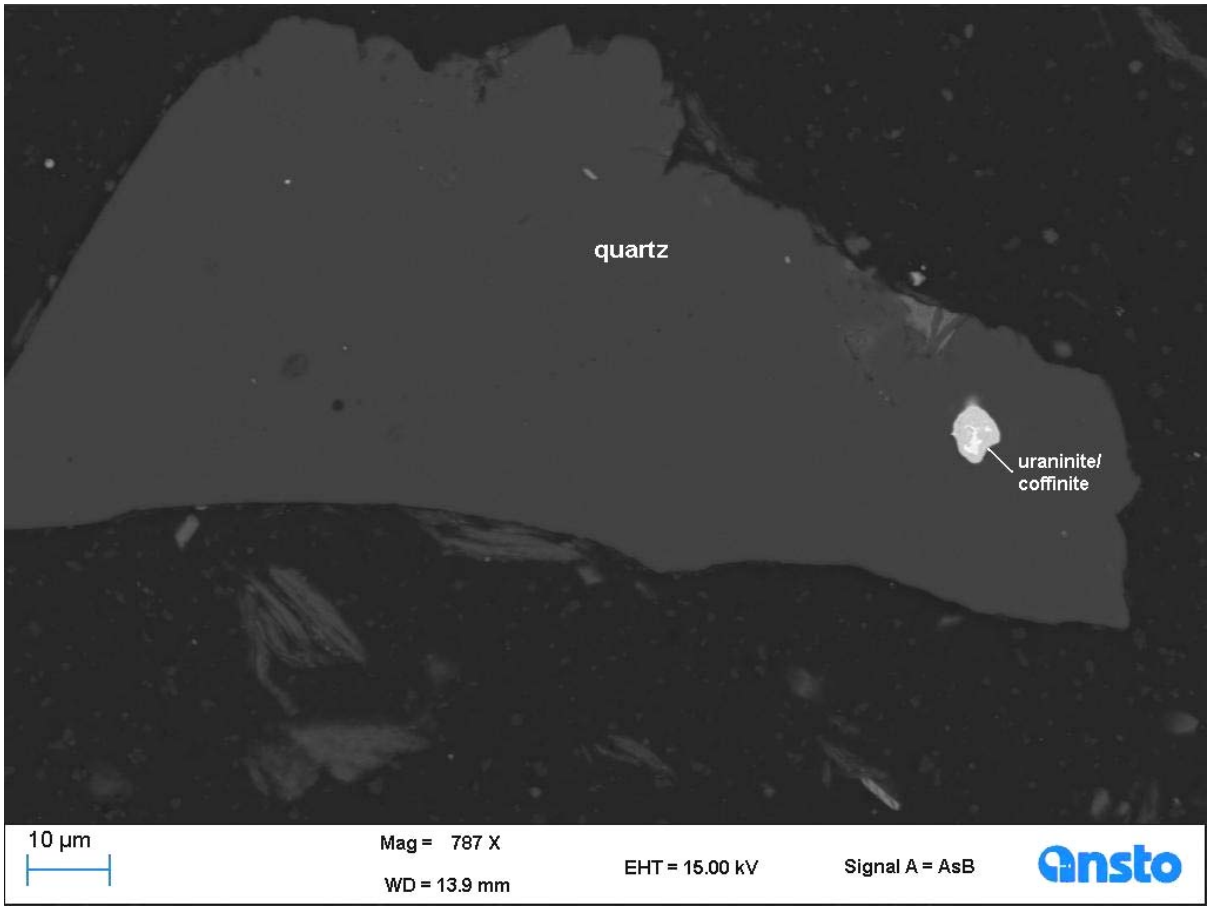
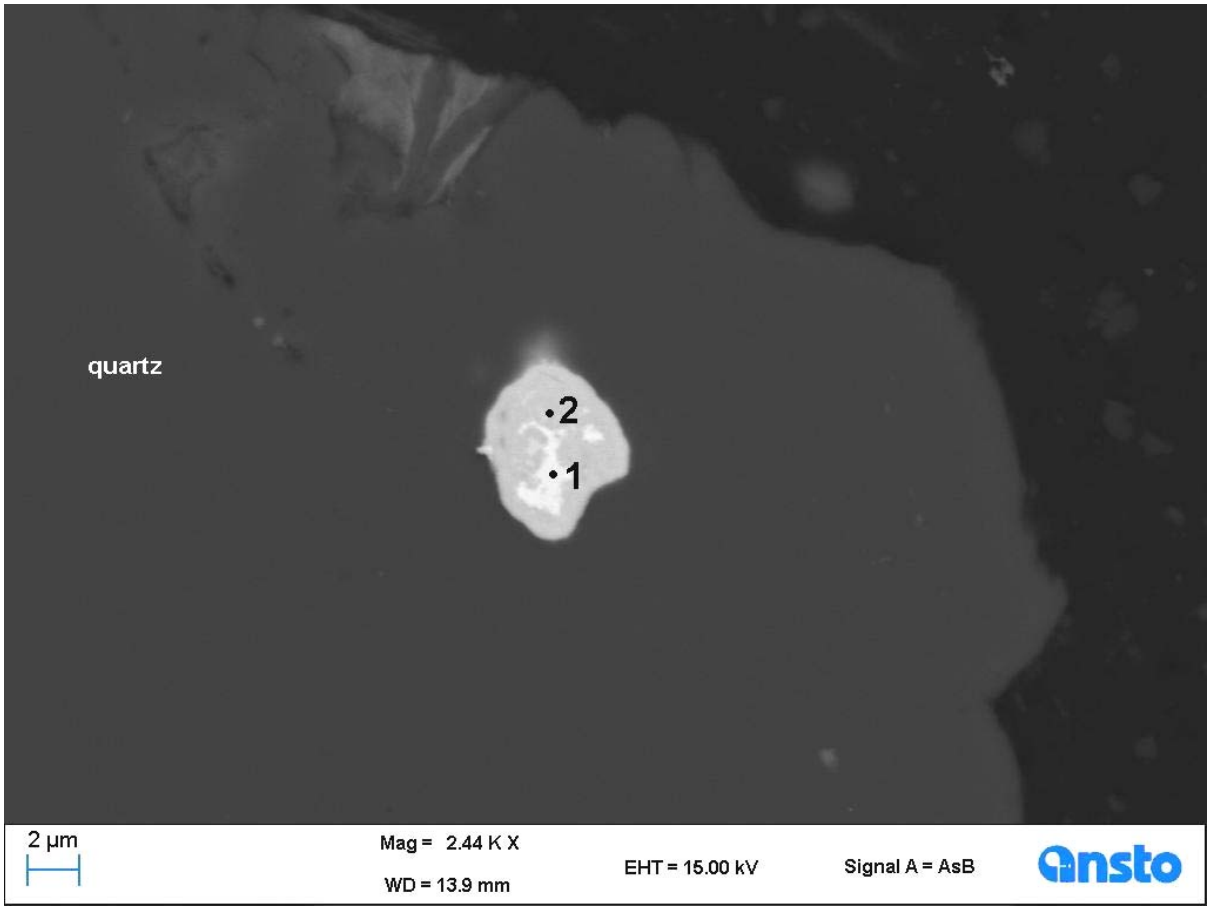
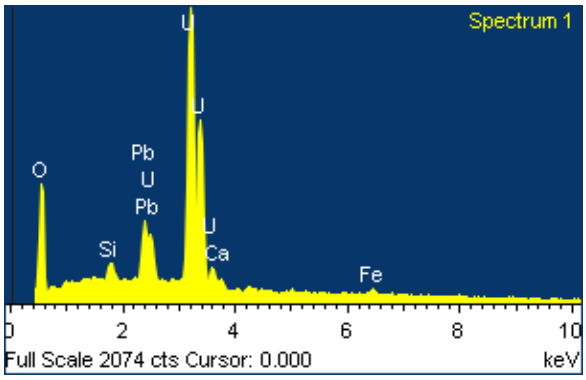


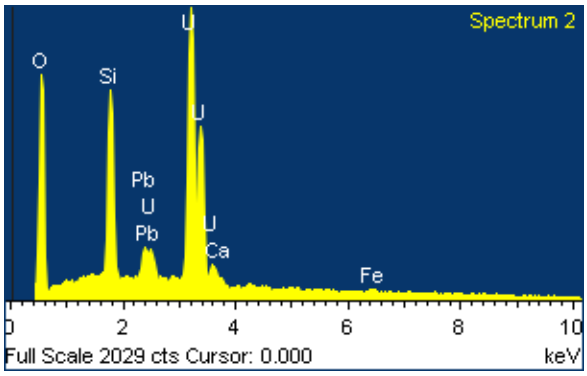
FIGURE A16 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A16 – (b)





S1 – uraninite

S2 – coffinite

FIGURE A17 GAREE (REDTREE) COMPOSITE - RESIDUE (LC 3 B): (a) BSE micrograph showing coffinite intergrown with rutile/anatase hosted by quartz; (b) magnified view of coffinite intergrown with rutile/anatase. Coffinite contains small amounts of lead.

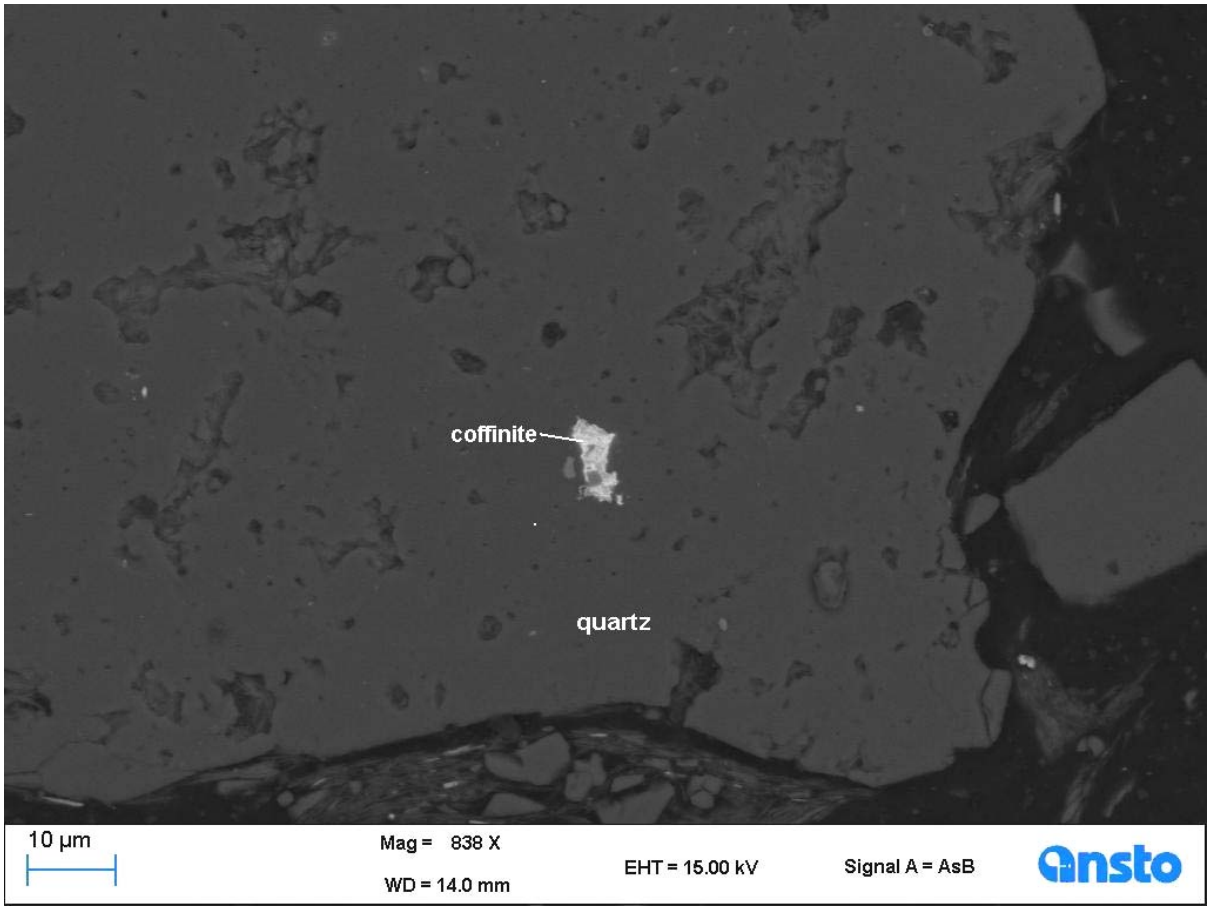
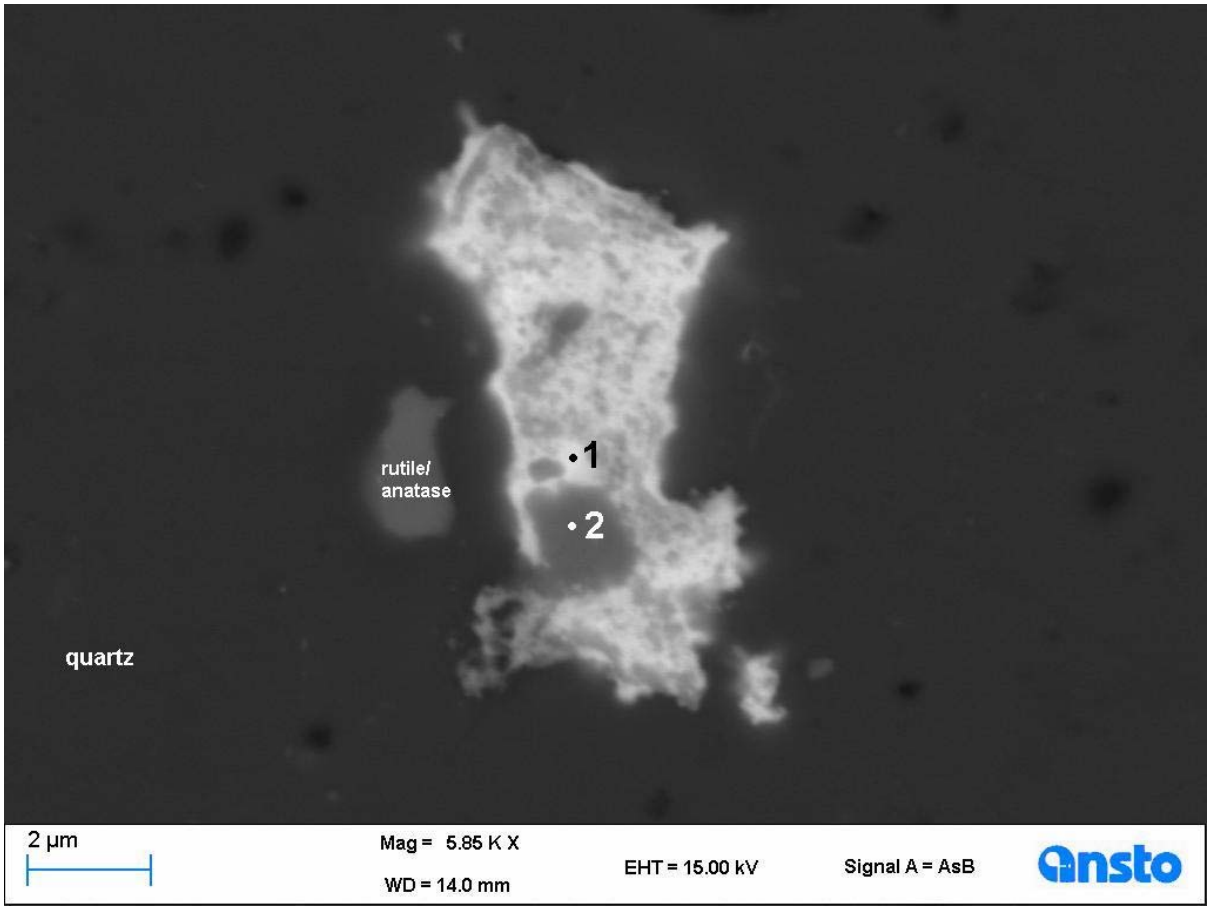
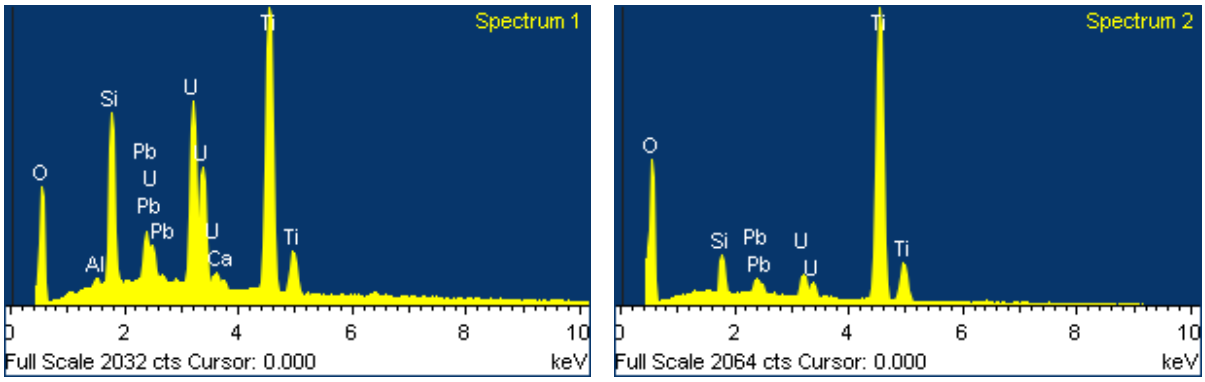


FIGURE A17 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A17 – (b)



S1 – coffinite (X-rays from rutile/anatase)

S2 – rutile/anatase (X-rays from coffinite)

FIGURE A18 GAREE (REDTREE) COMPOSITE - RESIDUE (LC 3 B): (a) BSE micrograph showing a uranium phosphate grain, most likely autunite, enclosed in quartz; (b) magnified view of the uranium phosphate grain. EDS data suggests that quartz may be finely intergrown with the uranium phosphate.

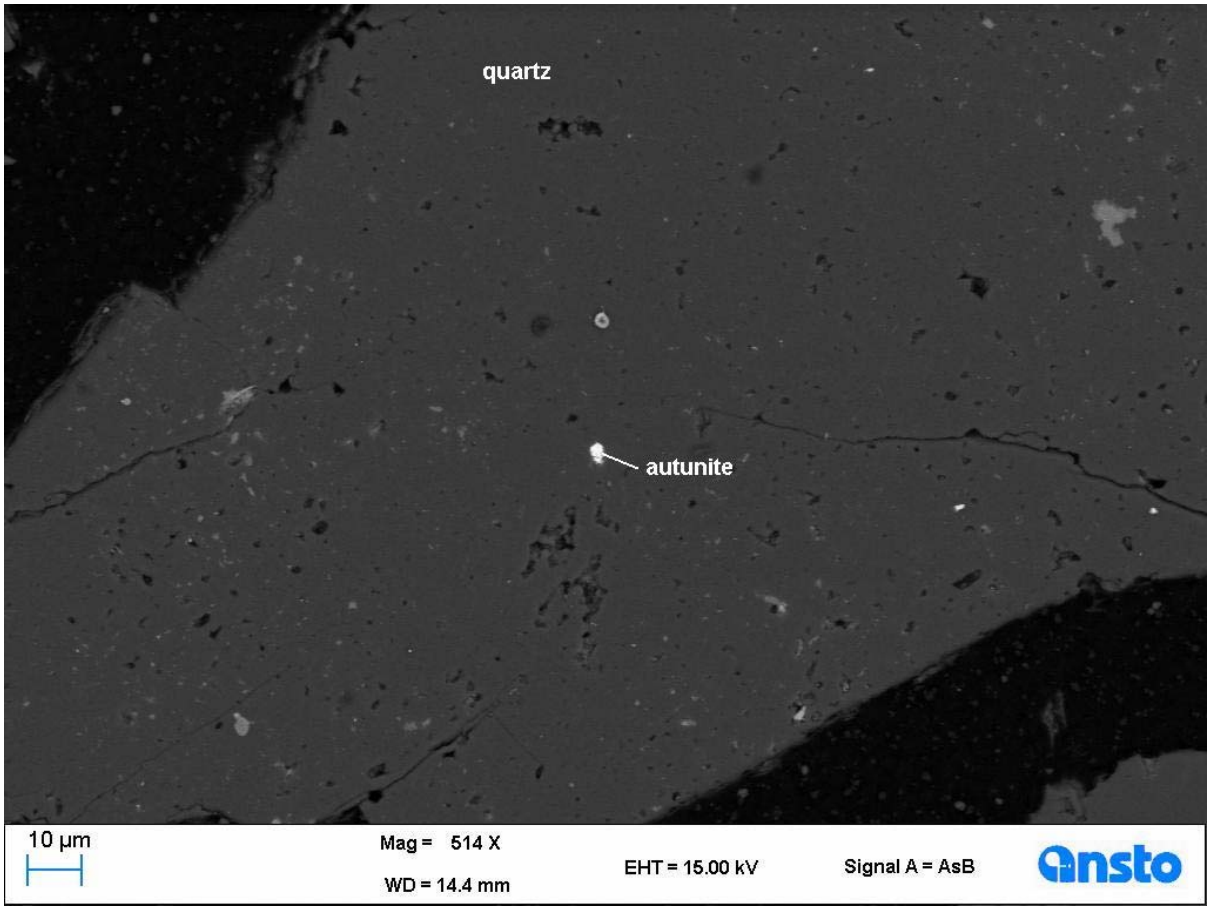
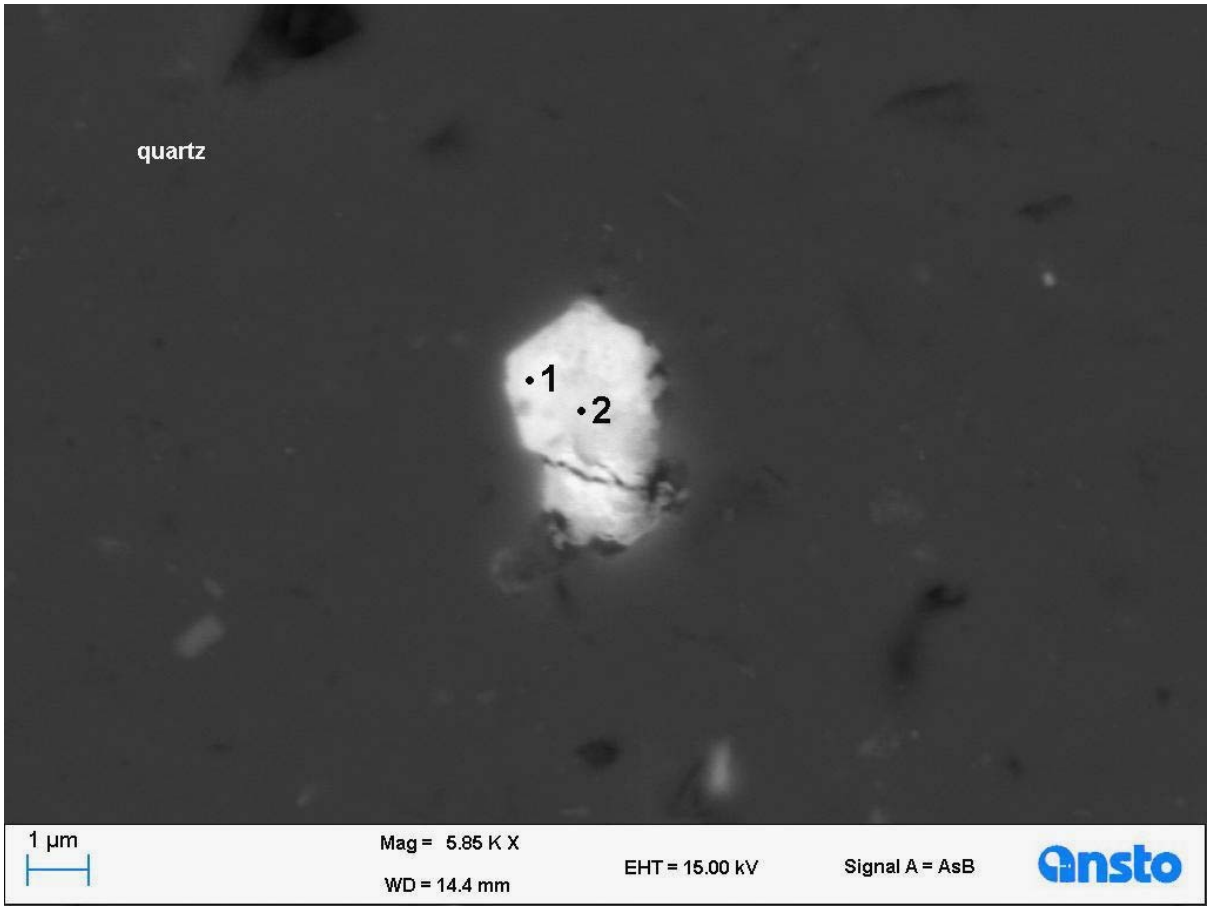
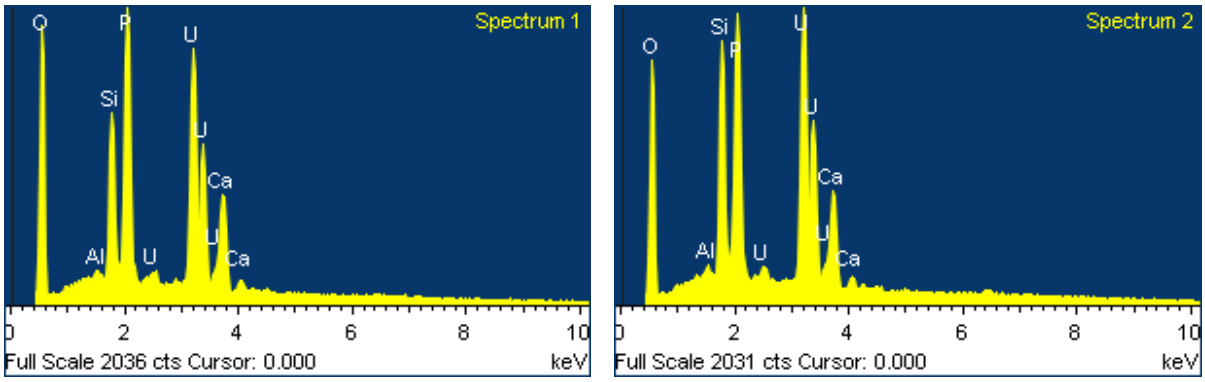


FIGURE A18 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A18 – (b)



S1and S2 – autunite (X-rays from adjacent quartz or/and finely intergrown quartz)

FIGURE A19 GAREE (REDTREE) COMPOSITE - RESIDUE (LC 3 B): (a) BSE micrograph showing uranium phosphate grains, with the composition indicative of autunite and phosphuranylite, hosted by quartz; (b) magnified view of the arsenic-rich phosphuranylite grain; (c) magnified view of the phosphuranylite grains. One of the phosphuranylite grains is intergrown with rutile/anatase.

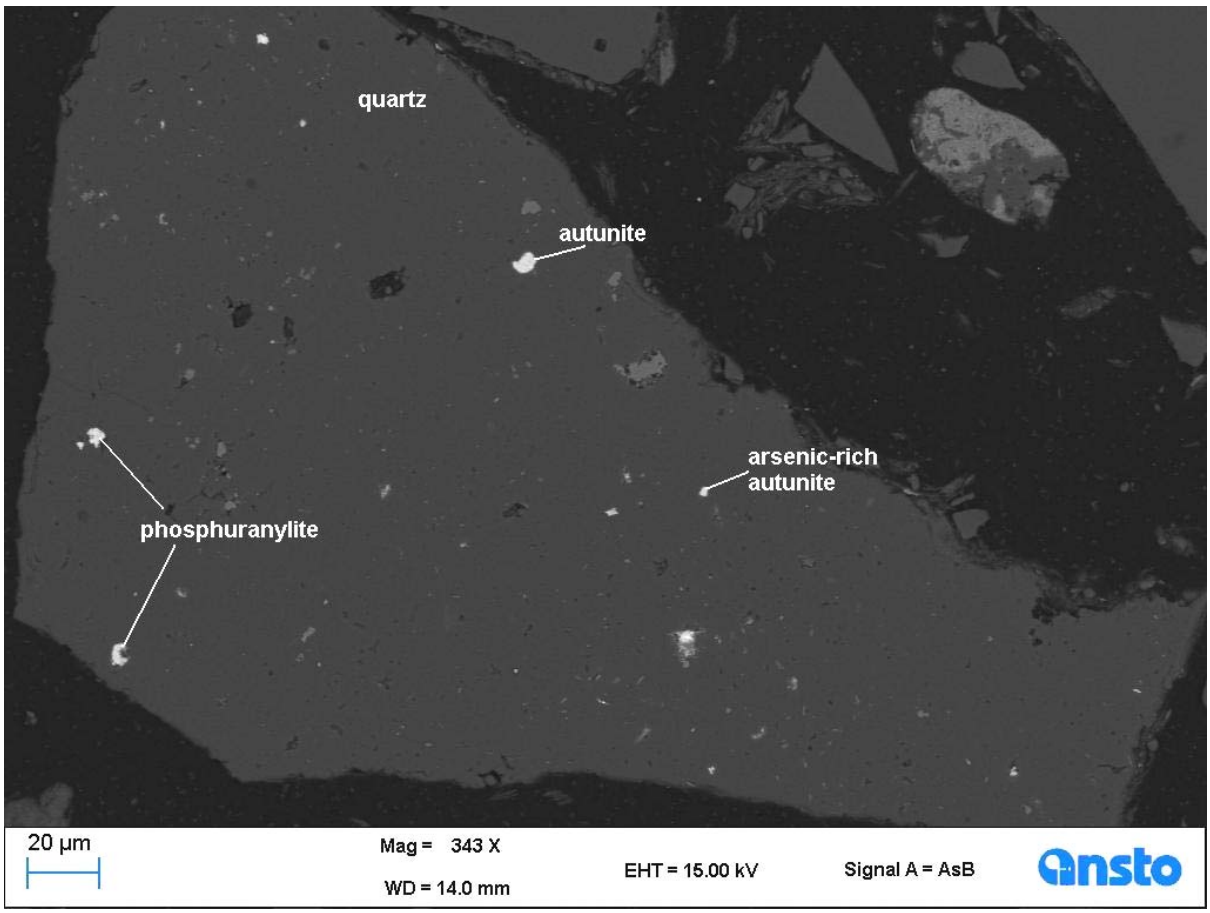
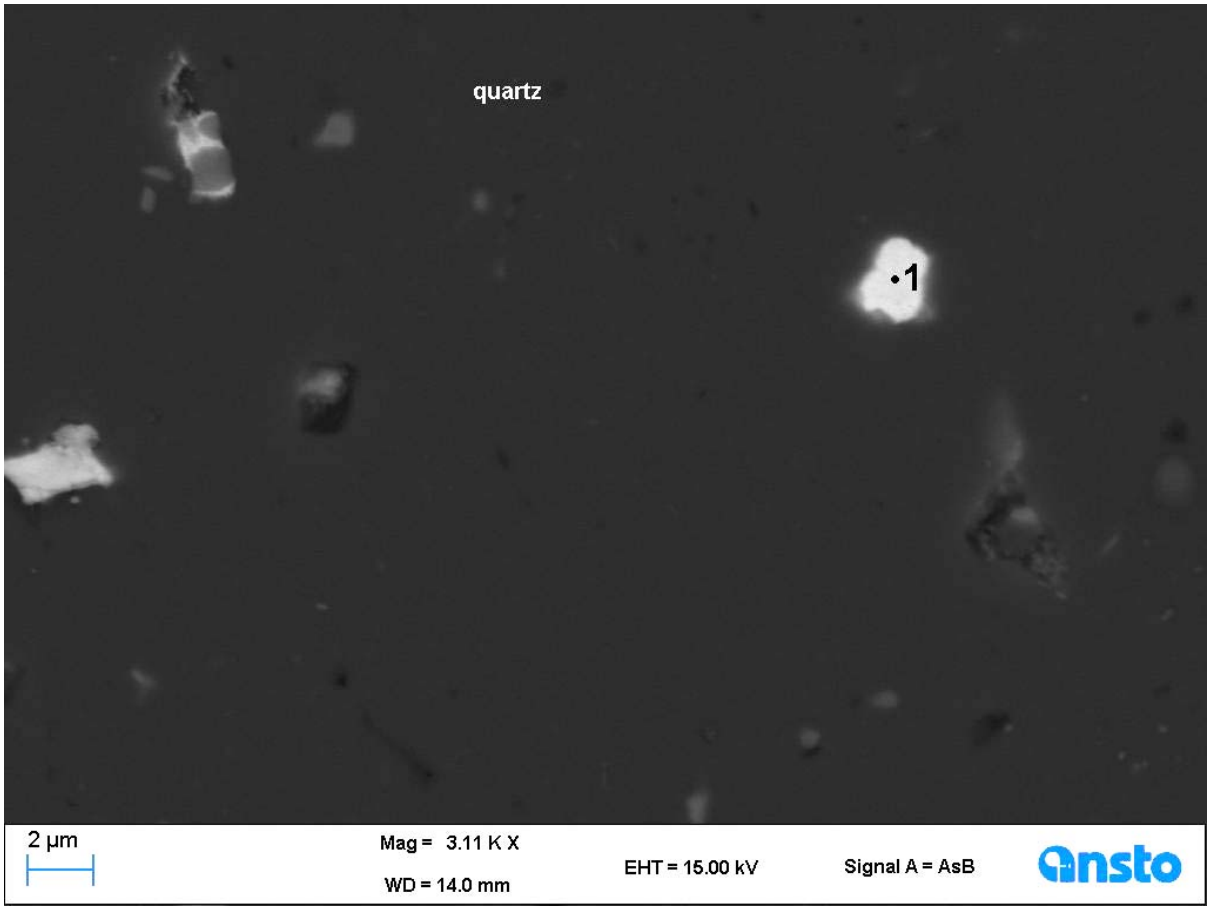
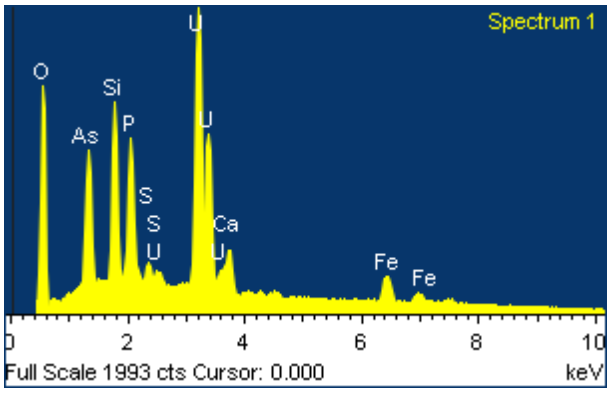


FIGURE A19 – (a)

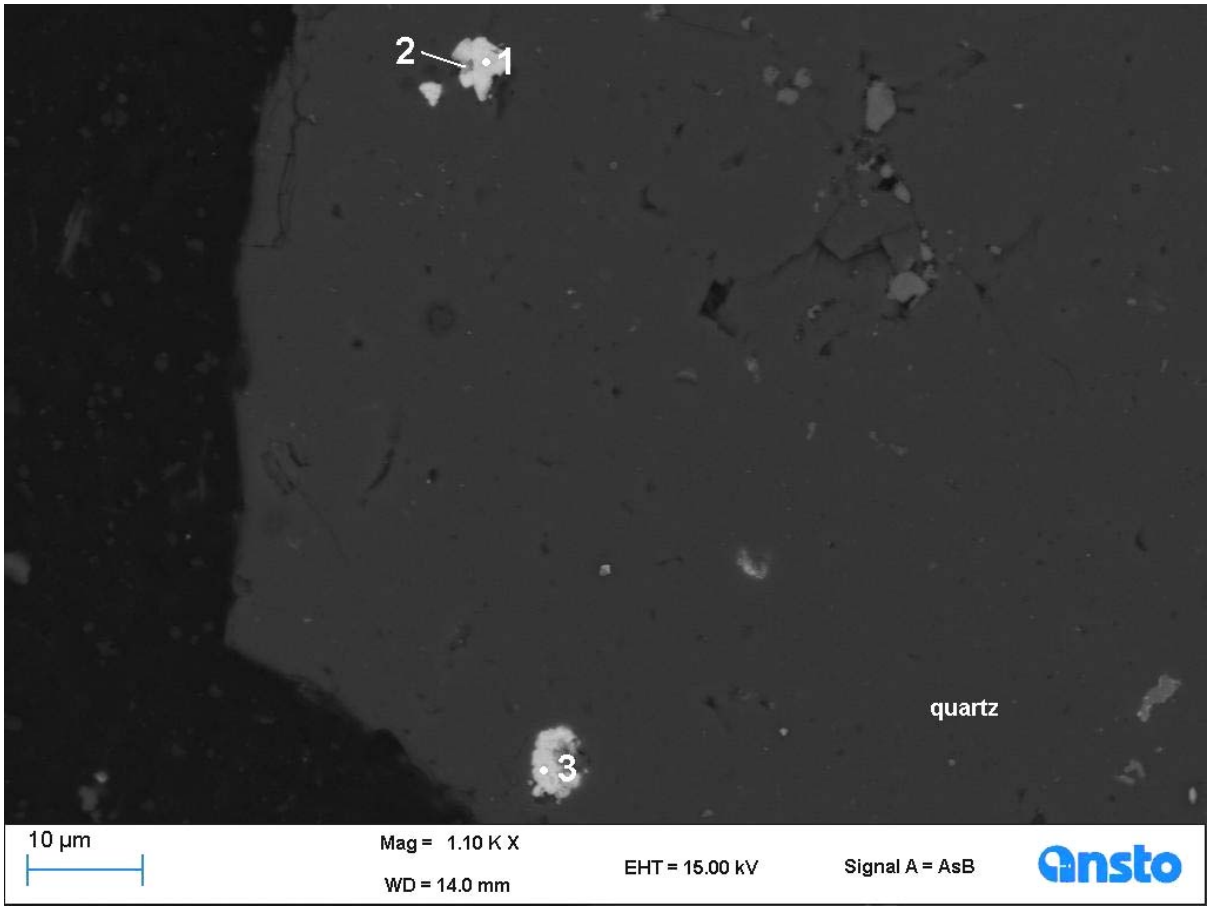


The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

FIGURE A19 – (b)

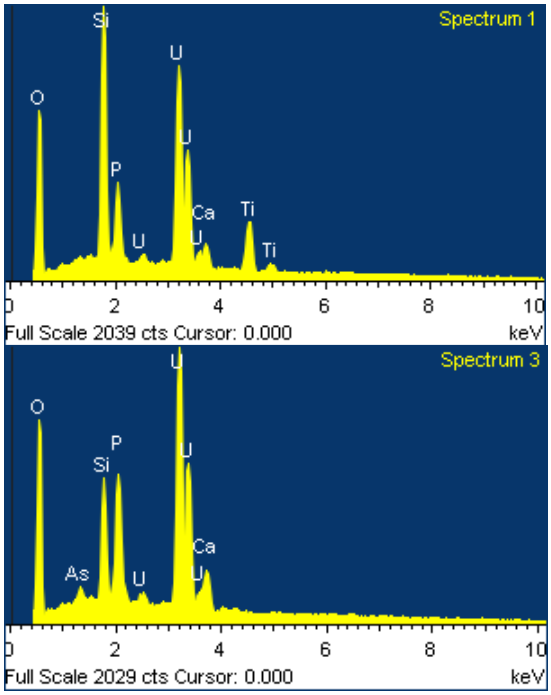


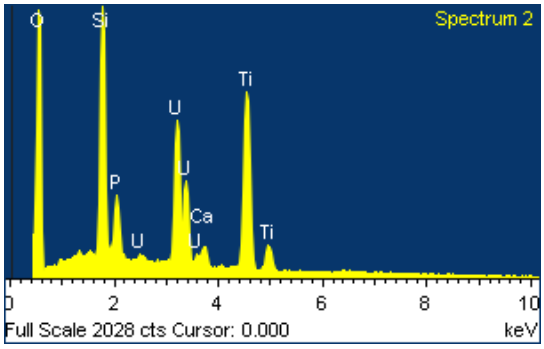
S1 – phosphuranylite (X-rays from adjacent quartz). As and Fe probably substitute P and Ca.



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

FIGURE A19 – (c)





S1 – uranium phosphate (X-rays from adjacent quartz and rutile/anatase)

S2 – rutile/anatase (X-rays from adjacent quartz and uranium phosphate)

S3 – uranium phosphate (X-rays from adjacent quartz)

FIGURE A20 GAREE (REDTREE) COMPOSITE - RESIDUE (LC 3 B): (a) BSE micrograph showing coffinite surrounding rutile/anatase, partially enclosed by quartz. The coffinite has high zirconium content; (b) magnified view of the coffinite-rutile composite grain aggregates. The dissolution of coffinite is not visible.

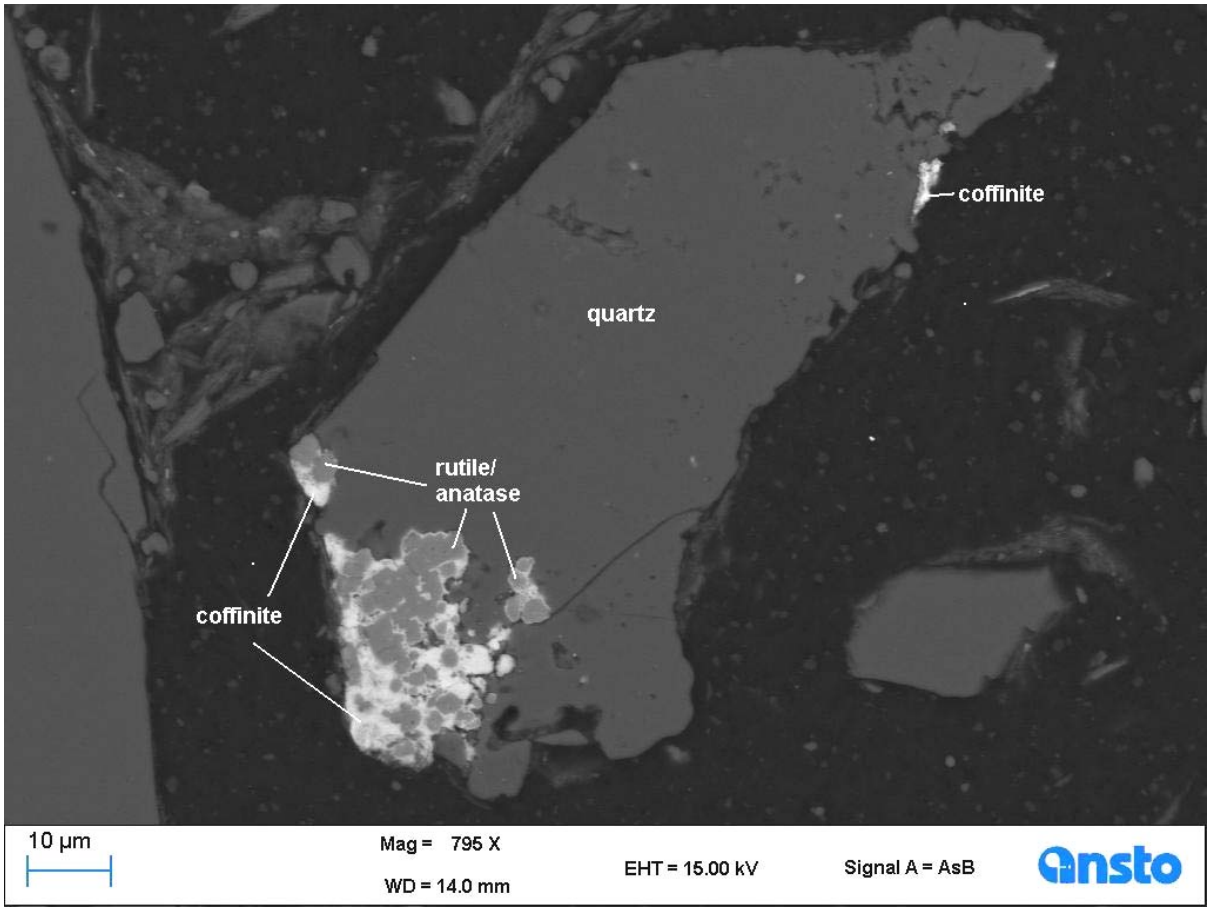
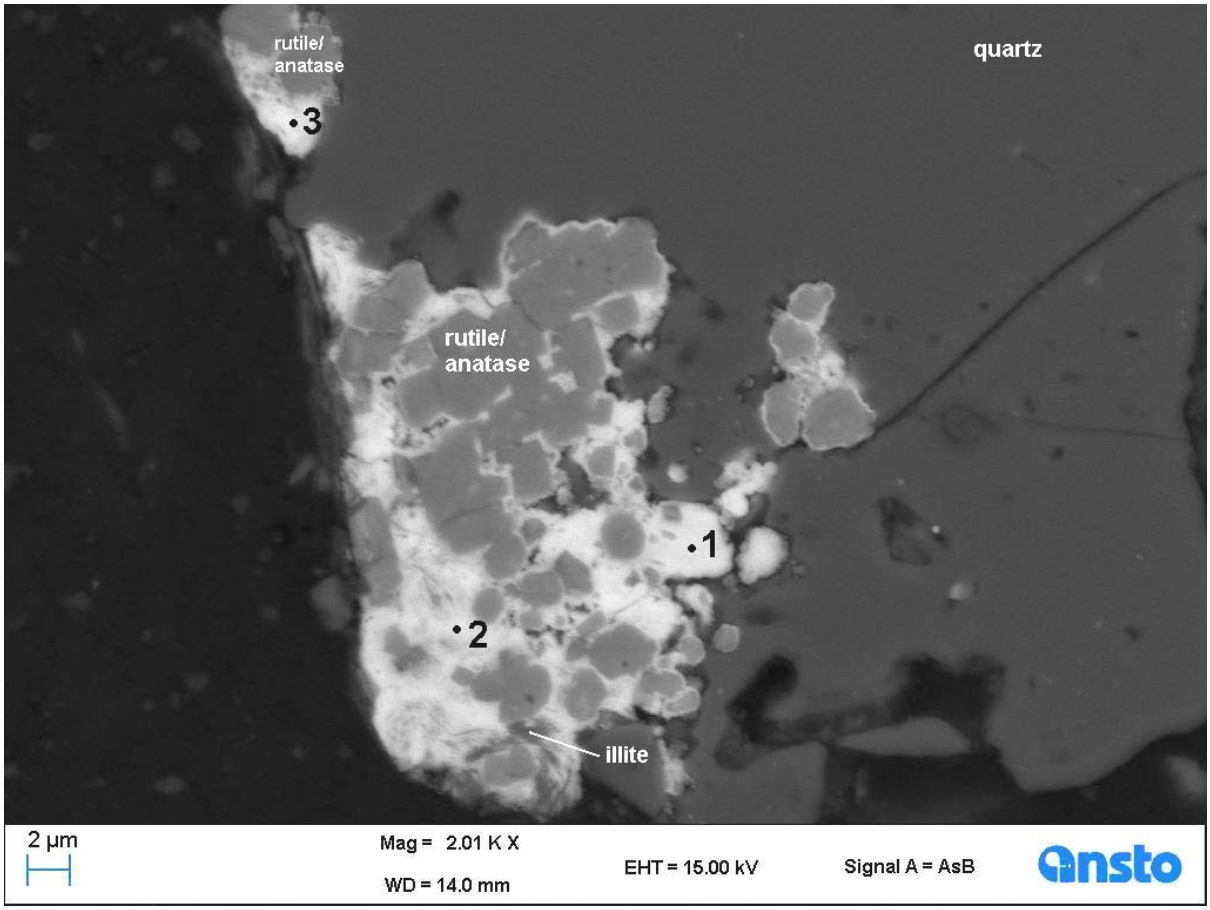
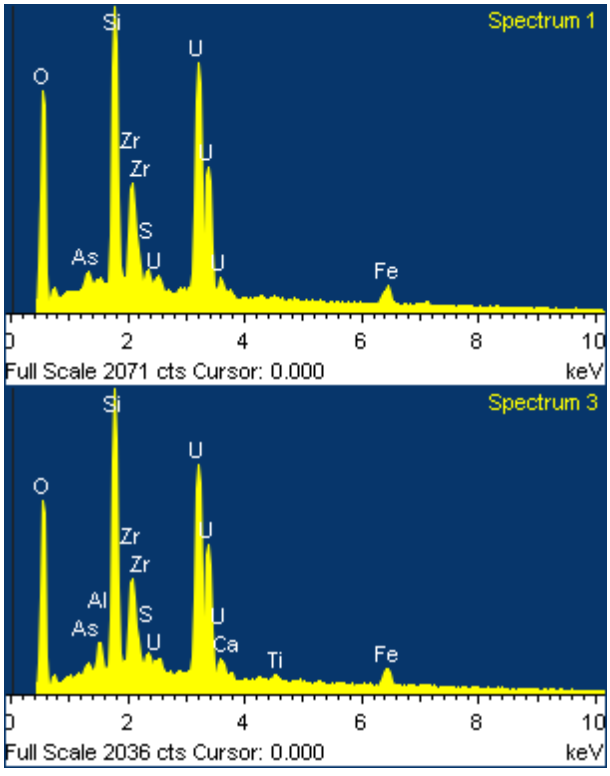


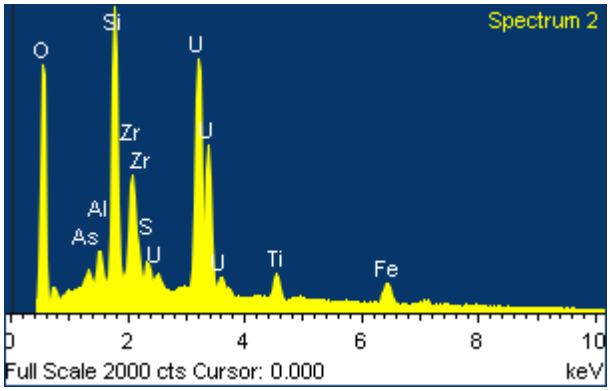
FIGURE A20 – (a)



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

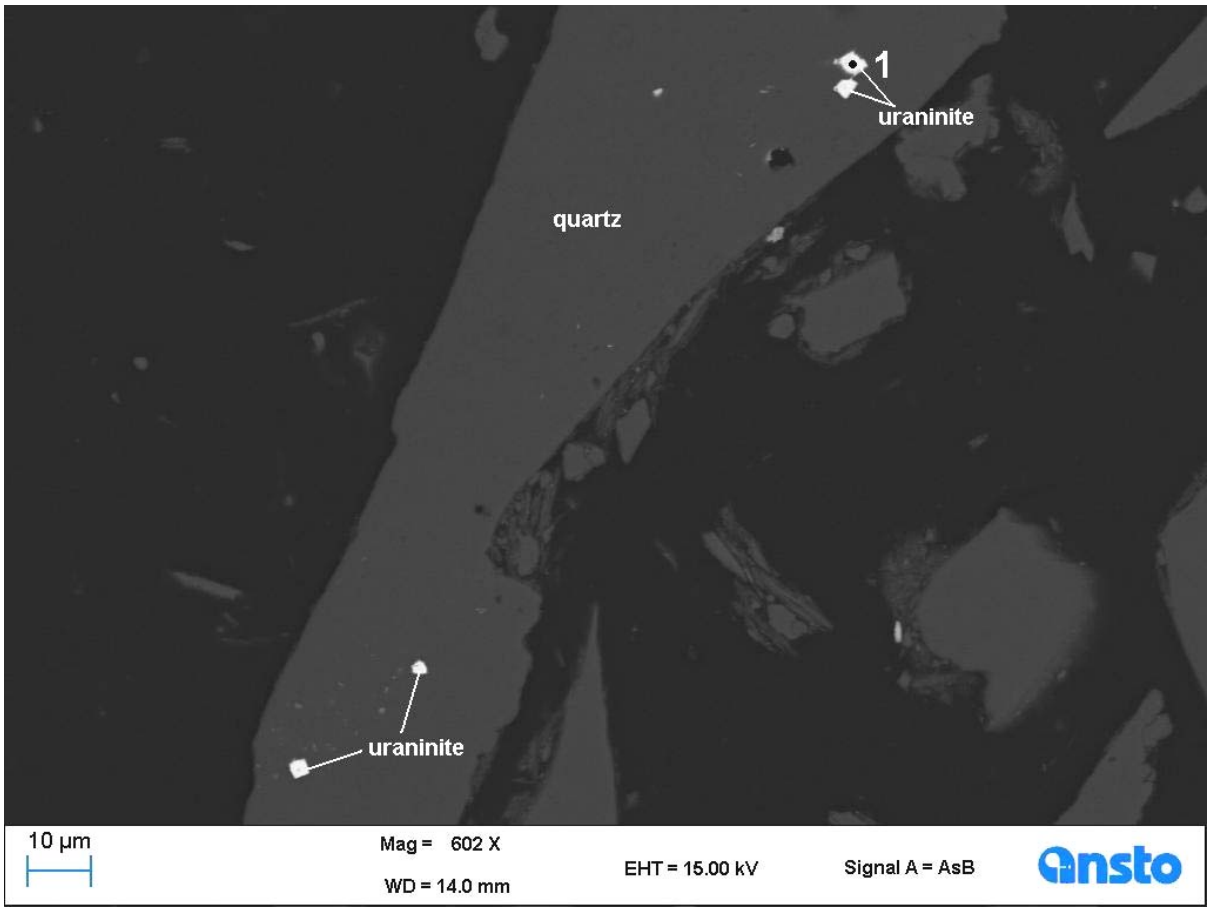
FIGURE A20 – (b)



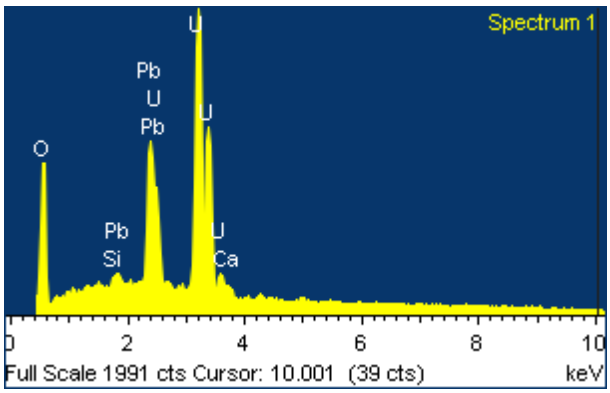


S1, S2 and S3 – zirconium-rich coffinite (X-rays from adjacent rutile/anatase)

FIGURE A21 ***JACK - RESIDUE (LC 12 C)*: BSE micrograph illustrating uraninite/pitchblende inclusions within quartz. Uraninite/pitchblende contains high amounts of lead.**



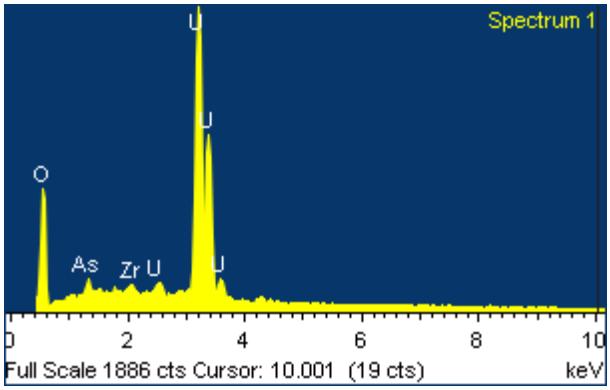
The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.



S1 – uraninite/pitchblende

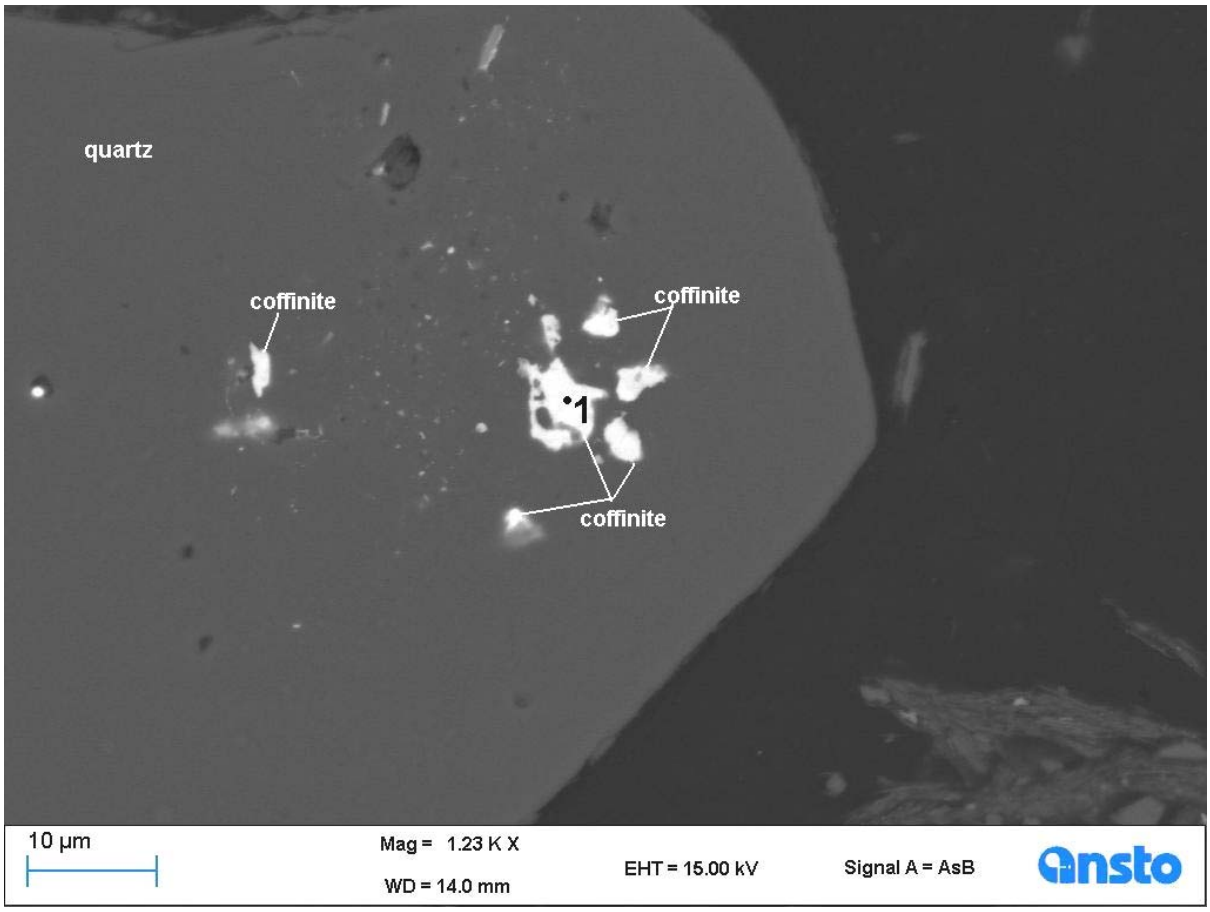
FIGURE A22 ***JACK - RESIDUE (LC 12 C)*: BSE micrograph illustrating partly dissolved uraninite/pitchblende enclosed by quartz. The partially dissolution of uraninite/pitchblende grain is indicated by small pits developed throughout the grain and the open space along grain boundary with quartz. Uraninite/pitchblende contains small amounts of arsenic and zircon.**

The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

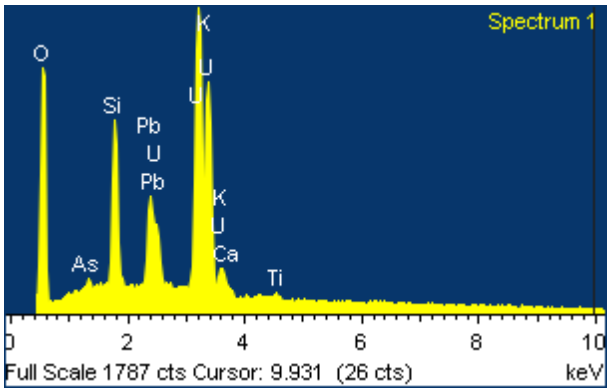


S1 – uraninite/pitchblende

FIGURE A23 ***JACK - RESIDUE (LC 12 C)*: BSE micrograph showing coffinite inclusions in quartz. Coffinite contains high amounts of lead.**

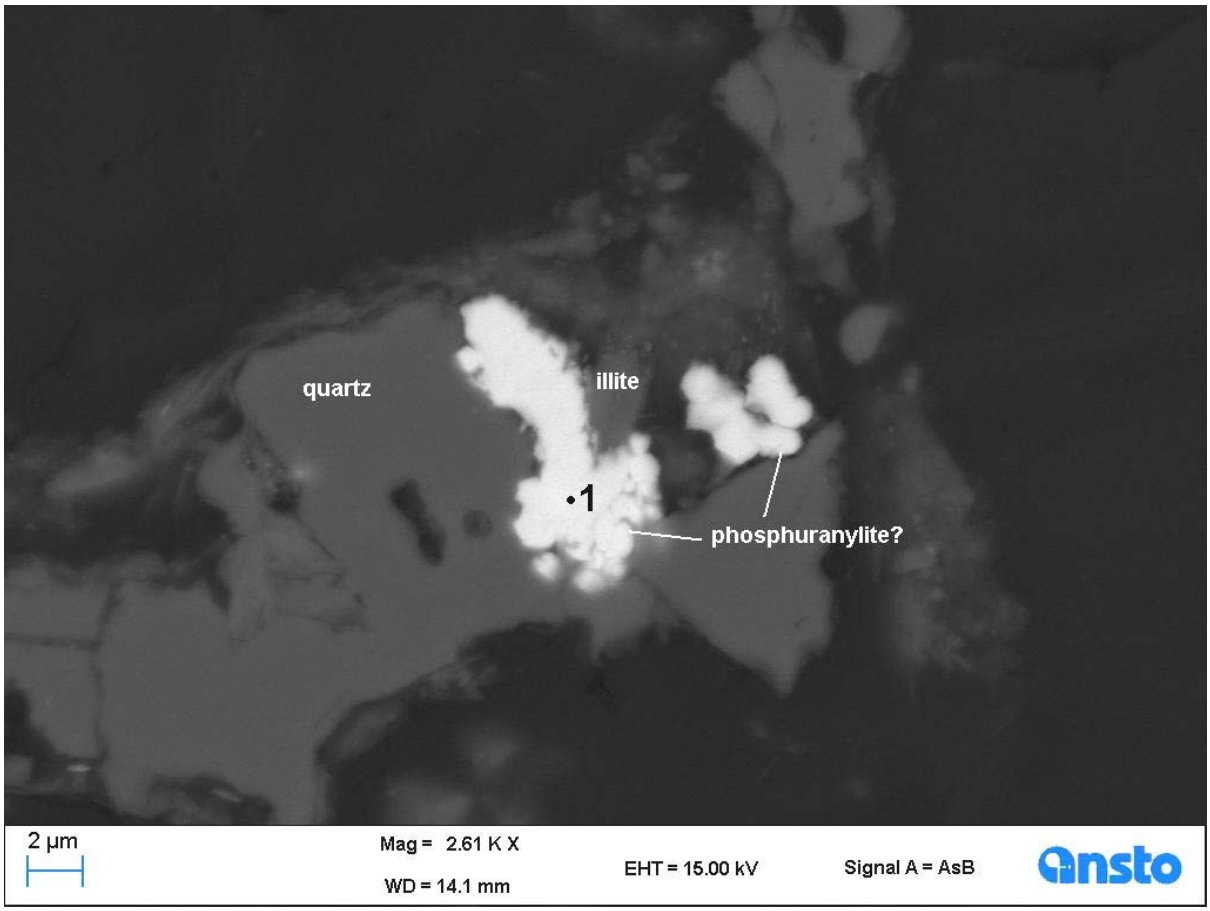


The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

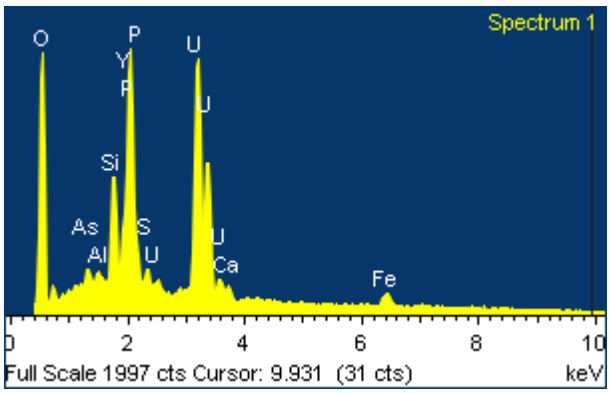


S1 – coffinite

FIGURE A24 ***JACK - RESIDUE (LC 12 C)*: BSE micrograph showing partially dissolved uranium phosphate, probably phosphuranylite. The phosphuranylite grains display slight acid attack along the margins.**

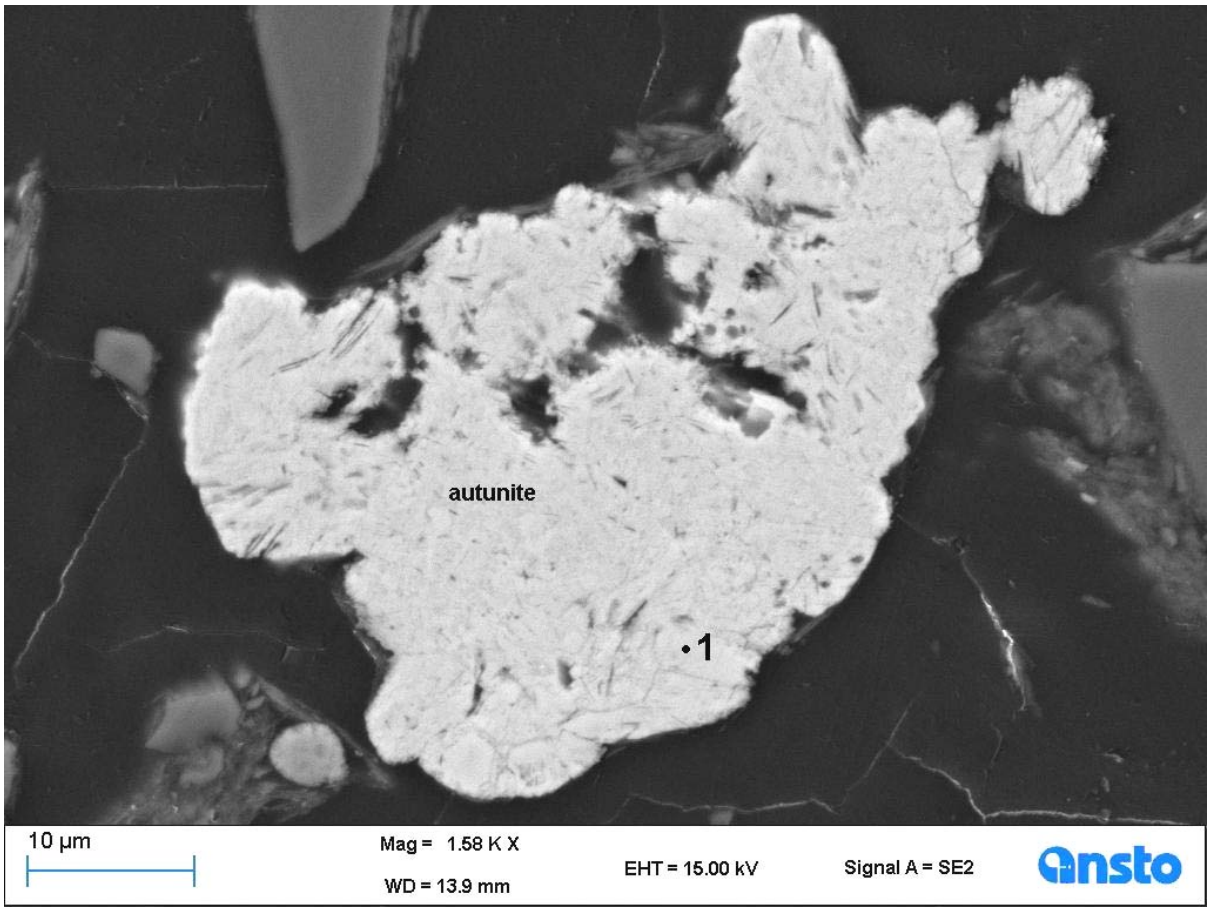


The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

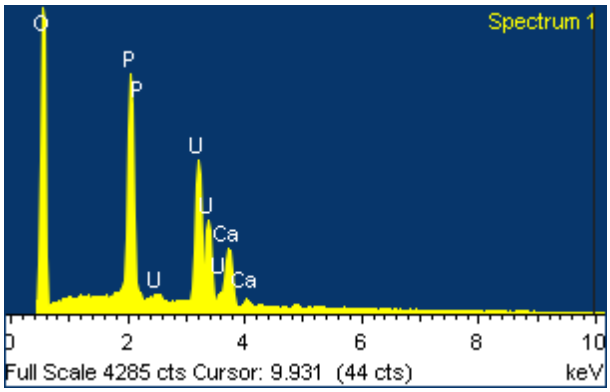


S1 – phosphuranylite? (X-rays from adjacent quartz). As and Fe probably substitute P and Ca.

FIGURE A25 ***JACK - RESIDUE (LC 12 C)*: Secondary electron (SE) micrograph illustrating partly dissolved autunite aggregate.**

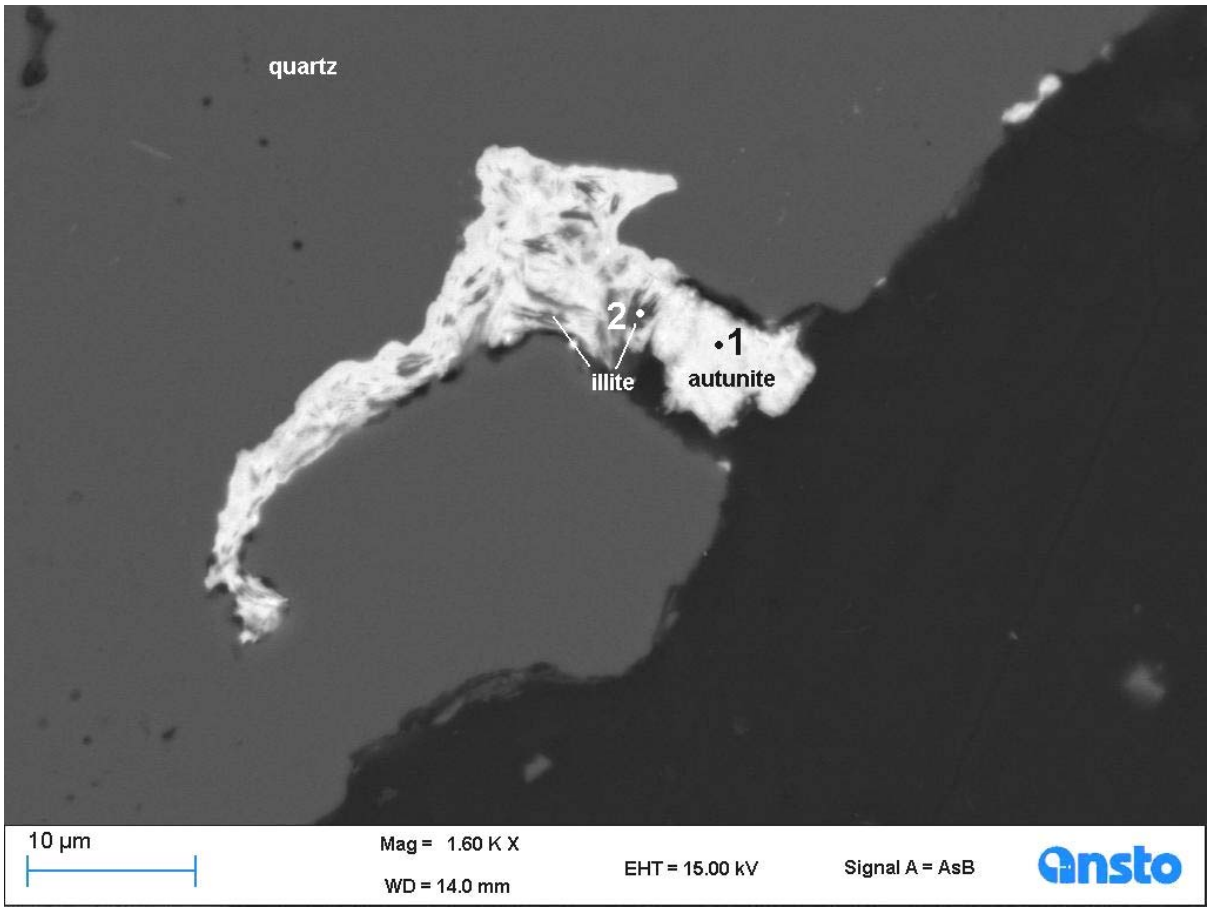


The number on the micrograph indicates the location of the EDS spectrum. The EDS spectrum is shown below.

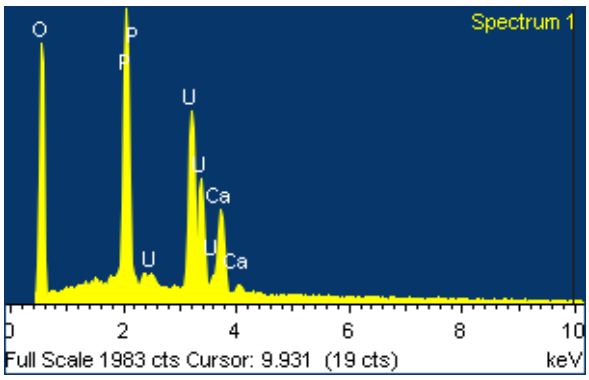


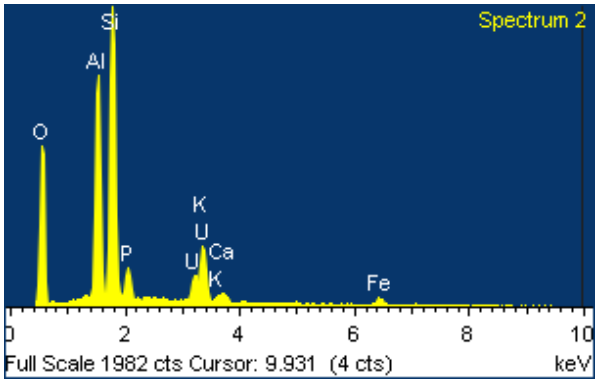
S1 – autunite

FIGURE A26 ***JACK - RESIDUE (LC 12 C)*: BSE micrograph showing autunite intergrown with illite. Autunite is partially dissolved. The dissolution of autunite is indicated by the cavities along the grain boundaries with quartz.**



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.

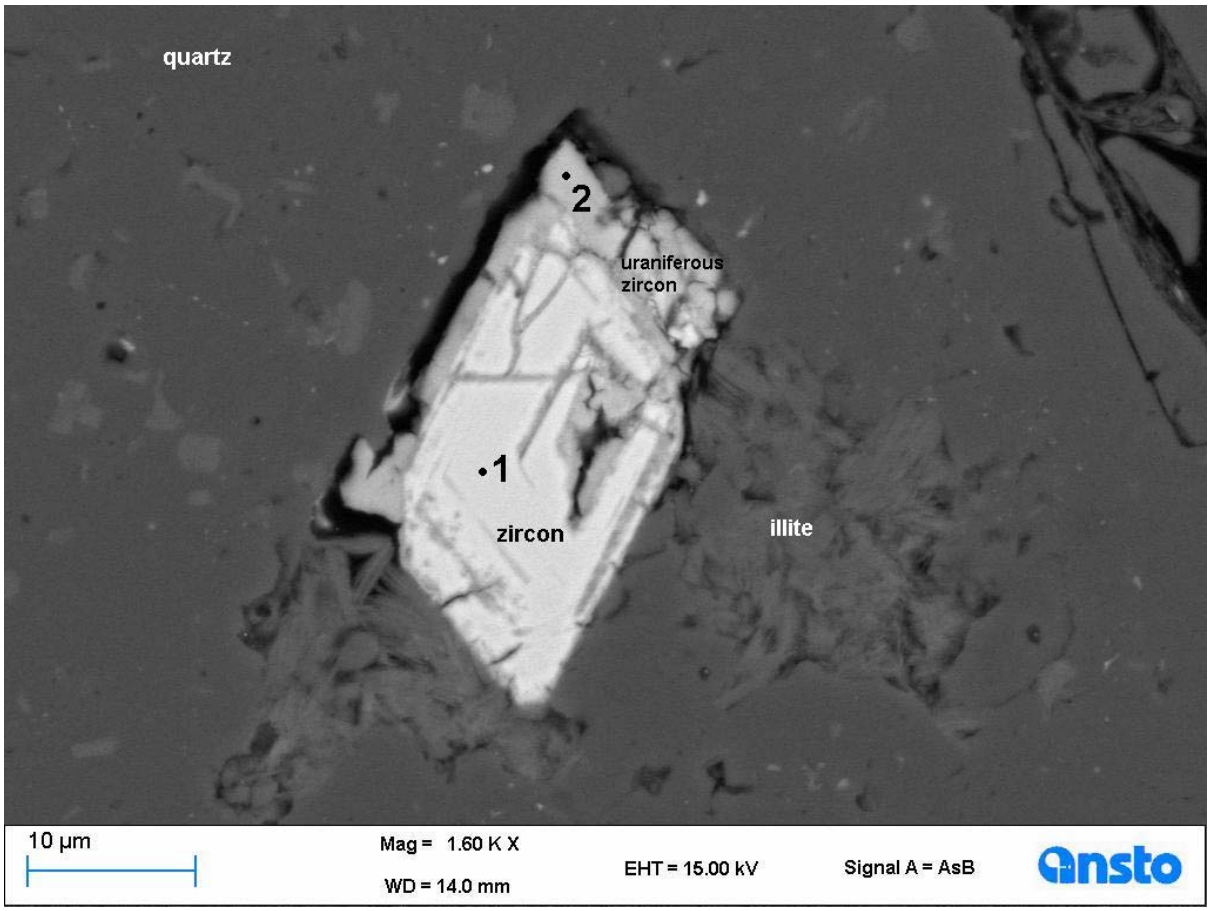




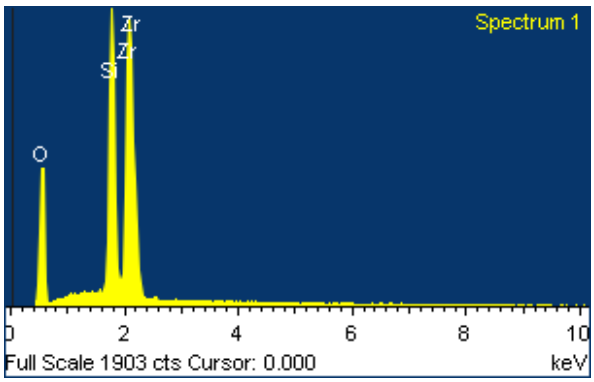
S1 – autunite

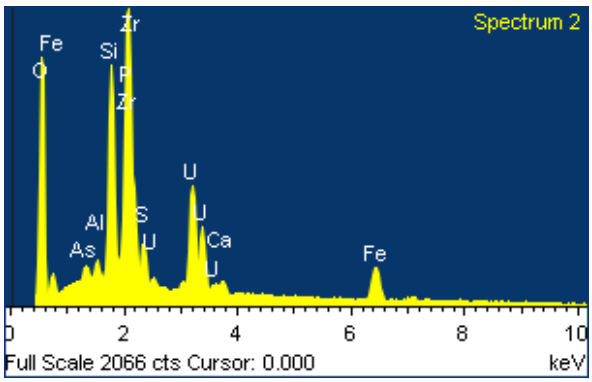
S2 – illite (X-rays from adjacent autunite)

FIGURE A27 ***JACK - RESIDUE (LC 12 C)*: BSE micrograph showing zoned zircon hosted by quartz. The cavities between the uraniferous zircon grain and quartz suggest that uraniferous zircon has begun to dissolve.**



The numbers on the micrograph indicate the location of the EDS spectra. The EDS spectra are shown below.





S1 – zircon

S2 – uraniferrous zircon

APPENDIX I

Settling Test Data

Lagoon Creek - Static Settling Tests Data

Test		**LC7 A**		**LC7 C**
Date		2/09/10		2/09/10
	Unit	Data	Unit	Data
Slurry				
dilution		8wt.%		8wt.%
tare	g	603.8	g	611.7
slurry + tare	g	1671.2	g	1676.8
slurry weight	g	1067.4	g	1065.0
volume	L	1.000	L	1.000
g/L	g/L	1067	g/L	1065
wt% solids	%	7.5	%	6.6
g solids /L	g/L	79.9	g/L	69.9
C_0 - t solids /m^3	t/m^3	0.08	t/m^3	0.07
Initial Height	mm	338	mm	335
H_0	m	0.34	m	0.34
Flocculant	mL	20.0	mL	20.0
Floc %	%	0.025	%	0.025
parts per million	ppm	5.0	ppm	5.0
grams per ton	g/t	62.5	g/t	71.6
Supernatant				
tare	g	594.8	g	594.8
weight + tare	g	1462.1	g	1474.9
supernatant weight	g	867.3	g	880.1
volume	mL	850	mL	865
SG	g/mL	1.020	g/mL	1.017
From Settling curve				
T_u	mins	16	mins	10
Days	days	0.011	days	0.007
Settled sludge				
tare	g	604	g	612
weight + tare	g	804	g	798
weight	g	200.1	g	185.9
volume	mL	150	mL	135
(g/L)	g/L	1334	g/L	1377
(g solids /L)	g/L	532.9	g/L	517.5
(wt% solids)	%	39.9	%	37.6
wet cake wt%	%	82.1	%	83.0
		17.9		17.0
Dry Solids @ 100°C				
tare	g	76	g	96
weight + tare (dry)	g	156	g	166
weight + tare (wet)	g	174	g	180
weight	g	79.9	g	69.9
Unit thickener area	(m^2/t solids/day)	0.41	(m^2/t solids/day)	0.29
Mass flux	t/m2/h	0.103	t/m2/h	0.142

Settling Test Data Sheets

Test	**LC7 A**	**Test**	**LC7 C**
Date	2/09/10	**Date**	2/09/10
Ore	Junnagunna 30ºC	**Ore**	Redtree 30ºC
pH	1.5	**pH**	1.5
Dilution	8 wt%	**Dilution**	8 wt%
Floc Type	E10	**Floc Type**	E10
Floc Dosage (mL)	20	**loc Dosage (ml**	20
Time (min)	**Height (mL)**	**Time (min)**	**Height (mL)**
0:00	1000	0:00	1000
0:21	900	0:17	900
0:37	800	0:28	800
0:54	700	0:40	700
1:13	600	0:52	600
1:34	500	1:05	500
2:03	400	1:20	400
2:32	350	1:29	350
3:48	300	1:48	300
6:15	260	2:29	260
13:30	217	4:13	220
20:00	200	8:00	187
80:00	168	65:00	142
217:00	160	203:00	140
1440:00	158	1440:00	140

APPENDIX J

FLSmidth – Settling and Filtration Report

REPORT OF INVESTIGATION

INTO THE

THICKENING

AND

VACUUM FILTRATION

OF

LEACH RESIDUE

WESTMORELAND URANIUM PROJECT

FOR

LARAMIDE RESOURCES

by

Paul Gray & Kim Vance
FLSmidth Pty Limited
May 2011

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1.0 SUMMARY

FLSmidth was commissioned by ANSTO Minerals on behalf of Laramide Resources to conduct bench scale thickening and vacuum filtration testwork on one sample of Westmoreland Leach Residue slurry from their proposed Uranium Project in Queensland.

The testwork was conducted by FLSmidth at the ANSTO Minerals facility at Lucas Heights, NSW.

The testwork indicated that the Westmoreland Leach Residue can be thickened and filtered in the following Thickener and Filter sizes:-

1.1 Thickener Sizing

The testwork indicated that the design feed rate of 30 t/h of Westmoreland Leach Residue solids can be thickened to 60% – 61% w/w respectively in one 10 m ϕ High Rate Thickener.

The Table 1.1 below summarises the expected performances of the 10m ϕ High Rate Thickener.

Table 1.1 – Expected Performance of Westmoreland Leach Residue Thickener

Parameter		High Rate Thickener
		1 x 10m ϕ
Thickener Feed Tonnage	**t/h**	30
Feed Solids	**% w/w**	45
Feedwell Solids	**% w/w**	7.5
Flocculant Addition Rate	**g/t**	50 - 100
Rise Rate	**m/h**	0.3
Expected Underflow Solids	**% w/w**	60 – 61
Underflow Yield Stress	**Pa**	14 – 19
Flux Rate	**t/m^2h**	0.38
Thickener Diameter	**m**	10
Number of Thickeners		1

1.2 Vacuum Filter Sizing

The testwork indicated the design feed rate of 30 t/h of Westmoreland Leach Residue solids at 60% w/w solids can be filtered to a cake moisture of 23% w/w with a cake wash ratio of one to provide a residual concentration of both U and U_3O_8 in the filter cake of approximately 50ppm using a 2.5m wide 2.5M65 Eimco Horizontal Belt Filter that has a filtration area of 65 m^2.

The Table below summarises the expected performance of the Horizontal Belt Filter vacuum filter.

Table 1.2 – Recommended Filter Sizing – Westmoreland Leach Residue

WESTMORELAND LEACH RESIDUE - FILTER SIZING	
Filter Type	***HBF***
Feed Solids % w/w	60
Solids Feed Rate t/h	30
Vacuum kPag	-70
Cake Thickness mm	11
Cake Moisture %	23
Cake Wash	Yes
Cake Wash Ratio (kg/kg solids)	1.0
Filtration Rate kg/h/m^2	472
Filtration Area Required m^2	63.5
Selected Filter	***2.5M65***
Selected Model Filtration Area Available m^2	65
No. of Filters Required	**1**

2.0 INTRODUCTION

FLSmidth was commissioned by ANSTO Minerals on behalf of Laramide Resources to conduct bench scale thickening and vacuum filtration testwork on one sample of Westmoreland Leach Residue slurry from their proposed Uranium Project in Queensland.

The objective of the thickening testwork was to size a thickener capable thickening a design feed rate of 30 t/h of Westmoreland Leach Residue solids to maximum underflow density.

The thickening testwork involved evaluating EIMCO High Rate Thickening technology in which the thickener typically operates with a mud bed depth of 1 – 2 metres.

The objective of the filtration testwork was to size an Eimco HBF vacuum belt filter capable of dewatering a design feed rate of 30 t/h of Westmoreland Leach Residue solids to to optimum cake moisture content.

The testwork was conducted by FLSmidth at the ANSTO Minerals facility at Lucas Heights, NSW.

This report details the results of the bench scale testwork conducted on the sample of Westmoreland Leach Residue slurry, and discusses the size thickener and size of HBF filter required to process the nominated 30 t/h solids feed rate to maximum underflow density and optimum cake moisture content.

3.0 PROCEDURES - THICKENING

The testwork was performed on a sample of Westmoreland Leach Residue slurry. The testwork was conducted by FLSmidth at the ANSTO Minerals facility at Lucas Heights, NSW.

3.1 Thickener Feed

One (1) sample of Westmoreland Leach Residue slurry was produced by ANSTO Minerals.

Settling flux tests were conducted to determine the optimum feedwell solids concentration to achieve maximum settling performance.

The optimum feedwell solids concentration was found to be lower than the nominated solids content of the feed stream. This is a typical phenomenon as most slurries exhibit improved settling characteristics as the solids concentration is reduced.

The slurry sample was adjusted to the optimum solids concentration by adding process water.

3.2 High Rate Thickener - 4 Litre Static Cylinder Settling Tests

A series of static 4 litre cylinders settling tests was conducted on the Westmoreland Leach Residue sample.

The test cylinders were fitted with slowly rotating pickets to simulate the action of the rake in the full scale thickener.

3.3 Continuous Fill Deep Tube Settling Tests

A continuous fill thickening test was also conducted on the Westmoreland Leach Residue sample. The continuous fill settling test involved pumping slurry at the optimum settling flux concentration and flocculant at the settling flux addition rate into a 4 litre test cylinder containing a feedwell to mix and flocculate the slurry. The flocculated slurry then settled towards the bottom of the cylinder and the clear overflow exited from the top of the cylinder.

The 4 litre cylinder was fitted with a slowly rotating rake to assist with the dewatering of the slurry the same way as the rake mechanism assists dewatering in the full scale thickener.

The objectives of the continuous fill test were to :-

- Confirm the optimum settling flux solids concentration determined in the static settling flux tests.
- Confirm the flocculant addition rate determined in the settling flux tests.
- Determine the bed residence time required for the full scale thickener to achieve maximum or target underflow solids levels.

Typical fill time for the continuous fill test is 25 to 40 minutes depending on the solids flux rate. The feed rate and flocculant addition rate were initially set to approximately 50% of the predicted solids flux rate and at 100% of the expected flocculant addition rate on a g/t basis. After initial observations of flocc structure, settling velocity and overflow clarity the feed rate was increased to the expected maximum with a corresponding increase in flocculant addition rate to maintain the correct addition rate on a g/t basis. If any degradation in flocc structure or significant decrease in overflow clarity was observed the flocculant addition rate was increased to bring these two parameters back into acceptable limits.

The continuous fill test continued until a solids bed depth of 0.5m to 0.8m was achieved. Once the target bed level was achieved the feed to the cylinder was stopped and readings of the bed height versus time taken until the there was no further decrease in interface height. Typically there is no further decrease in bed height after 6 – 12 hours.

Once there was no further decrease in interface height the time was noted, the clear liquor was decanted off, and the compacted slurry removed from the cylinder, dried and weighed in order to measure the solids concentration in the cylinder and check the volume of feed slurry added during the test.

3.4 Flocculant

The flocculant primarily used for the bench-scale thickening tests was BASF Magnafloc 800HP. Magnafloc 800HP was selected for the testwork after a number of other flocculants were evaluated, including BASF Magnafloc 10, Magnafloc 155, Magnafloc 5250 and Magnafloc 919.

Magnafloc 800HP flocculant was the best performing flocculant in terms of free settling rate and overflow clarity.

3.5 Underflow Rheology

The yield stresses for the Westmoreland Leach Residue slurry thickened to a range of solids densities was measured using a Brookfield YR-1 Vane Viscometer.

3.6 Particle Size Distribution

The particle size distribution of the Westmoreland Leach Residue solids used in the bench scale testwork was conducted by laser sizing.

3.7 Filter Leaf Test

A vacuum filter leaf test, in which the filter cake remains fully saturated with filtrate, was conducted on the Westmoreland Leach Residue sample. The filter leaf test is an important characterisation test for solids to be thickened in Thickeners. The saturated cake approximates the limit to which the solid particles can be concentrated and thus provides valuable information related to the target underflow solids for the thickener.

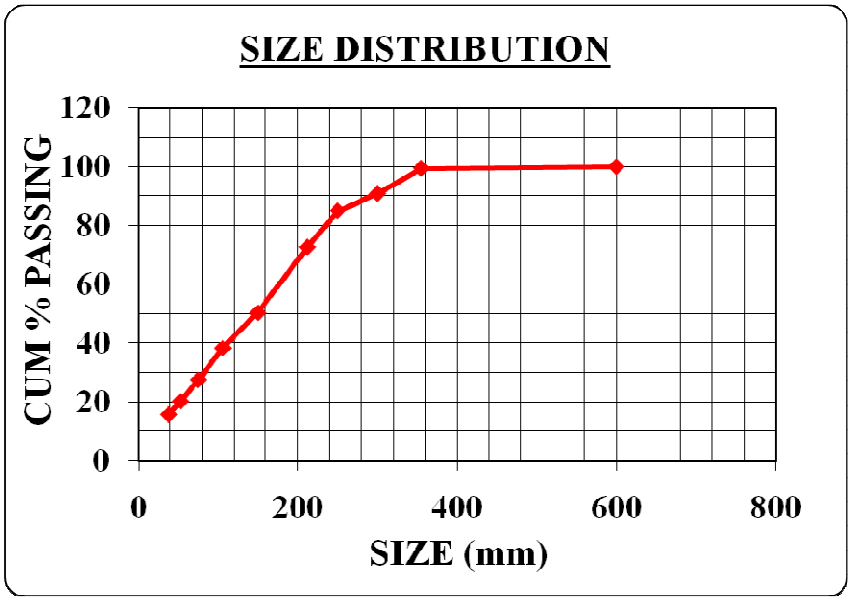
4.0 RESULTS – THICKENING

4.1. Solids Characterisation

4.1.1 Particle Size

Table 4.1.1 – Particle Size Analysis

Size (µm)	% Passing
355	99.5
300	90.9
250	85.1
212	72.7
150	50.4
106	38.4
75	27.5
53	20.3
38	15.7
P80	*234.4*



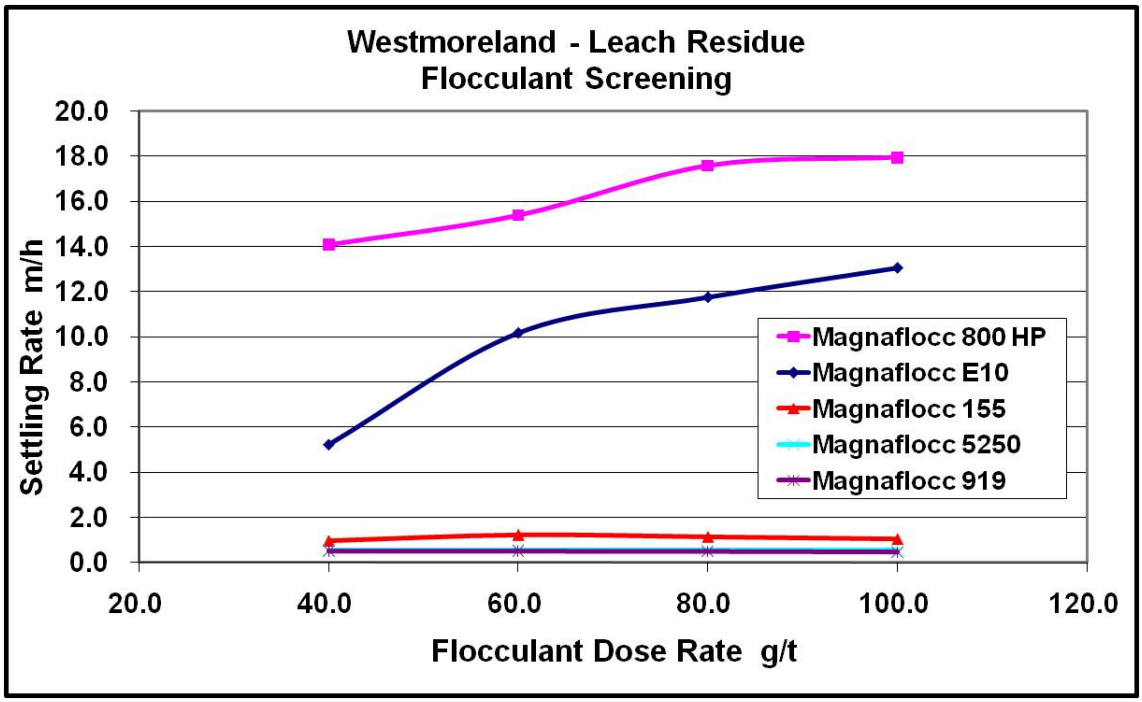
4.1.2 Specific Gravities

SG of Solids	2.65
SG of Process Water	1.127

4.2 Flocculant Screening

The flocculant used for the onsite bench scale thickening for the Westmoreland Leach Residue slurry was BASF Magnafloc 800 HP.

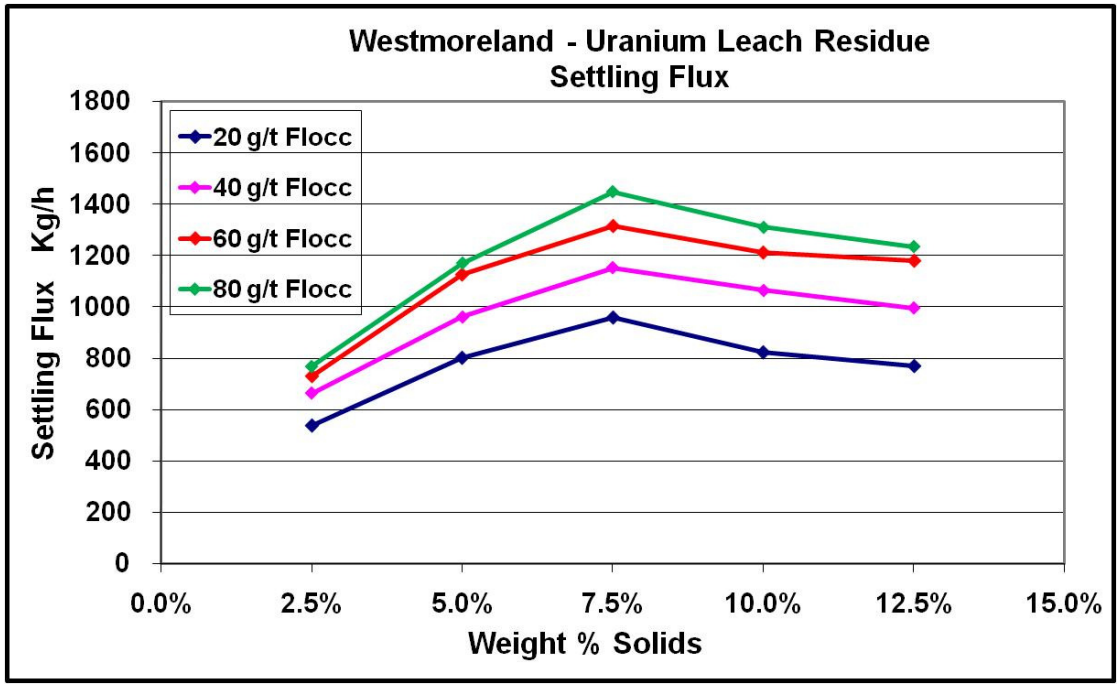
Graph 4.2 – Flocculant Screening – Leach Residue



4.3 Effect of Feed Dilution

The settling flux curve, Graph 4.3 indicates that the sample of Westmoreland Leach Residue slurry exhibits optimum settling performance at feedwell solids concentrations of 7.5% w/w. Above the optimum feed solids concentration there is deterioration in settling performance as the settling rate is adversely affected by hindered settling.

Graph 4.3 – Settling Flux – Westmoreland Leach Residue



4.4 4 Litre Static Cylinder Tests

The results of the thickener simulations on the Westmoreland Leach Residue slurry are summarised in Table 4.4. The data was obtained from the settling curves that are provided along with the testwork summary sheets in Appendix 1.

Table 4.4 – 4 Litre Static Cylinder Settling Test Results

Test Parameter		Test – 1	Test – 2
Test Size	**litres**	4.0	4.0
Feed Solids	**% w/w**	7.5	7.4
Flocculant Addition	**g/t**	50	102
Free Settling Rate	**m/h**	28	48
Overflow Solids	**mg/l**	<100	<200
Ultimate Solids	**% w/w**	60.8	61.6

Table 4.4 indicates that the sample of Westmoreland Leach Residue slurry exhibits the following settling and thickening characteristics:-

- Settling rates of 28 – 48 m/h when the solids are flocculated at 7.4% - 7.5% w/w with 50 – 102 g/t of BASF Magnafloc 800HP flocculant.
- Overflow solids of < 100 mg/l.
- Ultimate underflow solids values of 60.8% – 61.6 % w/w.

4.5 Vacuum Filter Cake Test

The results of the vacuum filter cake test on the Westmoreland Leach Residue in which the filter cake remained saturated with filtrate a recorded solids value of 77.7 % w/w.

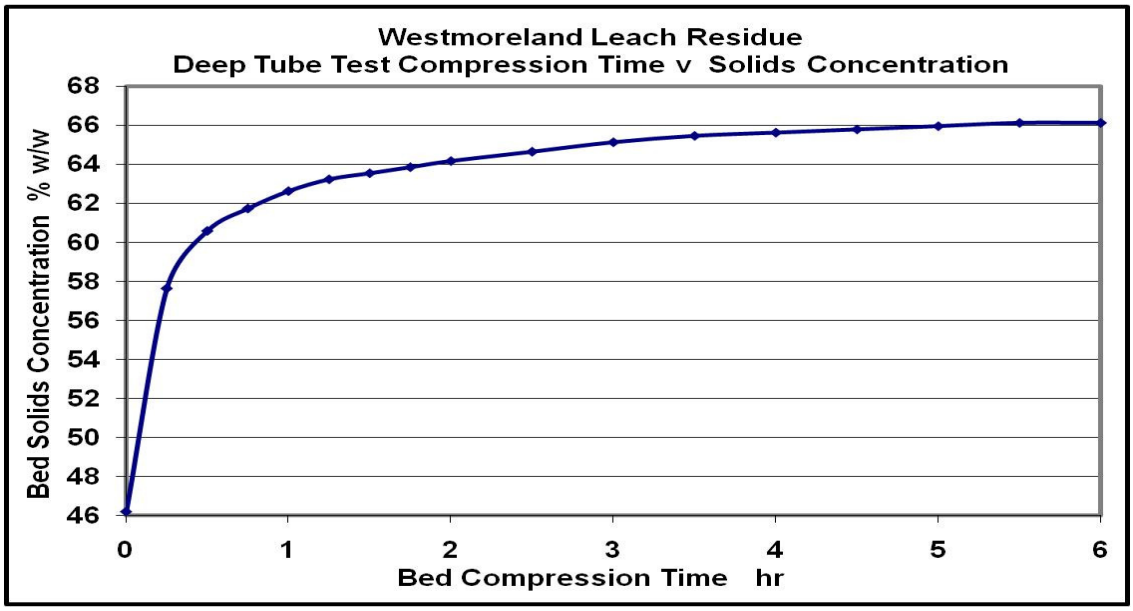
4.6 Continuous Fill Deep Tube Settling Tests

The results of the continuous fill deep tube settling tests conducted on the sample of Westmoreland Leach Residue slurry is summarised in Table 4.6 and the raked compression Graph 4.6.

Table 4.6 – Westmoreland Leach Residue
Continuous Fill Deep Tube Settling Test Parameters and Results

Test Parameter		Results
Feed Solids	**% w/w**	7.5%
Flocculant Type	**BASF**	Magnafloc 800HP
Flocculant Addition Rate	**g/t**	50
Flux Rate	**t/m^2h**	0.40
Unit Area	**m^2/tpd**	0.14
Rise Rate	**m/h**	6.6
Overflow Solids	**mg/l**	<100
Bed Solids % w/w – 1 hr Residence Time		62.6 %
Final Average Bed Solids	**% w/w**	66.1 %

Graph 4.6 – Westmoreland Leach Residue
Continuous Fill Bed Compression Rate



4.7 Mud Rheology

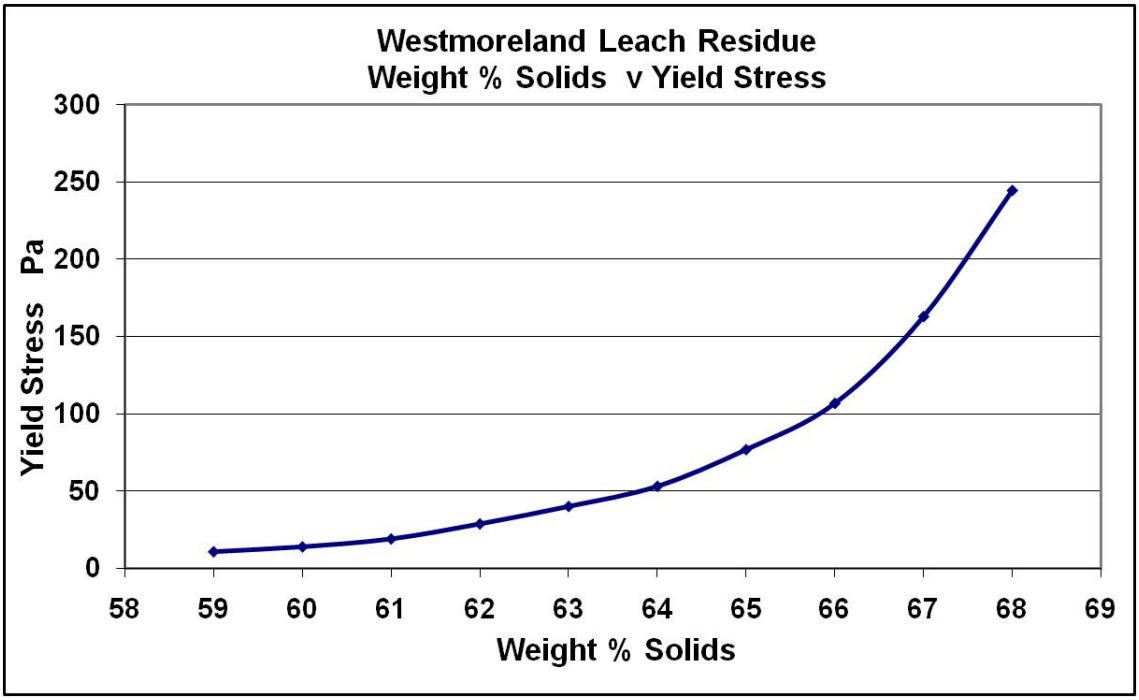
Mud rheology data was obtained on the Westmoreland Leach Residue slurry sample over a range of solids levels using a Brookfield YR-1 vane viscometer.

The yield stress results are presented on Graph 4.7 are also summarised in the following Table 4.7.

Table 4.7 – Westmoreland Leach Residue Slurry Yield Stress Results

Underflow Solids % w/w	Yield Stress Pa	Underflow Solids % w/w	Yield Stress Pa
59 %	11	64 %	53
60 %	14	65 %	77
61 %	19	66 %	107
62 %	29	67 %	163
63 %	40	68 %	244

Graph 4.7 – Westmoreland Leach Residue Slurry Yield Stress Results



5.0 DISCUSSION – THICKENING

5.1 Feed Dilution

The optimum solids settling flux for the Westmoreland Leach Residue slurry was observed when the solids were diluted to 7.5% w/w. As the feed stream to the thickener is expected to have a typical feed solids concentration of 45.0% w/w, the thickener requires a feed dilution system.

An EIMCO Open Channel E-DUC® Feed System is capable of diluting the feed stream to the desired level. The EIMCO E-DUC® Feed System uses clarified liquor from within the thickener to dilute the incoming feed stream resulting in improved thickener performance through uniform feed dilution and improved flocculation of the feed stream. It also provides a means of de-aeration which can beneficial for flotation streams to reduce froth formation.

Figure 5.1 – Open Channel EIMCO E-DUC® Feed Dilution System

5.2 Thickener Size Evaluation

Based on the static settling data detailed in Section 4.4, the dynamic settling data detailed in section 4.6 the filter leaf test results, and the underflow slurry yield stress results, the size of High Rate Thickener to process 30 t/h of Westmoreland Leach Residue solids has been calculated. The results of these calculations are summarised in Table 5.2.

Table 5.2 – Westmoreland Leach Residue - High Rate Thickener Sizing

Parameters		High Rate Thickener
Thickener Feed Tonnage	**t/h**	30
Feed Solids	**% w/w**	45
Feedwell Solids	**% w/w**	7.5
Flocculant Addition Rate	**g/t**	50 - 100
Free Settling Rate	**m/h**	30
Rise Rate	**m/h**	4.1
Underflow Solids	**% w/w**	60 - 61
Underflow Yield Stress @ 60 – 61%	**Pa**	14 – 19 Pa
Settling Flux	**t/m^2h**	0.38
Thickener Diameter	**m**	10 m ϕ
Number of Thickeners		1

The testwork indicated the target feed rate of 30 t/h of Westmoreland Leach Residue solids can be thickened to 60% – 61% w/w in a 10m ϕ Eimco High Rate Thickener.

6.0 RECOMMENDED THICKENER SPECIFICATION
Westmoreland Leach Residue

Based on the testwork results the following Eimco High Rate Thickener specification is recommended:

- Feed Tonnage — 30 t/h
- Feed Solids — 45% w/w
- Feedwell Solids — 7.5% w/w
- Overflow Solids — <100 mg/l
- Feed Dilution Method — EIMCO E-DUC® Feed System
- Flocculant Addition — 50 – 100 g/t BASF Magnafloc 800HP or equivalent
- EIMCO Thickener Type — **High Rate**
- Underflow Solids — 60% - 61 % w/w
- Underflow Yield Stress — 14 – 19 Pa
- Flux Rate — 0.38 t/m^2h
- Thickener Diameter — 10 m ϕ

7.0 PROCEDURES - FILTRATION

The vacuum filtration test program was performed on one (1) sample of Westmoreland Leach Residue. The testwork was conducted by FLSmidth at the ANSTO Minerals facility at Lucas Heights, NSW.

7.1 Filter Feed

A slurry sample of Westmoreland Leach Residue solids was received by FLSmidth from ANSTO Minerals for vacuum filtration evaluation.

All of the filtration tests were conducted at 60% w/w solids as the thickening testwork conducted prior to the filtration testwork, indicated underflow solids of 60% w/w could be readily achieved in a High Rate thickener

7.2 Vacuum Filter Simulations

Standard FLSmidth bench scale test procedures were used for the vacuum filter simulations.

Testing was performed using a circular vacuum leaf with a filtration area of 0.0072m^2. The laboratory testwork program simulated Eimco Horizontal Belt Filters. Various form, wash and dry times were assessed to determine the optimum cake thickness, throughput and moisture content.

The filtration media used in the filter simulations was Clear-Edge HE 4575.

7.3 Additives and Wash

The filtration testwork was conducted utilising the following test parameters :-

Series 1 Testwork - As received slurry at 60% w/w solids with 100 g/t of flocculant.

Series 2 Testwork - As received slurry at 60% w/w solids with 200 g/t of flocculant.

Series 3 Testwork - As received slurry at 60% w/w solids with 200 g/t of flocculant and an addition water wash.

7.4 Particle Size Distribution

The particle size distribution of the Westmoreland Leach Residue solids used in the bench scale testwork was conducted by laser sizing. The results are presented in the Thickening section of this report.

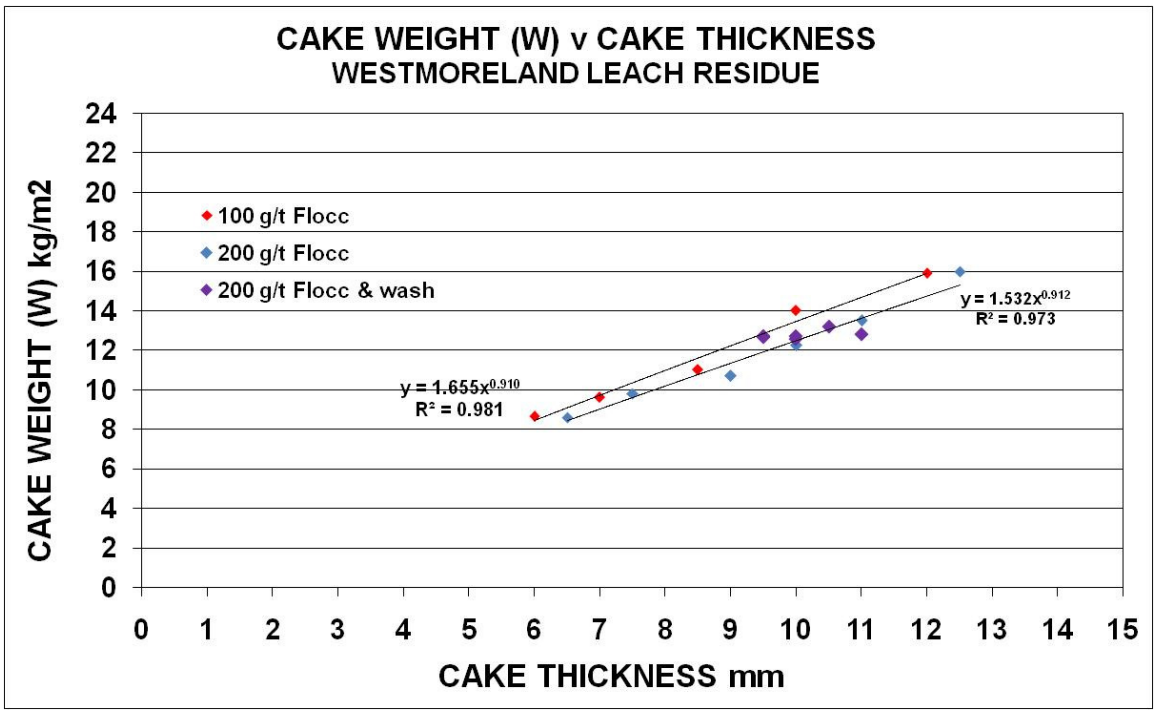
8.0 RESULTS - FILTRATION

8.1 Vacuum Filter Simulations

8.1.1 Cake Thickness vs. Cake Loading(W)

It is convenient to convert the test dry cake weights to weight of dry cake per unit area and plot these values as a function of cake thickness. The plot of cake thickness vs cake loading (W) reveals a straight line graph through the origin as shown overleaf in Graph 8.1.1

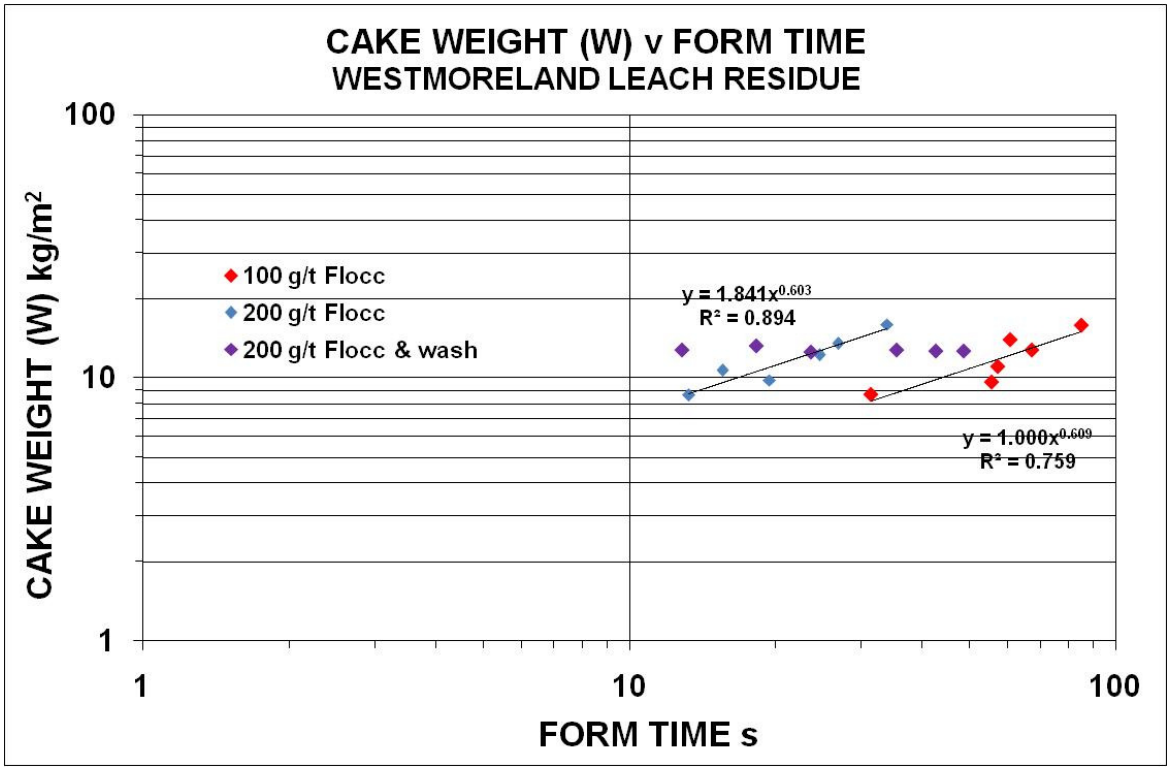
Graph 8.1.1 – Westmoreland Leach Residue
Cake Weight v Cake Thickness



8.1.2 Cake Formation Rate

The rate of cake formation slows as the cake thickness and therefore cake loading increases. A log-log plot of cake formation rate vs. cake loading (W) should give a straight-line for constant conditions of feed solids concentration, temperature, and particle size distribution. This data is illustrated below in Graph 8.1.2.

Graph 8.1.2 – Westmoreland Leach Residue
Cake Weight v Form Time



8.1.3 Cake Moisture

Results on a wide variety of materials have shown that the following correlation factor is very useful for correlating cake moisture content data:

$$\text{Correlation Factor} = (CFM/ft^2)(\Delta P/W)(\Theta_d/\mu)$$

Where:

CFM/ft^2 = air rate through filter cake measured at the downstream pressure vacuum.
ΔP = Pressure drop across cake.
W = Dry cake weight /unit area.
Θ_d = Dry time during the filter cycle.
μ = Viscosity of liquid phase.

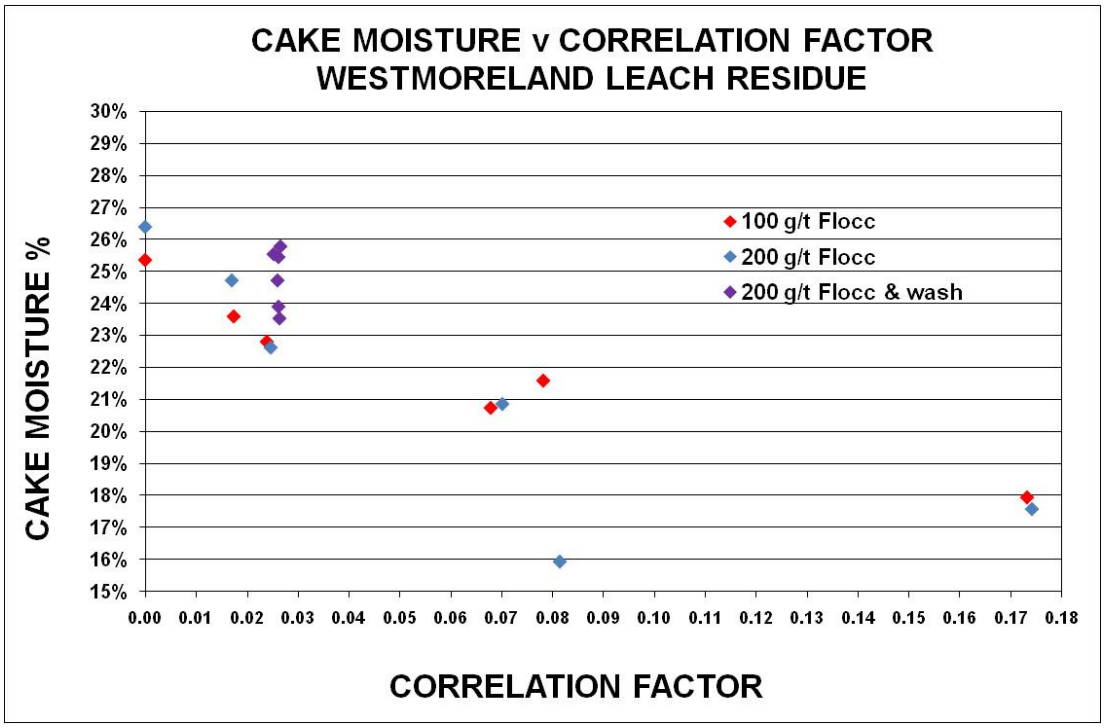
There will always be some degree of data scatter in the moisture content correlation. Any point selected on the best-fit curve correlation will represent an average operation condition.

It is often useful to use the simplified form of the correlation factor

Simplified Factor = Θ_d/W

The most convenient moisture correlation is a plot of Cake Moisture vs Θ_d/W which gives the moisture achievable for different drying times across a range of cake thicknesses. . The moisture correlation for this material is shown in Graph 8.1.3 below.

Graph 8.1.3 – Westmoreland Leach Residue
Cake Moisture v Correlation Factor



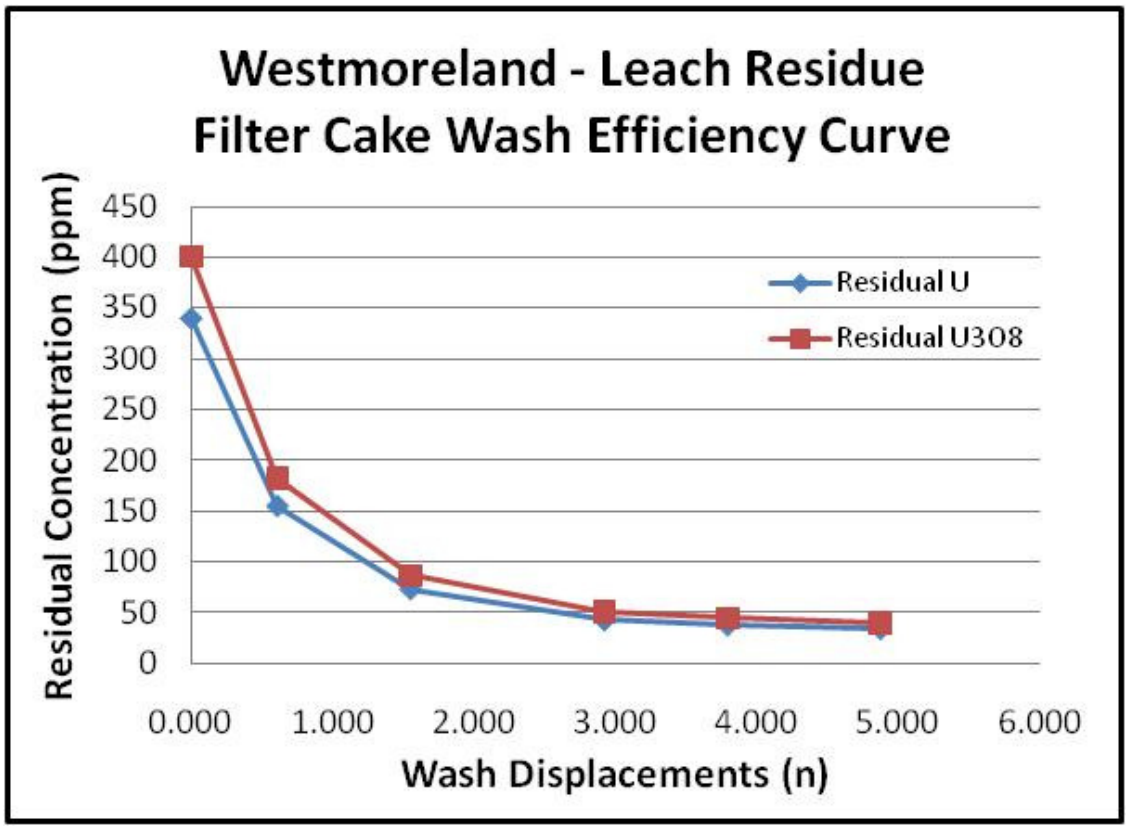
It can be seen that cake moistures of 18% can be achieved with sufficient drying time. Cake formation moisture is approximately 26.5%.

8.1.4 Filter Cake Wash Efficiency Curve

The filter cake wash efficiency is determined by washing the filter cake with different quantities of wash water and testing the washed filter cake for the residual concentration of the soluble material.

The filter cake wash water volume is measured in displacements. A single displacement is the volume of wash water equivalent to the residual filter cake moisture before washing. The following graph, graph 8.1.4 depicts the residual concentration of metals left within the filter cake after being washed with a given number of wash water displacements.

Graph 8.1.4 – Wash Efficiency Curve – Leach Residue



From Graph 8.1.4 it can be seen that there is no significant reduction in the residual concentrations of U and U_3O_8 after 3 wash displacements. A filter cake wash of 3 displacements provides a residual concentration of both U and U_3O_8 of approximately 50ppm. As a result, 3 wash displacements, which is equivalent to a wash ratio of 1 kg of wash water per kg of filter cake solids is recommended.

8.1.5 Full Scale Filtration Rate

The test data was used to calculate a Full Scale Filtration Rate (FSFR) using the equation

$$FSFR = (W)\ (60)\ (0.8)/\Theta_{cycle}$$

Where

W = Cake Weight (kg/m^2)
60 minutes per hour
0.8 scale up factor
Θ_{cycle} = cycle time (minutes)

The calculated FSFR and Filtration Area for a cake thickness of 11mm are tabulated below in Table 8.1.5 for the nominated 60% w/w feed solids concentration and including a cake wash ratio of one

Table 8.1.5 – Filtration Rate for 60% Solids & 11mm Cake Thickness

Filter Parameters	*HBF Filtration Rate & Filtration Area Required*
Solids Feed Rate t/h	30
Feed Solids % w/w	60
Filter Vacuum kPag	-70
Selected Cake Thickness mm	11
Form Moisture %	26.5
Final Moisture %	***23***
Filtrate Suspended Solids mg/l	1500
Dry Time Factor – from Graph 8.1.3	0.026
Dry Time (mins) Cake weight x Dry Time Factor	0.44
Cake Wash Displacements (n)	3.0
Cake Wash Ratio (kg/kg solids)	1.0
Filtration Rate (FSRF) ($kg/m^2.hr$)	472
Filter Area Required (m^2)	63.5
Filter Model Selected	***2.5M65***
Available Filter Area per Filter (m^2)	65
No. of Filters Required	**1**

9.0 RECOMMENDED FILTER SIZING

Based on the filtration testwork results the recommended filter size to process the design solids feed rate of 30 t/h of Westmoreland Leach Residue, including a cake wash ratio of one, has been calculated. The results of these calculations are summarised in Table 9.0.

Table 9.0 Recommended Filter Sizing – Leach Residue

WESTMORELAND LEACH RESIDUE - FILTER SIZING	
Filter Type	***HBF***
Solids Feed Rate t/h/	30
Feed Solids % w/w	60
Vacuum kPag	-70
Cake Thickness mm	11
Cake Moisture %	23
Cake Wash	Yes
Cake Wash Ratio kg/kg solids	1.0
Filtration Rate $kg/h/m^2$	472
Filtration Area Required m^2	63.5
Selected Filter	2.5M65
Selected Model Filtration Area Available m^2	65
No. of Filters Required	**1**

APPENDIX 1

Thickener Simulation

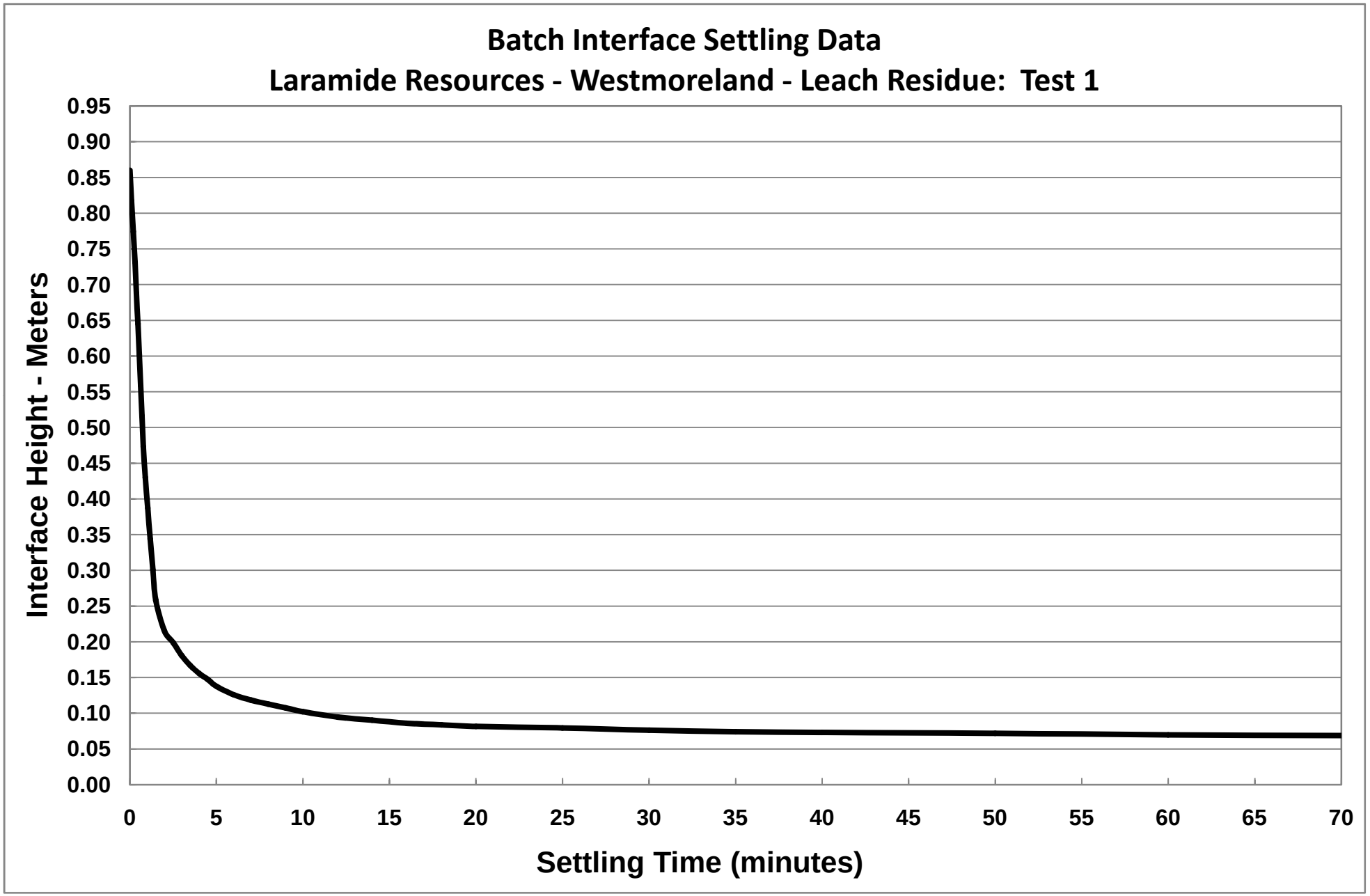
Test Results

Thickener Test Summary for Laramide Resources - Westmoreland March 30, 2011

Job:	Westmoreland - Leach Residue	Undecanted Slurry Vol (ml):	4000.00	Depth Correction Type:	Auto
Test:	Test 1	Weight (g):	4198.33	Exponent:	
Company:	Laramide Resources	Decanted Slurry Vol (ml):	320.00	UF % Solids: Final:	60.77
Address:	Queensland	Weight (g):	518.33	Ultimate:	60.77
Material:	Uranium	Dry Solids Weight (g):	315.00	Init Settling Vel (m/hr):	27.52
Flocculant:	BASF Magnafloc 800HP	Settling Vessel Size (ml/ft):	1520.00	Intial Feed Concentration:	7.50
Concentration (g/l):	0.25	Ultimate Interface Height (ml):	320.00		
Volume Added (ml):	63.00	Specific Gravity Supernatant:	1.00		
Dosage (g/mt):	50.00	Specific Gravity Solids:	2.70		

Notes:

Time(min)	Height(ml)	Underflow Weight % Solids	Underflow CU (mt/cu.m)
0	4000	60.77	0.9844
0.1	3800	60.00	0.9643
0.2	3600	59.00	0.9387
0.3	3400	58.00	0.9137
0.38	3200	57.00	0.8891
0.47	3000	56.00	0.8650
0.55	2800	55.00	0.8414
0.63	2600	54.00	0.8182
0.7	2400	53.00	0.7954
0.78	2200	52.00	0.7731
0.9	2000	51.00	0.7512
1.03	1800	50.00	0.7297
1.18	1600	49.00	0.7086
1.33	1400	48.00	0.6879
1.5	1200	47.00	0.6675
2	1000	46.00	0.6475
2.5	925	45.00	0.6279
3	840	44.00	0.6086
3.5	775	43.00	0.5896
4	725	42.00	0.5710
4.5	685	41.00	0.5527
5	640	40.00	0.5347
6	585	39.00	0.5169
7	550	38.00	0.4995
8	525	37.00	0.4824
9	500	36.00	0.4655
10	475	35.00	0.4489
12	440	34.00	0.4326
14	420	33.00	0.4165
16	400	32.00	0.4007
18	390	31.00	0.3852
20	380	30.00	0.3699
25	370	29.00	0.3548
30	355	28.00	0.3399
35	345	27.00	0.3253
40	340	26.00	0.3109
50	335	25.00	0.2967
60	325	24.00	0.2827
70	320	23.00	0.2689

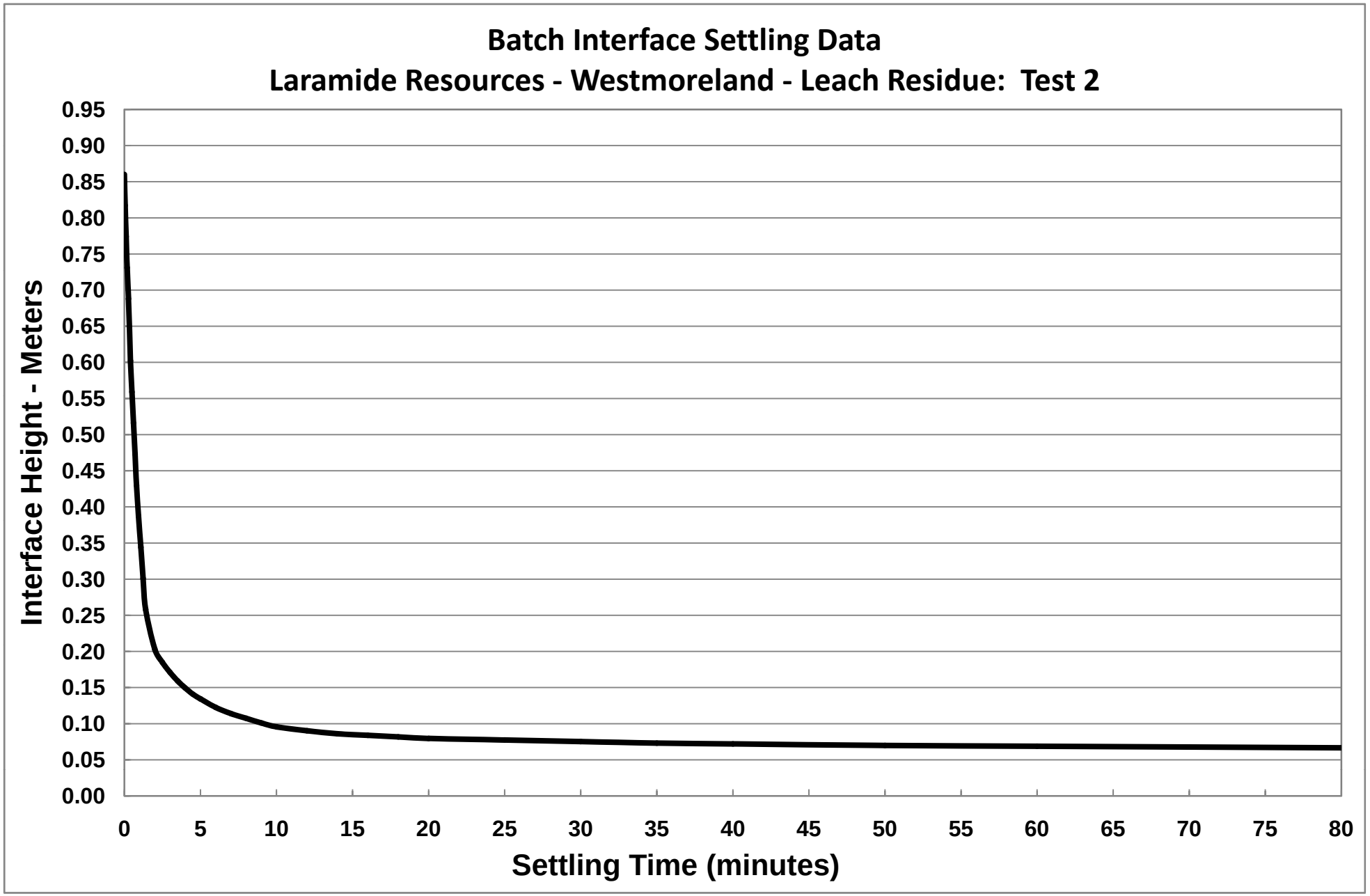

Batch Interface Settling Data
Laramide Resources - Westmoreland - Leach Residue: Test 1
Interface Height - Meters
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
Settling Time (minutes)

Thickener Test Summary for Laramide Resources - Westmoreland March 30, 2011

Job:	Westmoreland - Leach Residue	Undecanted Slurry Vol (ml):	4000.00	Depth Correction Type:	Auto
Test:	Test 2	Weight (g):	4196.26	Exponent:	
Company:	Laramide Resources	Decanted Slurry Vol (ml):	310.00	UF % Solids: Final:	61.57
Address:	Queensland	Weight (g):	506.26	Ultimate:	61.57
Material:	Uranium	Dry Solids Weight (g):	311.70	Init Settling Vel (m/hr):	48.09
Flocculant:	BASF Magnafloc 800HP	Settling Vessel Size (ml/ft):	1520.00	Intial Feed Concentration:	7.43
Concentration (g/l):	0.25	Ultimate Interface Height (ml):	310.00		
Volume Added (ml):	126.00	Specific Gravity Supernatant:	1.00		
Dosage (g/mt):	101.06	Specific Gravity Solids:	2.70		

Notes:

Time(min)	Height(ml)	Underflow Weight % Solids	Underflow CU (mt/cu.m)
0	4000	61.57	1.0055
0.05	3800	61.00	0.9904
0.12	3600	60.00	0.9643
0.18	3400	59.00	0.9387
0.27	3200	58.00	0.9137
0.4	2800	57.00	0.8891
0.5	2600	56.00	0.8650
0.6	2400	55.00	0.8414
0.7	2200	54.00	0.8182
0.8	2000	53.00	0.7954
0.93	1800	52.00	0.7731
1.08	1600	51.00	0.7512
1.23	1400	50.00	0.7297
1.4	1200	49.00	0.7086
2	945	48.00	0.6879
2.5	860	47.00	0.6675
3	795	46.00	0.6475
3.5	740	45.00	0.6279
4	695	44.00	0.6086
4.5	655	43.00	0.5896
5	625	42.00	0.5710
6	570	41.00	0.5527
7	530	40.00	0.5347
8	500	39.00	0.5169
9	470	38.00	0.4995
10	445	37.00	0.4824
12	420	36.00	0.4655
14	400	35.00	0.4489
16	390	34.00	0.4326
18	380	33.00	0.4165
20	370	32.00	0.4007
25	360	31.00	0.3852
30	350	30.00	0.3699
35	340	29.00	0.3548
40	335	28.00	0.3399
50	325	27.00	0.3253
60	320	26.00	0.3109
70	315	25.00	0.2967
80	310	24.00	0.2827


Batch Interface Settling Data
Laramide Resources - Westmoreland - Leach Residue: Test 2
Interface Height - Meters
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
Settling Time (minutes)

APPENDIX K

Rheology Testwork

K1. Rheology Data Bulk Leach

Rheology tests were carried out on the leach slurry from bulk leach and thickened underflow sample from vendor testwork (FLSmidth). The data was obtained using a HAAKE Viscotester 550. A MV1 bob and cup sensor system was used to measure torque at different speeds to generate a shear stress versus shear rate curve. Each set of readings was taken after the sample had been manually sheared by hand. **Figure K1** shows the curves generated from the viscometer measurements, along with Bingham model lines. Standard 60 wt.% (Leach concentration), and thickened 64 wt% slurry concentrations were measured.

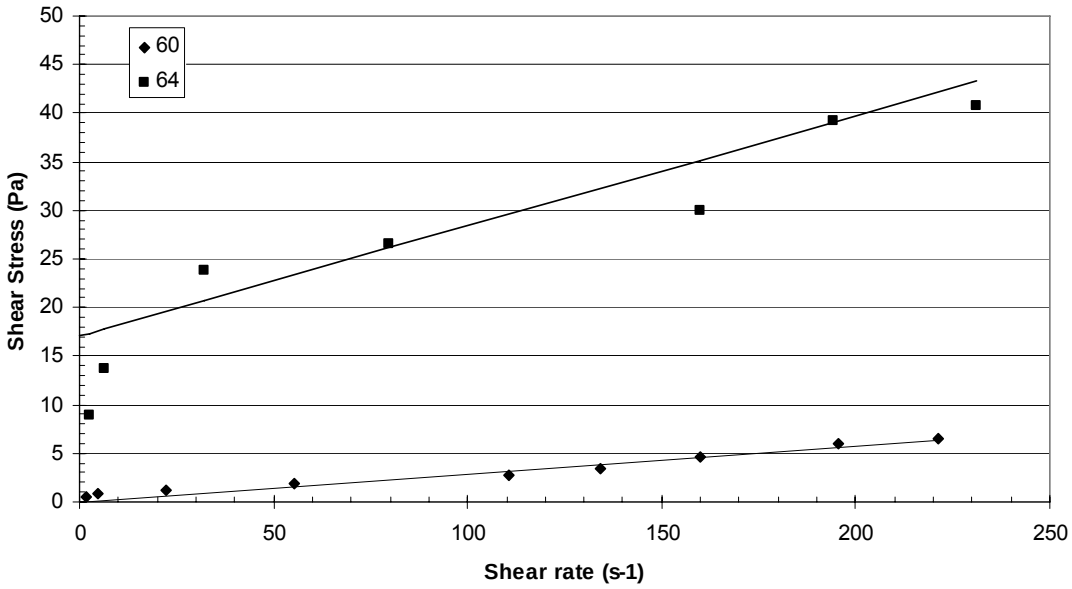


FIGURE K1 Shear Stress versus Shear Rate

Static yield stresses were measured using a FL100 vane sensor at 0.2 rpm. The 60 wt.% slurry sample did not have yield stress but the thickened sample, which was hand sheared prior to measurement had a yield stress of 32 Pa.

K2. Bingham Parameters

The data from the shear stress curves were fitted to the Bingham Plastic model which relates shear stress to shear rate by the simple equation

$$\tau = \tau_y + \mu_p \gamma$$

where τ is shear stress (Pa), τ_y represents the dynamic yield stress (Pa), μ is the plastic viscosity and γ is the shear rate (s^{-1}).

The data is fitted to the model such that the slope of the line represents the plastic viscosity of the slurry and the intercept at the shear stress axis is the Bingham yield stress. **Table K1** summarises the Bingham plastic parameters for the different solids concentrations.

TABLE K1
Bingham Plastic Parameters

	Wt.%	60	64
μ_p	Pa.s	0.026	0.113
τ_y	Pa	0	17
Static (τ_y)	Pa	0	32

The 60 wt% measurements match well, but the thickened sample appeared to reform the network of solids after manual shearing (result of flocculent addition). This meant for the static test, the yield stress was higher compared to calculated yield stress from bob and cup measurement, where there was continuous shearing of the slurry preventing the network from forming back with strength.

Raw Data

n (rpm)	Torque (μN.m)	
	60 wt% Slurry	64 wt% U/F
3.8	90	1400
3.8	90	2200
3.8	70	1400
3.8	80	1250
10.6	150	2000
10.6	130	2500
10.6	110	2300
10.6	120	2100
10.6	90	1900
51.27	260	3350
51.27	180	3800
51.27	180	3690
128	330	4850
128	290	3000
128	270	4180
256	420	4130
256	410	3800
256	390	5710
310.8	570	6700
310.8	490	6000
310.8	500	5850
370.2	770	7700
370.2	690	6000
370.2	620	6350
453	1000	8700
453	920	7530
453	850	7350
453	850	7890
512	1310	8540
512	990	8500
512	970	7200

APPENDIX L

Ion Exchange Detailed Results

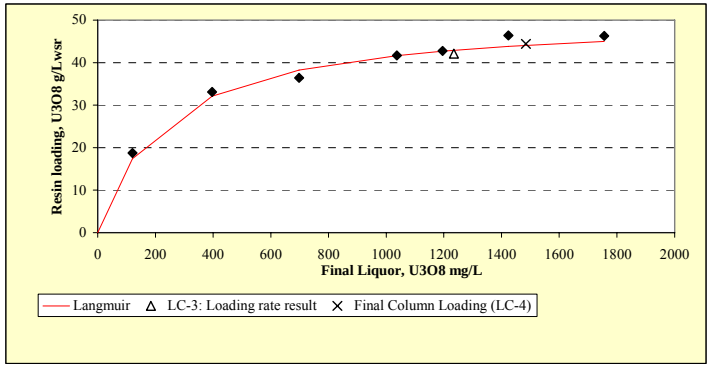
Uranium Ion Exchange Loading Isotherm – Data

Uranium Adsorption Isotherm

Test: LC-1
Feed: Undiluted PLS
pH: 1.5
ORP:
Fe (g/L):
Resin Type: AMBERSEP 920
Contact Time(h): 24
Contact Temp(°C): 35
Comment:
Total Capacity, Cl⁻ Form: ≥ 1.0

Ref:
Date: 13/04/2011
ICP Request No: 1100936
Elution ICP Request No: 1100938
DNA Request No: 1100940
Cl request no:

Test Conditions					Liquor Analysis										Resin Analysis							Selectivity	Statistics
	Initial aqueous									Equilibrium Aqueous					Liquor Assays	HNO3 Strip Assays					DNA	K(U3O8/Fe)	Accountability
Exp #	Resin	Soln vol	L/R	Comment	pH	Fe	SO4	Si	U3O8	pH	Fe	SO4	Si	U3O8	U3O8	Fe	SO4	Si	U3O8	P	U3O8		U3O8
	mL wsr	mL				mg/L	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	g/L wsr	g/L wsr	g/L wsr	g/L wsr	g/L wsr	g/Lwsr	g/L wsr		%
1	5.0	500	100		1.5	4,368	28,255		2269	1.3	4,247	27,880		1756	51.3	0.3	62	0	47.1	1.2	46.3	361	98
2	5.0	500	100		1.5	4,394	27,809		1901	1.4	4,284	27,628		1423	47.7	0.4	63	0	45.1	0.5	46.4	312	99
3	5.0	500	100		1.5	4,303	26,837		1627	1.4	4,293	28,039		1195	43.2	0.5	60	0	43.3	1.4	42.7	301	100
4	5.0	500	100		1.5	4,388	27,532		1469	1.4	4,308	27,844		1037	43.2	0.5	61	0	42.2	1.1	41.7	361	99
5	5.0	250	50		1.5	4,408	27,641		1469	1.4	4,243	27,101		698	38.5	0.8	60	0	37.6	0.9	36.4	292	97
6	5.0	150	30		1.5	4,378	27,711		1464	1.4	4,228	27,183		397	32.0	1.1	58	0	31.8	0.3	33.1	330	102
7	5.0	75	15		1.5	4,436	28,111		1500	1.5	4,013	25,795		120	20.7	1.7	54	0	19.0	0.8	18.8		91



Langmuir fit

$$L = \frac{L_{max} Kc}{1 + Kc}$$

experimental		calculated	Error		
[U3O8]aq mg/L	[U3O8]resin g/Lwsr	[U3O8]resin g/Lwsr			
1756	46.3	45.0	1.6	a_1=	51.0
1423	46.4	43.8	6.6	a_2=	0.0043
1195	42.7	42.7	0.0		
1037	41.7	41.6	0.0		
698	36.4	38.2	3.3		
397	33.1	32.1	1.0		
120	18.8	17.4	1.9		
0	0.0	0.0	0.0	Sum errors:	14.4

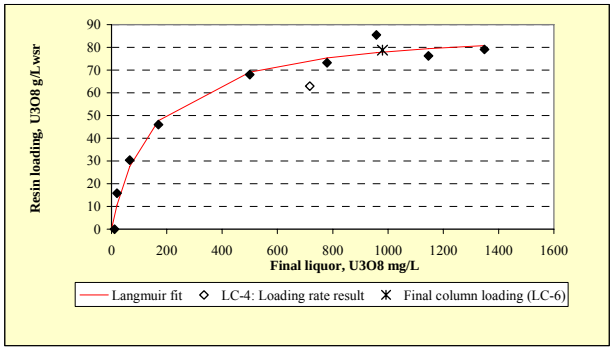
Uranium Adsorption Isotherm

Test: LC-2
Feed: Diluted PLS
pH: 1.5
ORP:
Fe (g/L):
Resin Type: AMBERJET 4400
Contact Time(h): 24
Contact Temp(°C): 35
Comment:
Total Capacity, Cl⁻ Form: ≥ 1.4

Ref:
Date: 13/04/2011
ICP Request No: 1100936
Elution ICP Request No: 1100938
DNA Request No: 1100940

Test					Liquor										Resin Analysis							Selectivity	Statistics
					Initial aqueous					Equilibrium Aqueous					Liquor Assays	HNO3 Strip Assays					DNA	K(U3O8/Fe)	Accountability
Exp #	Resin vol	Soln vol	L/R	Comme	pH	Fe	SO4	Si	U3O8	pH	Fe	SO4	Si	U3O8	U3O8	Fe	SO4	Si	U3O8	P	U3O8		U3O8
	mL wsr	mL				mg/L	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L	g/L wsr	g/L wsr	g/L wsr	g/L wsr	g/L wsr	g/L wsr	g/L wsr		%
1	5.0	500	100		1.5	3,202	21,525	353	2144	1.4	3,130	21,435	353	1349	79.6	1.0	102	0	81.3	0.4	79.1	182	100
2	5.0	500	100		1.5	3,171	21,478	399	1923	1.4	3,140	20,924	389	1146	77.7	1.1	102	0	79.1	1.8	76.2	191	99
3	5.0	500	100		1.5	3,174	21,649	349	1694	1.4	3,149	21,110	347	958	73.5	1.2	100	0	75.3	1.2	85.4	229	107
4	5.0	500	100		1.5	3,215	21,595	388	1489	1.4	3,147	21,123	366	780	70.9	1.3	102	0	73.8	0.8	73.2	221	102
5	5.0	400	80		1.5	3,216	21,562	387	1320	1.4	3,141	21,148	388	500	65.6	1.8	102	0	67.3	0.0	68.0	237	102
6	5.0	250	50		1.5	3,217	21,194	367	1061	1.4	3,074	20,221	362	170	44.6	2.9	94	0	46.0	0.9	46.0	287	103
7	5.0	150	30		1.5	3,173	21,036	369	1039	1.4	2,935	19,417	355	66	29.2	4.5	91	0	30.3	1.3	30.4	301	104
8	5.0	75	15		1.5	3,219	21,176	371	1058	1.5	2,632	17,996	369	20	15.6	6.1	89	0	15.7	2.6	15.8		102
														0									

A duplicate of contact 4 gave 72.7 g/Lwsr U



Langmuir fit

$$L = \frac{L_{max} Kc}{1 + Kc}$$

experimental		calculated	Difference	a_1=	89.8
[U3O8]aq mg/L	[U3O8]resin g/Lwsr	[U3O8]resin g/Lwsr		a_2=	0.00671
1349	79.1	80.8	3.0	Sum errors	118.2
1146	76.2	79.4	10.1		
958	85.4	77.7	60.3		
780	73.2	75.3	4.5		
500	68.0	69.1	1.3		
170	46.0	47.8	3.4		
66	30.4	27.6	7.8		
20	15.8	10.6	27.8		
0	0.0	0.0	0.0		

Uranium Loading Rate Isotherm - Data

Uranium Loading Rate

Liquor: UndilUted PLS
Resin: AMBERSEP 920
Contact Time(h): 24 h
Contact Temp(°C): 35
Sample Aliquot (mL): 1.0
Vol wsr (mL): 5.0
Density (g/mL): 1.040
wt of Feed (g): 1040

Exp No: LC-3
Ref:
Date: 15/04/11
ICP Request No: 1100968
Elution ICP Request No: 1100987
DNA Request No: 1100996

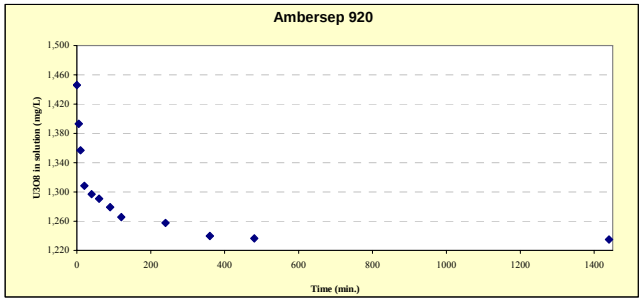
Elution Analysis	
Vol. wsr	Dil. Vol.
mL	mL
2.0	40

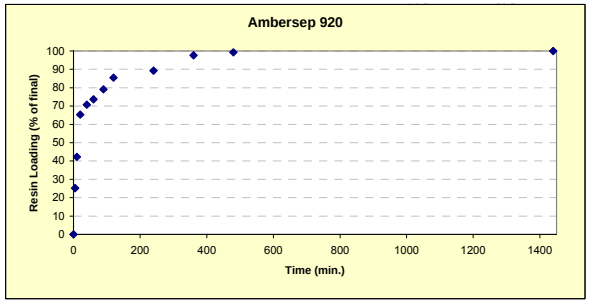
DNA Analysis on Equilibrium Resin				
Equilib. resin	Dry wt.	Dry wt./vol. wsr	U3O8	U3O8
mL wsr	g	g/L	ppm	g/L wsr
1.00	0.3382	338	125200	42.34

Final Resin Loading	
	U3O8 g/L_{wsr}
Elution	39.4
DNA	42.3
Calculated	42.1
% Accountability	100

		Liquor Analysis								Change in conc.	Adsorbed onto resin		Resin Composition		In samples	U3O8 Summary	
Sample Time	Liquor Vol	Fe	SO4	Si	U3O8	Zr	Mo	V	P	U3O8	U3O8	U3O8	U3O8	U3O8	U3O8	in liquor	on resin
min	mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	g/L	mg	g/L_{wsr}	g/L_{wsr}	%	mg	g/L	g/L wsr
0	1000	4,559	28,466	0	1,446	0.0	0.0	0.0	0.0	-	-	-	0.0	0.0	1.45	1.45	0.00
5	999	4,495	28,672	0	1,393	0.0	0.0	0.0	0.0	0.053	53.0	10.6	10.6	25.2	1.39	1.39	10.61
10	998	4,514	27,937	0	1,357	0.0	0.0	0.0	0.0	0.036	35.9	7.2	17.8	42.3	1.36	1.36	17.79
20	997	4,495	27,916	0	1,308	0.0	0.0	0.0	0.0	0.049	48.5	9.7	27.5	65.3	1.31	1.31	27.49
40	996	4,377	27,874	0	1,297	0.0	0.0	0.0	0.0	0.011	11.3	2.3	29.8	70.7	1.30	1.30	29.75
60	995	4,538	28,540	0	1,291	0.0	0.0	0.0	0.0	0.006	6.2	1.2	31.0	73.6	1.29	1.29	30.99
90	994	4,517	28,643	0	1,279	0.0	0.0	0.0	0.0	0.012	11.5	2.3	33.3	79.1	1.28	1.28	33.29
120	993	4,260	27,495	0	1,266	0.0	0.0	0.0	0.0	0.014	13.5	2.7	36.0	85.5	1.27	1.27	35.99
240	992	4,559	28,497	0	1,258	0.0	0.0	0.0	0.0	0.008	8.0	1.6	37.6	89.3	1.26	1.26	37.60
360	991	4,511	28,480	0	1,240	0.0	0.0	0.0	0.0	0.018	17.5	3.5	41.1	97.7	1.24	1.24	41.10
480	990	4,570	28,859	0	1,236	0.0	0.0	0.0	0.0	0.003	3.4	0.7	41.8	99.3	1.24	1.24	41.78
1440	989	4,491	28,331	0	1,235	0.0	0.0	0.0	0.0	0.001	1.5	0.3	42.1	100	1.23	1.23	42.08
													t_{50}	13.3 min	15.61		
													t_{75}	67.4 min			

HNO3 strip concentration (mg/L):	20	2886	0	1972	2	1.3	<1	3
ed Resin Composition	0	58	0	39.4	0.03	0.03	<0.02	0.07





RAW DATA **ICP** **Solution**

Uranium Loading Rate

Liquor: Diluted PLS
Resin: **AMBERJET 4400**
Contact Time(h): 24 h
Contact Temp(°C): 35
Sample Aliquot (mL): 1.0
Vol wsr (mL): 5.0
Density (g/mL): 1.040
wt of Feed (g): 1040

Exp No: **LC-4**
Ref:
Date: 15/04/11
ICP Request No: 1100968
Elution ICP Request No: 1100987
Digest Request No:
DNA Request No: 1100996
Cl request No:

Elution Analysis	
Vol. wsr	Dil. Vol.
mL	mL
2.0	40

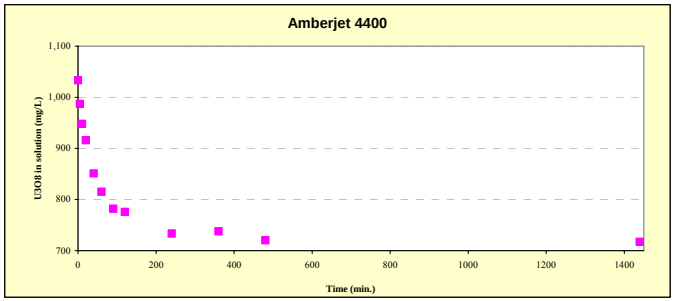
DNA Analysis on Equilibrium Resin				
Equilib. resin	Dry wt.	Dry wt./vol. wsr	U3O8	U3O8
mL wsr	g	g/L	ppm	g/L wsr
1.00	0.4658	466	164500	76.6

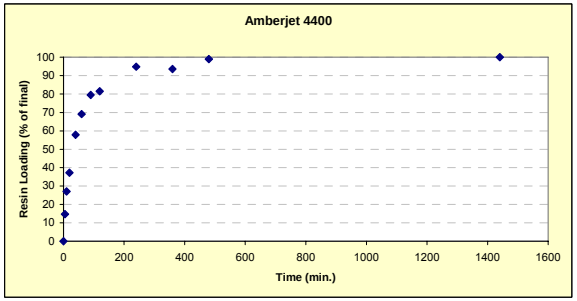
Final Resin Loading	U3O8 g/L_{wsr}
Elution	66.1
DNA	76.6
Calculated	62.9
Digest	0.1
% Accountability	107

		Liquor Analysis								Change in conc.	Adsorbed onto resin		Resin Composition		In samples
Sample Time	Liquor Vol	Fe	SO4	Si	U3O8	Zr	Mo	V	P	U3O8	U3O8	U3O8	U3O8	U3O8	U3O8
min	mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	g/L	mg	g/L_{wsr}	g/L_{wsr}	%	mg
0	1000	3,282	21,518	0	1,033	0.0	0.0	0.0	0.0	-	-	-	0.0	0.0	1.03
5	999	3,268	21,315	0	987	0.0	0.0	0.0	0.0	0.046	46.2	9.2	9.2	14.7	0.99
10	998	3,250	21,246	0	948	0.0	0.0	0.0	0.0	0.039	39.0	7.8	17.0	27.1	0.95
20	997	3,232	21,750	0	916	0.0	0.0	0.0	0.0	0.032	31.9	6.4	23.4	37.2	0.92
40	996	3,267	21,472	0	851	0.0	0.0	0.0	0.0	0.065	64.7	12.9	36.4	57.8	0.85
60	995	3,290	21,053	0	815	0.0	0.0	0.0	0.0	0.036	35.5	7.1	43.5	69.1	0.82
90	994	3,300	21,701	0	782	0.0	0.0	0.0	0.0	0.033	32.8	6.6	50.0	79.5	0.78
120	993	3,383	21,717	0	776	0.0	0.0	0.0	0.0	0.006	6.3	1.3	51.3	81.5	0.78
240	992	3,237	21,137	0	733	0.0	0.0	0.0	0.0	0.042	41.9	8.4	59.7	94.9	0.73
360	991	3,244	21,137	0	738	0.0	0.0	0.0	0.0	-0.004	-4.1	-0.8	58.9	93.6	0.74
480	990	3,235	21,222	0	720	0.0	0.0	0.0	0.0	0.017	17.1	3.4	62.3	99.0	0.72
1440	989	3,254	21,205	0	717	0.0	0.0	0.0	0.0	0.003	3.1	0.6	62.9	100	0.72
													t_{50}	32.4 min	10.02
HNO3 strip concentration (mg/L):		61	4800	0	3306	<1	1.2	<1	6				t75	77.0 min	
Loaded Resin Composition		1.2	96	0	66.1	<0.02	0.02	<0.02	0.11						

U3O8 Summary	
in liquor	on resin
g/L	g/L wsr
1.03	0.00
0.99	9.24
0.95	17.04
0.92	23.42
0.85	36.36
0.82	43.47
0.78	50.04
0.78	51.30
0.73	59.69
0.74	58.87
0.72	62.30
0.72	62.92

$-\ln(1-\%^2)$
0 #VALUE!
0.000





Ion Exchange Column Loading – Breakthrough Curve Data

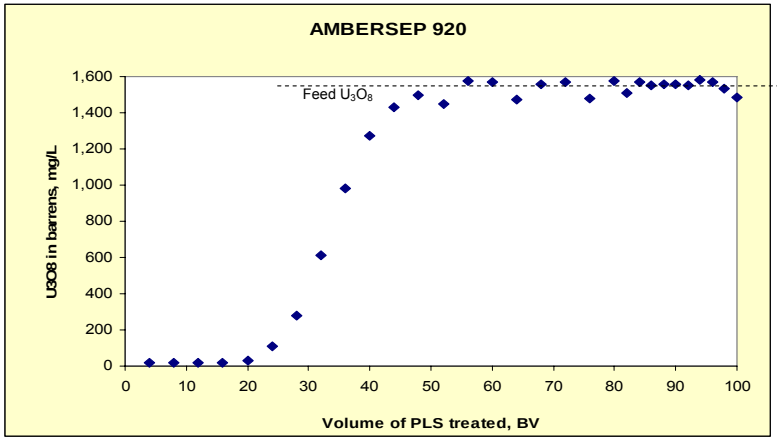
COLUMN LOADING - LAGOON CREEK

Feed: Undiluted PLS
Resin: Ambersep 920 - SO4 form
Contact Temp (˚ C): 35
Bed volume (mLwsr): 100
Feed flowrate (BV/h) 4.0 6.7 mL/min.
Linear Velocity (m/h): 1.05

Exp No: LC-5
Ref:
Date: 12/04/2011
Solution ICP Request No(s): 1100900
Resin elution job # 1100902
Silica strip job # 1100903
Resin DNA job # 1100940

	U3O8	Fe	SO4	Si	P
Feed composition, mg/L:	1,495	4,268	29,271	599	79
Fresh resin, g/Lwsr	0	0	43.2	0	0

Loading data			Barrens composition, mg/L (ICPOES)					Mass loaded, mg	Resin Loading, g/Lwsr
Exp No	Volume (BV)	(L)	S.Gfraction (g/mL)	U3O8	Fe	SO4	Si	U3O8	U3O8
0	0	0	1.05	1495	4268	29,271	599	0.0	
2	4	0.4	1.05	19.7	3,164	21,755	191	590	5.90
4	8	0.8	1.05	20.0	4,479	29,999	235	590	17.7
6	12	1.2	1.05	20.2	4,573	30,504	287	590	23.6
8	16	1.6	1.05	20.5	4,457	30,383	332	590	29.5
10	20	2.0	1.05	30.3	4,531	30,633	365	586	35.4
12	24	2.4	1.05	111.6	4,524	30,579	387	553	40.9
14	28	2.8	1.05	279.7	4,537	30,570	415	486	45.8
16	32	3.2	1.05	609.4	4,526	30,753	433	354	49.3
18	36	3.6	1.05	980.2	4,466	30,702	449	206	51.4
20	40	4.0	1.05	1274.0	4,426	30,718	464	88.4	52.2
22	44	4.4	1.05	1432.4	4,425	30,414	468	25.0	52.5
24	48	4.8	1.05	1499.6	4,358	29,503	479	-1.8	52.5
26	52	5.2	1.05	1449.8	4,089	28,929	487	18.1	52.7
28	56	5.6	1.05	1575.9	4,417	30,444	493	-32.4	52.3
30	60	6.0	1.05	1567.0	4,387	30,344	495	-28.8	52.0
32	64	6.4	1.05	1473.2	4,160	28,844	496	8.7	52.1
34	68	6.8	1.05	1556.4	4,369	30,020	501	-24.6	51.9
36	72	7.2	1.05	1571.4	4,394	29,930	501	-30.6	51.6
38	76	7.6	1.05	1479.5	4,152	28,848	512	6.2	51.6
40	80	8.0	1.05	1573.7	4,438	30,530	513	-31.5	45.4
42	84	8.4	1.05	1511.1	4,205	29,356	519	-6.4	45.4
43	86	8.6	1.05	1568.4	4,372	30,008	519	-14.7	45.2
44	88	8.8	1.05	1549.5	4,301	29,852	515	-10.9	45.1
45	90	9.0	1.05	1557.3	4,338	30,064	515	-12.5	45.0
46	92	9.2	1.05	1559.2	4,377	29,888	511	-12.8	44.8
47	94	9.4	1.05	1552.2	4,325	30,292	514	-11.4	44.7
48	96	9.6	1.05	1579.8	4,402	30,363	516	-17.0	44.6
49	98	9.8	1.05	1566.7	4,366	30,493	523	-14.3	44.4
50	100	10.0	1.05	1535.6	4,267	30,172	521	-8.1	44.3
	Final bulk barrens assay (mg/L):			1,105	4,380	29,193	441	4,434	



	U3O8	Fe	SO4	Si	P
Loaded resin assay (g/Lwsr), HNO3 strip:	45.8	<0.02	59.4	17.6	0.35
Loaded resin assay (g/Lwsr), DNA:	45.3				
Accountability (%)	104				

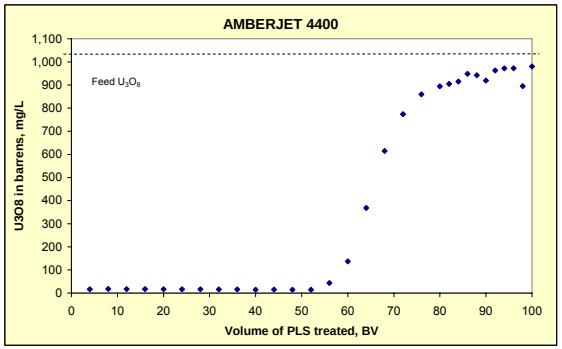
COLUMN LOADING - LAGOON CREEK

Feed: Diluted PLS
Resin: Amberjet 4400 - SO4 form
Contact Temp (˚ C): 35
Bed volume (mLwsr): 100
Feed flowrate (BV/h) 4.0 6.7 mL/min.
Linear velocity (m/h):: 1.05

Exp No: LC-6
Ref:
Date: 12/04/2011
Solution ICP Request No(s): 1100900
Resin elution job # 1100902
Silica strip job # 1100903
Resin DNA job # 1100940

	U3O8	Fe	S	Si
Feed composition, mg/L:	1,053	2,970	7,170	410
	U3O8	Fe	S	Si
Fresh resin composition (g/Lwsr):	0	0	20.9	0

Loading Column data			Barrens composition, mg/L (ICPOES)				Mass loaded to resin, mg	Resin Composition, g/Lwsr
Exp No	Volume (BV)	Volume (L)	U3O8	Fe	S	Si	U3O8	U3O8
0	0	0	1,053	2,970	7,170	410		
1	2	0.2						
2	4	0.4	16.6	1,850	5,166	498	415	4.15
3	6	0.6						
4	8	0.8	18.1	3,757	8,232	510	414	8.29
5	10	1.0						
6	12	1.2	17.2	3,506	8,360	503	414	12.4
7	14	1.4						
8	16	1.6	17.1	3,711	8,678	506	415	16.6
9	18	1.8						
10	20	2.0	16.5	3,729	8,545	498	415	20.7
11	22	2.2						
12	24	2.4	16.2	3,602	8,287	484	415	24.9
13	26	2.6						
14	28	2.8	16.2	3,578	8,413	477	415	29.0
15	30	3.0						
16	32	3.2	16.0	3,550	8,353	474	415	33.2
17	34	3.4						
18	36	3.6	15.9	3,209	7,552	468	415	37.3
19	38	3.8						
20	40	4.0	15.0	3,369	8,041	446	415	41.5
21	42	4.2						
22	44	4.4	15.0	3,254	7,503	432	415	45.6
23	46	4.6						
24	48	4.8	14.4	3,086	7,253	422	416	49.8
25	50	5.0						
26	52	5.2	15.0	3,070	7,267	422	415	53.9
27	54	5.4						
28	56	5.6	43.1	3,128	7,381	425	404	58.0
29	58	5.8						
30	60	6.0	137	3,114	7,380	420	367	61.6
31	62	6.2						
32	64	6.4	369	2,975	7,163	393	274	64.4
33	66	6.6						
34	68	6.8	615	2,888	7,062	391	176	66.1
35	70	7.0						
36	72	7.2	774	2,945	7,162	401	112	67.3
37	74	7.4						
38	76	7.6	860	2,913	7,054	396	77.5	68.0
39	78	7.8						
40	80	8.0	895	2,920	7,231	393	31.7	68.4
41	82	8.2	905				29.7	
42	84	8.4	915	2,888	7,182	389	27.6	68.9
43	86	8.6	949	2,898	7,244	395	20.9	69.1
44	88	8.8	943	2,871	7,109	391	22.1	69.4
45	90	9.0	920	2,500	6,488	389	26.7	69.6
46	92	9.2	963	2,910	7,232	389	18.1	69.8
47	94	9.4	972	2,892	7,268	390	16.2	70.0
48	96	9.6	973	2,590	6,741	385	16.1	70.1
49	98	9.8	895	2,638	6,694	392	31.7	70.4
50	100	10.0	980	2,888	7,261	390	14.6	70.6
1275								7,059



	U3O8	Fe	S	Si	P
Loaded resin assay (g/Lwsr), HNO3 strip:	74.0	0.3	31.43	1.7	0.6
Loaded resin assay (g/Lwsr), DNA:	78.7				
Accountability (%)	142				

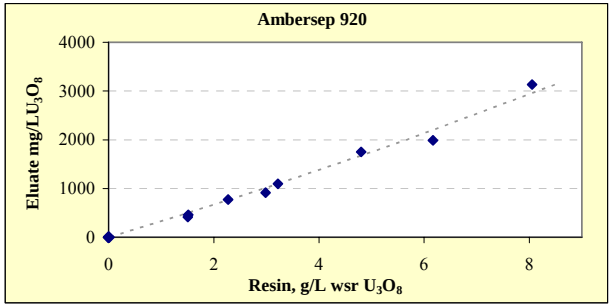
Elution Isotherm Results

Eluant 1 M H2SO4

H_2SO_4 g/L: 98
Resin Type: AMBERSEP 920
Contact Time(h): 24
Contact Temp (^oC): 35
Resin Analysis: Batch Contact with ~2 mLwsr: 40 mL 1M HNO_3 for 24 h for all samples
DNA Analysis: Oven dried at 110˚C for 24 h

Exp No: LC-7
Ref:
Date: May-11
ICP Request No: 1100989
Elution ICP Request No: 1101004
Digest Request No:
DNA Request No: 1100996

Experiment Details			Eluant Analysis												Resin Analysis								
			Initial concentration						Equilibrium concentration						Elution							DNA	Accountablity
Exp #	Resin	Soln vol	Fe	SO4	U3O8	Zr	V	Mo	Fe	SO4	U3O8	Zr	V	Mo	Fe	SO4	U3O8	Zr	V	Mo	P	U3O8	U3O8
	mL wsr	mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/Lwsr	g/Lwsr	g/Lwsr	mg/Lwsr	mg/Lwsr	mg/Lwsr	mg/Lwsr	g/L wsr	%
A	B	C									0				Initial:		45.8					45.3	
1	5.0	500	<1	87,000	2,782	<1	<1	<1	2.5	84,900	3,134	<1	<1	<1	<0.02	52	8.5	<0.02	<0.02	<0.02	<0.02	8.1	99
2	5.0	500	<1	86,100	1,372	<1	<1	<1	2.0	84,000	1,750	<1	<1	<1	<0.02	51	5.1	<0.02	<0.02	<0.02	<0.02	4.8	99
7	5.0	250	<1	85,800	349	<1	<1	<1	1.9	84,000	1,096	<1	<1	<1	<0.02	55	3.4	<0.02	<0.02	<0.02	<0.02	3.2	92
3	5.0	500	<1	85,200	325	<1	<1	<1	8.5	84,300	774	<1	<1	<1	<0.02	49	2.3	<0.02	<0.02	<0.02	<0.02	2.3	102
4	5.0	500	<1	85,800	2	<1	<1	<1	1.6	84,000	416	<1	<1	<1	<0.02	54	0.8	<0.02	<0.02	<0.02	<0.02	1.5	95
5	5.0	1000	<1	86,100	3	<1	<1	<1	2.3	84,300	459	<1	<1	<1	<0.02	54	1.5	<0.02	<0.02	<0.02	<0.02	1.5	104
6	5.0	250	<1	85,800	2	<1	<1	<1	7.9	81,300	1,989	1	<1	<1	<0.02	53	2.7	<0.02	<0.02	<0.02	<0.02	6.2	133
8	5.0	100	<1	85,200	3	<1	<1	<1	4.8	84,600	915	<1	<1	<1	<0.02	56	6.4	<0.02	<0.02	<0.02	<0.02	3.0	87
											0											0	



Calc R	Exp R	Exp C
8.48	8.1	3,134
5.63	6.2	1,989
5.00	4.8	1,750
3.22	3.2	1,096
2.71	3.0	915
2.30	2.3	774
1.38	1.5	459
1.25	1.5	416
0.00	0.0	0

Diff		
0.184	a1	70.96
0.290	a2	4.33E-05
0.039	Sumdiff2	0.671
0.000		
0.077		
0.001		
0.017		
0.062		
0		

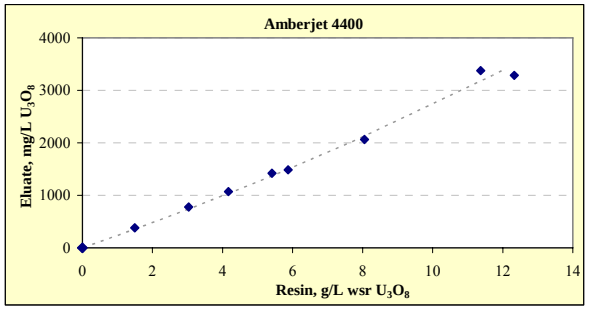
3.07E-03

Eluant 1 M H2SO4

H_2SO_4 g/L: 98
Resin Type: AMBERJET 4400
Contact Time(h): 24
Contact Temp (°C): 35
Resin Analysis: Batch Contact with ~2 mLwsr: 40 mL 1M HNO_3 for 24 h for all samples
DNA Analysis: Oven dried at 110˚C for 24 h

Exp No: LC-8
Ref:
Date: May-11
ICP Request No: 1100989
Elution ICP Request No: 1101004
Digest Request No:
DNA Request No: 1100996

Experiment Details			Eluant Analysis													Resin Analysis								
			Initial concentration						Equilibrium concentration							Elution							DNA	Accountablity
Exp #	Resin vol	Soln vol	Fe	SO4	U3O8	Zr	V	Mo	Fe	SO4	U3O8	Zr	V	Mo	P	Fe	S	U3O8	Zr	V	Mo	P	U3O8	U3O8
	mL wsr	mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/Lwsr	mg/Lwsr	g/Lwsr	mg/Lwsr	mg/Lwsr	mg/Lwsr	mg/Lwsr	g/L wsr	%
											0					**Initial**		**74.0**					**78.7**	
1	5.0	500	<1	86,700	2,756	<1	<1	<1	8	84,600	3,373	<1	<1	<1	<1	<0.02	29.8	11.1	<0.02	<0.02	<0.02	<0.02	11.4	98
2	5.0	500	<1	84,900	1,334	<1	<1	<1	8	84,900	2,064	<1	<1	<1	<1	<0.02	38.6	8.2	<0.02	<0.02	<0.02	<0.02	8.1	101
3	5.0	500	<1	85,200	695	<1	<1	<1	9	84,600	1,422	<1	<1	<1	<1	<0.02	34.4	5.3	<0.02	<0.02	<0.02	<0.02	5.4	100
4	5.0	500	<1	86,100	330	<1	<1	<1	8	84,000	1,071	<1	<1	<1	<1	<0.02	34.8	4.1	<0.02	<0.02	<0.02	<0.02	4.2	100
5	5.0	1000	<1	84,900	2.2	<1	<1	<1	4	84,900	383	<1	<1	<1	<1	<0.02	32.8	1.4	<0.02	<0.02	<0.02	<0.02	1.5	99
6	5.0	500	<1	84,900	2.3	<1	<1	<1	9	84,300	779	<1	<1	<1	<1	<0.02	34.2	3.0	<0.02	<0.02	<0.02	<0.02	3.0	102
7	5.0	250	<1	85,800	2.5	<1	<1	<1	17	83,700	1,485	<1	<1	<1	<1	<0.02	35.6	5.7	<0.02	<0.02	<0.02	<0.02	5.9	102
8	5.0	100	<1	85,500	3.0	<1	<1	<1	44	81,900	3,285	<1	<1	<1	<1	<0.02	34.4	12.4	<0.02	<0.02	<0.02	<0.02	12.3	99
											0												0.0	



Calc R	Exp R	Exp C
11.96	11.4	3,373
11.70	12.3	3,285
7.83	8.1	2,064
5.82	5.9	1,485
5.59	5.4	1,422
4.29	4.2	1,071
3.17	3.0	779
1.60	1.5	383
0.00	0.0	0

Diff		
0.354	a1	70.90
0.393	a2	6.02E-05
0.049	Sumdiff2	0.876
0.003		
0.032		
0.015		
0.019		
0.011		
0		

0.0042662

Elution Kinetics Results

Uranium Elution Rate

Eluant 1 M H2SO4
Resin: Loaded Ambersep 920
Contact Time(h): 24
Contact Temp(°C): 35
Sample Aliquot (mL): 1.0
Vol wsr (mL): 10.0
Vol eluant (mL): 2000

Exp No: LC-9 (EK-9)
Ref:
Date: 19.04.11
ICP Request No: 1100968
Elution ICP Request No: 1100987
Digest Request No: -
DNA Request No: 1100996

Elution Analysis	
Vol. wsr	Dil. Vol.
mL	mL
2.0	40

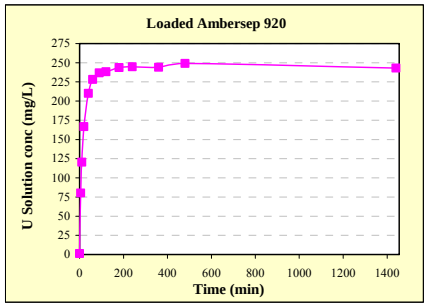
DNA Analysis on Equilibrium Resin				
Equilib. resin	Dry wt.	Dry wt./vol. wsr	U3O8	U3O8
mL wsr	g	g/L	ppm	g/L wsr
1.00	0.2511	251	3100	0.78

Resin Loading	Final	Initial
	U3O8 g/L_{wsr}	**U3O8 g/L_{wsr}**
Elution	0.8	45.8
DNA	0.8	45.3

% Accountability	109

Eluate Analysis									Change in conc.	Desorbed from resin		Resin composition	
Sample Time	Liquor Vol	Fe	SO4	Si	Zr	U3O8	Mo	V	U3O8	U3O8		U3O8	U3O8
min	mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg	g/L_{wsr}	g/L_{wsr}	%
0	2000	<1	92,040		<1	1.2	<1	<1	-	-		45.3	0
5	1999	2.4	92,259		<1	80.1	<1	<1	78.9	157.8	15.78	29.5	35
10	1998	2.7	90,572		<1	120	<1	<1	40.1	80.2	8.02	21.5	53
20	1997	2.7	91,505		<1	167	<1	<1	46.5	92.8	9.28	12.2	73
40	1996	2.8	89,627		<1	210	<1	<1	43.3	86.3	8.63	3.55	92
60	1995	2.8	92,410		<1	228	<1	<1	18.1	36.2	3.62	0.00	100
90	1994	2.8	89,278		<1	237	<1	<1	8.76	17.5	1.75	0.00	100
120	1993	2.7	90,516		<1	238	<1	<1	1.31	2.6	0.26	0.00	100
180	1992	2.8	93,043		<1	244	<1	<1	5.42	10.8	1.08	0.00	100
240	1991	2.8	89,684		<1	245	<1	<1	1.15	2.3	0.23	0.00	100
360	1990	2.8	93,987		<1	244	<1	<1	-0.59	-1.2	-0.12	0.12	100
480	1989	2.9	91,968		<1	249	<1	<1	5.09	10.1	1.01	0.00	100
1440	1988	2.8	93,068		<1	243	<1	<1	-6.29	-12.5	-1.25	1.25	97
												t50	9 min
Final resin loading (mg/L		<0.02	16		<0.02	0.7	<0.02	<0.02	<0.02			t75	22 min

In samples	U Summary	
U3O8	in liquor	on resin
mg	g/L	g/L wsr
0.01	0.00	45.27
0.80	0.08	29.49
1.20	0.12	21.47
1.67	0.17	12.19
2.10	0.21	3.55
2.28	0.23	0.00
2.37	0.24	0.00
2.38	0.24	0.00
2.44	0.24	0.00
2.45	0.24	0.00
2.44	0.24	0.12
2.49	0.25	0.00
2.43	0.24	1.25
Total: 25.06		



Uranium Elution Rate

Eluant 1 M H2SO4
Resin: Loaded Amberjet 4400
Contact Time(h): 24
Contact Temp(°C): 35
Sample Aliquot (mL): 1.0
Vol wsr (mL): 10.0
Vol eluant (mL): 2000

Exp No: LC-10 (EK-10)
Ref:
Date: 19.04.11
ICP Request No: 1100968
Elution ICP Request No: 1100987
Digest Request No: -
DNA Request No: 1100996

Elution Analysis	
Vol. wsr	Dil. Vol.
mL	mL
2.0	40

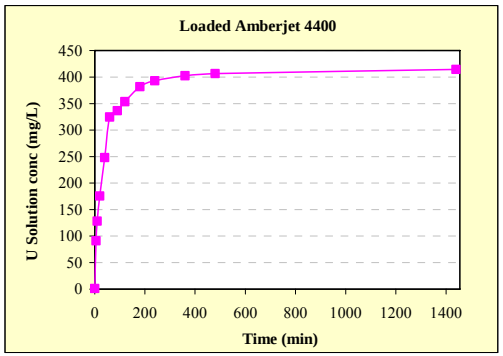
DNA Analysis on Equilibrium Resin				
Equilib. resin	Dry wt.	Dry wt./vol. wsr	U3O8	U3O8
mL wsr	g	g/L	ppm	g/L wsr
1.00	0.4018	402	3560	1.43

	Final U3O8 g/L_{wsr}	Initial U3O8 g/L_{wsr}
Elution	1.4	74.0
DNA	1.4	78.7

% Accountability	104

		Eluate Analysis							Change in conc.	Desorbed from resin		Resin composition	
Sample Time	Liquor Vol	Fe	SO4	Si	Zr	U3O8	Mo	V	U3O8	U3O8		U3O8	U3O8
min	mL	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg	g/L_{wsr}	g/L_{wsr}	%
0	2000	<1	92,546		<1	1.2	<1	<1	-	-		78.7	0
5	1999	3.1	90,503		<1	91.1	<1	<1	89.9	179.8	17.98	60.8	23
10	1998	3.7	89,475		<1	128	<1	<1	37.0	73.9	7.39	53.4	32
20	1997	4.5	89,803		<1	176	<1	<1	47.8	95.4	9.54	43.8	44
40	1996	5.6	96,606		<1	248	<1	<1	72.2	144.2	14.42	29.4	63
60	1995	10.0	91,836		<1	325	<1	<1	76.6	152.8	15.28	14.1	82
90	1994	6.8	90,228		<1	337	<1	<1	11.89	23.7	2.37	11.8	85
120	1993	7.1	91,482		<1	354	<1	<1	17.18	34.2	3.42	8.35	89
180	1992	7.3	90,220		<1	382	<1	<1	28.06	55.9	5.59	2.76	96
240	1991	7.5	93,065		<1	393	<1	<1	11.45	22.8	2.28	0.48	99
360	1990	7.5	93,918		<1	403	<1	<1	9.433	18.8	1.88	0.00	100
480	1989	7.6	93,266		<1	406	<1	<1	3.71	7.4	0.74	0.00	100
1440	1988	7.7	94,680		<1	414	<1	<1	8.10	16.1	1.61	0.00	100
												t50	26 min
Final resin loading (mg		<0.02	30		<0.02	1.2	<0.02	<0.02				t75	53 min

In samples	U Summary	
U3O8	in liquor	on resin
mg	g/L	g/L wsr
0.01	0.00	78.74
0.91	0.09	60.77
1.28	0.13	53.38
1.76	0.18	43.84
2.48	0.25	29.42
3.25	0.32	14.14
3.37	0.34	11.77
3.54	0.35	8.35
3.82	0.38	2.76
3.93	0.39	0.48
4.03	0.40	0.00
4.06	0.41	0.00
4.14	0.41	0.00
Total: 36.58		



Column Elution Results

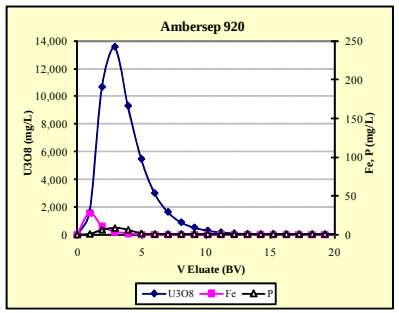
Column Elution rate for U Loaded Resins

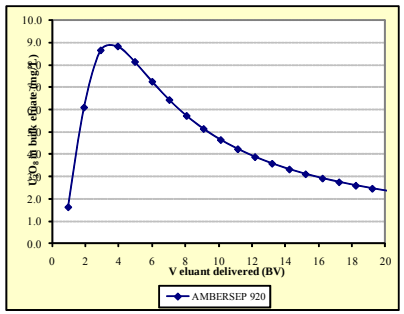
Eluant: 1 M H2SO4
Resin: AMBERSEP 920
Contact Temp: 35
Bed volume (mLwsr): 35
Elution Volume (BV): 20
Eluant flowrate (BV/h) 1.0 #######
Linear Velocity (m/h): 0.09
0.09212

Exp No: LC-11
Ref:
Date: 27/04/11
Solution ICP Request No(s): 1101006
Resin elution job # 1101017
Silica strip job # 1101019
Resin DNA job # 1101030

Elution data						Eluate composition, mg/L (ICPOES)							Mass in eluate, mg							Resin Composition, g/Lwsr			Stripped (%)		U3O8 in bulk eluate (mg/L)
Exp No	Volume (BV)	Time (min).	Vfraction (mL)	Wfraction (g)	S.Gfraction (g/mL)	U3O8	Fe	V	Mo	Zr	P	Si	U3O8	Fe	V	Mo	Zr	P	Si	U3O8	Fe	P	U3O8	Fe	
	0	0	0	0	0	0	0	0	0	0	0	0			0	0		0		45.3	0.02	0.35			
1	0.98	59	34.3	34.420	1.00	1,642	28.2	1	<2	1	1.0	65	56.3	0.967	<0.04	<0.07	0.034	0.0	2.2	43.7	0.0	0.35	3.4	62.7	1.6
2	1.93	116	33.2	34.850	1.05	10,681	11.1	1	<2	5.51	6.5	282	355	0.369	<0.04	<0.07	0.183	0.2	9.4	33.5	0.0	0.34	24.7	86.6	6.1
3	2.9	176	34.9	37.080	1.06	13,578	4.02	1	<2	8.49	9.0	398	474	0.140	<0.04	<0.07	0.297	0.3	13.9	20.0	0.0	0.34	53.2	95.7	8.6
4	4.0	237	35.9	38.460	1.07	9,311	1.83	1	<2	7.51	6.7	367	335	0.066	<0.04	<0.07	0.270	0.2	13.2	10.4	0.0	0.33	73.4	100.0	8.8
5	5.0	299	36.0	38.300	1.06	5,470	<1	1	<2	4.95	1.7	316	197	<0.04	<0.04	<0.07	0.178	0.1	11.4	4.8	0.0	0.33	85.2	100.0	8.1
6	6.0	361	36.2	38.560	1.06	3,000	<1	1	<2	3.44	1.0	280	109	<0.04	<0.04	<0.07	0.125	0.04	10.1	1.7	0.0	0.33	91.7	100.0	7.2
7	7.0	423	36.0	38.610	1.07	1,642	<1	1	<2	2.43	1.0	250	59.1	<0.04	<0.04	<0.07	0.088	0.04	9.0	0.0	0.0	0.33	95.3	100.0	6.4
8	8.1	485	36.2	38.640	1.07	890	<1	1	<2	1.7	1.0	220	32.2	<0.04	<0.04	<0.07	0.061	0.04	8.0	0.0	0.0	0.32	97.2	100.0	5.7
9	9.1	546	35.7	38.410	1.08	517	<1	1	<2	1.26	1.0	202	18.4	<0.04	<0.04	<0.07	0.045	0.04	7.2	0.0	0.0	0.32	98.3	100.0	5.1
10	10.1	608	36.1	38.350	1.06	299	<1	1	<2	1	1.0	180	10.8	<0.04	<0.04	<0.07	<0.04	0.04	6.5	0.0	0.0	0.32	99.0	100.0	4.6
11	11.2	669	35.8	37.990	1.06	168	<1	1	<2	1	1.0	166	6.02	<0.04	<0.04	<0.07	<0.04	0.04	5.9	0.0	0.0	0.32	99.4	100.0	4.2
12	12.2	731	36.2	38.530	1.07	105	<1	1	<2	1	1.0	157	3.78	<0.04	<0.04	<0.07	<0.04	0.04	5.7	0.0	0.0	0.32	99.6	100.0	3.9
13	13.2	793	36.0	38.320	1.06	61	<1	1	<2	1	1.0	147	2.19	<0.04	<0.04	<0.07	<0.04	0.04	5.3	0.0	0.0	0.32	99.7	100.0	3.6
14	14.3	855	36.2	38.620	1.07	34	<1	1	<2	1	1.0	139	1.25	<0.04	<0.04	<0.07	<0.04	0.04	5.0	0.0	0.0	0.32	99.8	100.0	3.3
15	15.2	913	34.0	36.250	1.07	55	<1	1	<2	1	1.0	148	1.86	<0.03	<0.04	<0.07	<0.04	0.03	5.0	0.0	0.0	0.32	99.9	100.0	3.1
16	16.2	974	35.6	37.690	1.06	31	<1	1	<2	1	1.0	139	1.09	<0.04	<0.04	<0.07	<0.04	0.04	4.9	0.0	0.0	0.32	100.0	100.0	2.9
17	17.2	1034	34.8	37.010	1.06	7	<1	1	<2	1	1.0	124	0.25	<0.04	<0.04	<0.07	<0.04	0.03	4.3	0.0	0.0	0.32	100.0	100.0	2.8
18	18.2	1094	35.2	37.360	1.06	4	<1	1	<2	1	1.1	116	0.16	<0.04	<0.04	<0.07	<0.04	0.04	4.1	0.0	0.0	0.31	100.0	100.0	2.6
19	19.2	1154	34.6	36.780	1.06	3	<1	1	<2	1	1.0	110	0.09	<0.04	<0.04	<0.07	<0.04	0.03	3.8	0.0	0.0	0.31	100.0	100.0	2.5
20	20.2	1213	34.5	36.630	1.06	3	<1	1	<2	1	1.0	104	0.09	<0.04	<0.04	<0.07	<0.04	0.03	3.6	0.0	0.0	0.31	100.0	100.0	2.4
													0.00	0.000	0.000	0.000	0.000	0.0							
												Total M:	1,663	1.5	0.0	0.0	1.3	1.4	138.6						

Back calculated loading (g/Lwsr):	47.5		
Loaded resin assay (g/Lwsr):	45.3	0.02	0.4
HNO3/NaOH stripped final resin assay (g/Lwsr):	0.1	0.02	0.02
DNA Final resin assay (g/Lwsr):	0.2		
Accountability (%)	105		





Column Elution rate for U, V Loaded Resins

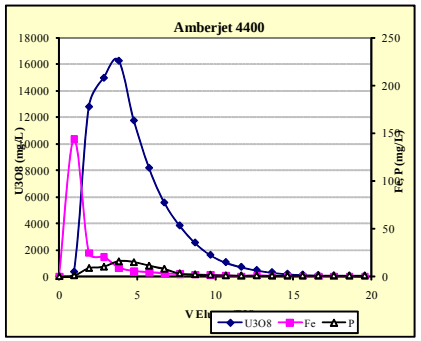
Eluant: 1 M H2SO4
Resin: AMBERJET 4400
Contact Temp: 35
Bed volume (mLwsr): 35
Elution Volume (BV): 20
Eluant flowrate (BV/h) 1.0 ######
Linear Velocity (m/h): 0.26

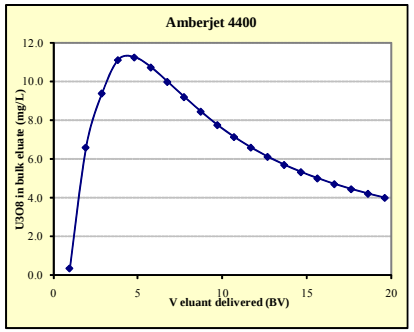
Exp No: LC-11
Ref:
Date: 27/04/11
Solution ICP Request No(s): 1101006
Resin elution job # 1101017
Silica strip job # 1101019
Resin DNA job # 1101030

Elution data						Eluate composition, mg/L (ICPOES)							Mass in eluate, mg							Resin Composition, g/Lwsr			Stripped (%)		U3O8 in bulk eluate (mg/L)
Exp No	Volume (BV)	Time (min).	Vfraction (mL.)	Wfraction (g)	S.Gfraction (g/mL)	U3O8	Fe	V	Mo	Zr	P	Si	U3O8	Fe	V	Mo	Zr	P	Si	U3O8	Fe	P	U3O8	Fe	
	0	0	0	0	0	0	0	0	0	0	0	0			0	0		0		78.7	0.25	0.58			
1	0.95	#DIV/0!	33.3	33.450	1.00	340	144	<1	<2	1	1	8.33	11.3	4.800	0.03	0.07	<0.03	0.03	0.278	78.4	0.11	0.58	0.4	63.3	0.3
2	1.91	#DIV/0!	33.5	34.850	1.04	12,815	24.5	<1	<2	4.97	8.94	26.6	429	0.821	0.03	0.07	0.167	0.30	0.891	66.2	0.09	0.57	16.1	74.2	6.6
3	2.9	#DIV/0!	33.3	35.680	1.07	15,000	20.6	<1	<2	5.95	10.3	36.2	500	0.687	0.03	0.07	0.198	0.34	1.207	51.9	0.07	0.56	34.4	83.2	9.4
4	3.8	#DIV/0!	33.5	36.150	1.08	16,294	9.32	<1	<2	6.34	16.1	38.2	545	0.312	0.03	0.07	0.212	0.54	1.279	36.3	0.06	0.54	54.3	87.4	11.1
5	4.8	#DIV/0!	33.9	36.600	1.08	11,781	5.63	<1	<2	4.64	15.2	33.5	399	0.191	0.03	0.07	0.157	0.52	1.135	24.9	0.06	0.53	68.9	89.9	11.3
6	5.8	#DIV/0!	34.2	36.890	1.08	8,199	4.38	<1	<2	3.26	11.4	29	280	0.150	0.03	0.07	0.111	0.39	0.991	16.9	0.05	0.52	79.1	91.8	10.7
7	6.7	#DIV/0!	34.2	36.640	1.07	5,573	3.02	<1	<2	2.23	8.12	24.7	190	0.103	0.03	0.07	0.076	0.28	0.844	11.4	0.05	0.51	86.1	93.2	10.0
8	7.7	#DIV/0!	34.5	36.890	1.07	3,841	2.35	<1	<2	1.57	3.3	21.5	133	0.081	0.03	0.07	0.054	0.11	0.743	7.64	0.05	0.51	90.9	94.3	9.2
9	8.7	#DIV/0!	34.5	36.950	1.07	2,547	2.01	<1	<2	1.09	2.15	18.2	88.0	0.069	0.03	0.07	0.038	0.07	0.628	5.12	0.05	0.50	94.1	95.2	8.4
10	9.7	#DIV/0!	34.5	36.630	1.06	1,616	1.38	<1	<2	<1	1.81	15.2	55.8	0.048	0.03	0.07	0.03	0.06	0.525	3.53	0.04	0.50	96.2	95.8	7.8
11	10.7	#DIV/0!	34.5	36.630	1.06	1,066	1.01	<1	<2	<1	1	13.3	36.8	0.035	0.03	0.07	0.03	0.03	0.459	2.48	0.04	0.50	97.5	96.3	7.1
12	11.7	#DIV/0!	34.8	37.100	1.07	706	<1	<1	<2	<1	1	12.4	24.6	0.03	0.03	0.07	0.03	0.03	0.432	1.78	0.04	0.50	98.4	96.7	6.6
13	12.7	#DIV/0!	34.5	36.730	1.06	472	1.21	<1	<2	<1	1	10.7	16.3	0.042	0.03	0.07	0.03	0.03	0.370	1.31	0.04	0.50	99.0	97.2	6.1
14	13.7	#DIV/0!	34.5	36.730	1.07	303	<1	<1	<2	<1	1	9.88	10.4	0.03	0.03	0.07	0.03	0.03	0.340	1.01	0.04	0.50	99.4	97.6	5.7
15	14.6	#DIV/0!	34.7	36.940	1.07	191	<1	<1	<2	<1	1	8.92	6.64	0.03	0.03	0.07	0.03	0.03	0.309	0.82	0.04	0.50	99.6	98.0	5.3
16	15.6	#DIV/0!	34.1	36.180	1.06	127	<1	<1	<2	<1	1	8.27	4.34	0.03	0.03	0.07	0.03	0.03	0.282	0.70	0.04	0.50	99.8	98.4	5.0
17	16.6	#DIV/0!	35.0	37.260	1.06	90.3	<1	<1	<2	<1	1	7.71	3.16	0.03	0.03	0.07	0.03	0.04	0.270	0.61	0.04	0.50	99.9	98.8	4.7
18	17.6	#DIV/0!	34.9	37.110	1.06	52.3	<1	<1	<2	<1	1	6.99	1.83	0.03	0.03	0.07	0.03	0.03	0.244	0.56	0.04	0.49	100.0	99.2	4.4
19	18.6	#DIV/0!	34.8	36.980	1.06	24.7	<1	<1	<2	<1	1	6.43	0.86	0.03	0.03	0.07	0.03	0.03	0.224	0.53	0.04	0.49	100.0	99.6	4.2
20	19.6	#DIV/0!	34.7	36.820	1.06	10.8	<1	<1	<2	<1	1	5.92	0.37	0.03	0.03	0.07	0.03	0.03	0.205	0.52	0.04	0.49	100.0	100.0	4.0
											Total M:		2,738	7.6	<0.6	<1.4	1.3	3.0	11.7			3			

Back calculated loading (g/Lwsr):	78.2		
Loaded resin assay (g/Lwsr):	78.7	0.3	0.6
HNO3/NaOH stripped final resin assay (g/Lwsr):	0.07	0.02	0.02
DNA Final resin assay (g/Lwsr):	0.01		
Accountability (%)	99		

1-16:





ANALYTICAL DATA

Precipitation Data and Results

Amberjet 4400U	
Total Eluate Weight	492.80 g
Density	1.09 g/mL

Gypsum & Iron Precipitation

20% lime (g)	150.78 g
Final pH	1.58
20% NaOH (mL)	2.94 mL
Final pH	3.56
Filtrate Weight	N/A
Density	N/A
Gypsum wet weight	200.36
Gypsum dry weight	55.32
Moisture (%):	72

Uranium Peroxide Precipitation

30% H2O2 added	0.985 g
20% NaOH added	1.97 mL
pH	3.52
Yellow cake wet Wt	4.38
Yellow cake dry Wt	1.732
Moisture (%):	60

Analysis

For ICP dissolve solid Weight	0.5491
V digest solution (mL):	100

Ambersep 920U	
Total Eluate Weight	327.97g
Density	1.07 g/mL

Gypsum & Iron Precipitation

30% Lime (g)	68.50 g
Final pH	1.61
20% NaOH (mL)	1.46 mL
Final pH	3.62
Filtrate Weight	251.60 g
Density	1.03 g/mL
Gypsum wet weight	121.93
Gypsum dry weight	39.66
Moisture (%):	67

Uranium Peroxide Precipitation

30% H2O2 added	0.803 g
20% NaOH added	1.22 mL
pH	3.55
Yellow cake wet Wt	2.39
Yellow cake dry Wt	0.87
Moisture (%):	64

Analysis

For ICP dissolve solid Weight	0.3452
V digest solution (mL):	100

M	AMBERJET 4400		AMBERSEP 920	
	% M in ppt	M/U (%)	% M in ppt	M/U (%)
Al	0.056	0.078	0.048	0.067
As	0.018	0.026	0.029	0.041
Ba	0.018	0.026	0.029	0.041
Bi	0.030	0.042	0.042	0.059
Ca	0.335	0.470	0.228	0.321
Cl	0.38	0.53	<0.3	0.42
Co	0.018	0.026	0.029	0.041
Cr	0.018	0.026	0.029	0.041
Cu	0.053	0.074	0.054	0.076
Fe	0.135	0.189	0.161	0.227
F	0.05	0.07	<0.03	0.04
K	0.260	0.365	0.410	0.578
Mg	0.018	0.026	0.029	0.041
Mn	0.018	0.026	0.029	0.041
Mo	0.018	0.026	0.029	0.041
Na	0.184	0.259	0.143	0.201
Ni	0.018	0.026	0.029	0.041
P	0.194	0.272	0.200	0.282
Pb	0.100	0.141	0.092	0.129
S	1.821	2.557	2.897	4.081
Si	0.091	0.128	0.145	0.204
Ti	0.018	0.026	0.029	0.041
U	71.23		70.98	
V	0.018	0.026	0.029	0.041
Zn	0.072	0.102	0.029	0.041
Zr	0.018	0.026	0.029	0.041

APPENDIX M

Solvent Extraction Detailed Results

Lagoon Creek Resources
Phase Disengagement Test

Solvent : 5 vol. % Alamine 336 + 2 vol.% Isodecanol in Shellsol 2046 (fresh)
Organic Vol (mL): 200

Exp No: 31
Aqueous: Leach Feed
Date: 13-14/04/2011
Aqueous Vol (mL): 200
ref: A.P-B.6.pp42-43.

O:A: 1
Stirrer Speed (rpm): 1800
Stir Time (min): 3
Equipment: Square 0.5L container and 4 blade impeller
Method: Measurement of bottom interface to breakaway from the bottom of the container giving a clear aqueous phase

Organic Continuous: Organic in beaker first, aqueous added while stirring (step 1)
Aqueous Continuous: Organic + aqueous , stirrer in aqueous and restirred (step 2)

Organic Continuous		Aqueous continuous	
calc Volume(mL)	Time(sec)	Calc Volume(mL)	Time(sec)
45	26	23	16
68	31	45	21
90	36	68	25
113	40	90	29
136	44	113	32
158	48	136	38
181	55	158	42
199	60	181	49
		190	55
		199	61

Observations:
Organic Continuous: Failed to return to 200mL within 2 minutes.
minicus is a little hazy
Aqueous Continuous: Returned to original height within 2 minutes.

Lagoon Creek Resources
Bulk Loading - with Leach Feed

SOLVENT: 5 vol.% Alamine 336 + 2 vol.% Isodecanol in Shellsol 2046

Exp No: 27

AQUEOUS Feed: Leach Feed **Ref:** A.P-B6.p44

Method: Overhead stirrer and the organic was contacted twice **Date:**

pH: 1.5 **ICP Request No:** 1101112

A:O 3.25

Contact Time: as required for constant pH

Temperature: **35°C**

Stripping: Stripped with 1M Na_2CO_3 at A:O = 3 for 20 minutes for U accountability
Stripped with 5M H_2SO_4 at A:O = 2 for 20 minutes for Fe accountability

Observations:

27.1 After 1st cycle, brownish crud in organic layer at end.

EXPERIMENTAL DETAILS

Sample No	**27.1**	**27.2**
Aqueous Volume (mL)	6500	6500
Organic Volume (mL)	2000	2000
Conc H_2SO_4 (mL)	4.0	3.0
pH (before adjustment)	1.5	1.6
pH (after adjustment)	1.5	1.5
EXPERIMENTAL RESULTS (mg/L)		
A:O	**3.25**	**3.25**
U initial	970	970
U Aq equilibrium	19	256
U Org	2910	4740
% Extraction	**98**	**74**
Mo initial	<1	<1
Mo Aq equilibrium	<1	<1
Mo Org	<3	<3
S initial	7390	7390
S Aq equilibrium	7500	8520
S Org	1833	2145
Fe initial	3060	3060
Fe Aq equilibrium	3090	3120
Fe Org (H+)		6
V initial	19	19
V Aq equilibrium	20	20
V Org	<3	<3

Lagoon Creek Batch Testwork
Ammonium sulphate Strip curve - pH 4.2

SOLVENT: Loaded -5 vol % Alamine 336 + 2 vol % isodecanol in Shellsol 2046 (exp AP27)
Solvent Loading: **A:O=3.25 at 35°C twice with fresh feed (pH 1.5)**

Exp No: 28
AQUEOUS Strip: 100 g/L($NH_4)_2SO_4$ **Ref:** A.P-B6, pp39-40,45.
Method Beaker with overhead stirrer **Date:** 13.5.11
and pH control with [13 M] NH_4OH **ICP No:** 1101155
pH: 4.2
Contact Time: As required for stable pH reading
Temperature (oC): 35
Stripping: Stripped with 1M Na_2CO_3 at A:O =3 for 20 minutes

EXPERIMENTAL DETAILS

Sample No		**28.1**	**28.2**	**28.3**	**28.4**	**28.5**	**28.6**	**28.7**
Aqueous Volume (mL)		10	10	10	20	25	40	100
Organic Volume (mL)		200	70	50	40	25	20	10
Equilibrium pH		**4.2**	**4.2**	**4.2**	**4.3**	**4.3**	**4.2**	**4.2**
0.5M H_2SO_4 (mL)				0.70				
1.0M H_2SO_4 (mL)				1.10	0.80	2.00	0.60	0.15
13 M-$(NH_4)OH$ vol(mL)								

Observations

28.1 Slow to stabilise pH, unstable. Dark yellow crud at end of experiment in aqueous layer. (U pption)
28.2 Small amount of dark yellow crud, similar to exp28.1; still slow to react to atain desired pH. (U pption)
28.3 Moderate yellow crud present. Acid addition required to correct pH. (U pption)
28.4 Moderate yellow crud present. Acid addition required to correct pH, getting faster to separate layers. (U pption)
28.5 Fast separation. No crud present. Acid required to correct pH.
28.6 Fast separation. No crud present.pH sensitive to (NH4)OH additions.Acid required to correct pH.
28.7 Fast separation. No crud present.pH sensitive to (NH4)OH additions.Acid required to correct pH.

Note: uranium pption may have occurred due to localised NH4 addtion

EXPERIMENTAL RESULTS (mg/L)

O:A	**Initial (org)**	**pption 20**	**7**	**pption 5**	**2**	**1**	**0.5**	**0.1**
U Aq equilibrium		68700	30400	14800	8720	4890	2570	542
U Org	4750	231	192	179	115	124	77	61
% Stripping		**94**	**94**	**95**	**98**	**98**	**99**	**99**
S Aq equilibrium		52500	35900	30600	28300	26500	25000	24000
S Org	2145	<300	<300	<300	<300	<300	<300	<300
Fe Aq equilibrium		11	4.6	3.0	2.3	2.3	1.1	1
Fe Org	6							
Si Aq equilibrium		27	12	7	<5	<5	<5	<5
Si Org	15	<15	<15	<15	<15	<15	<15	<15
V Aq equilibrium		<10	<10	<10	<10	<10	<10	<10
V Org	<3	<3	<3	<3	<3	<3	<3	<3
Mo Aq equilibrium		7	4	<1	<1	<1	<1	<1
Mo Org	<3	<3	<3	<3	<3	<3	<3	<3
Zr Aq equilibrium		20	5	2.8	1.9	<1	<1	<1
Zr Org	<3	<3	<3	<3	<3	<3	<3	<3

Lagoon Creek Resources Batch Testwork
Bulk Strip - with 100 g/L $(NH_4)_2SO_4$

Exp No: 29
Ref: A.P-B6, p46.
SOLVENT: Loaded solvent density(g/mL)= 0.797 **Date:** 13.5.11
Solvent loaded (batch 1 feed) **ICP Request No:** 1101112
AQUEOUS Strip: 100 g/L(NH4)2SO4 density(g/mL)= 1.064
Method: Square cell with overhead stirrer and pH control with [13.3 M] NH4OH
initial pH 2.3
final pH 4.3
O:A: 4.8
Contact Time: as required for stable reading
Temperature: **35°C**
Stripping: Stripped with 1M Na_2CO_3 at A:O = 3 for 20 minutes for U accountability
Stripped with 5M H2SO4 at A:O = 2 for 20 minutes for Fe accountability

EXPERIMENTAL DETAILS

Sample No	**16**
Aqueous Volume (mL)	300
Organic Volume (mL)	1500
Equilibrium pH	**4.3**
13.4 M-(NH4)OH vol(mL)	12.1
EXPERIMENTAL RESULTS (mg/L)	
A:O	**0.20**
O:A	**4.8**
Fe initial (org)(H+)	7
Fe Aq equilibrium	12
Fe Org (H+)	2
S initial (org)	2145
S Aq equilibrium	31800
Si initial (org)	<15
Si Aq equilibrium	<5
Si Org	<15
U initial (org)	4740
U Aq equilibrium	25700
U Org	228
% Stripping	**96**

URANIUM PRECIPITATION WITH AMMONIUM HYDROXIDE-(ADU)

Precipitation Details

Date: 19.5.11
Exp No: AP30
Reference A.P-B6. pp47-49.
ICP Request No: 1101112
ICP Request No: 1101194
ICP Request No: 1101199
ISE Request No: 1101205

Initial Conditions

Feed Type = Loaded strip liquor (exp AP29) $(NH4)_2SO_4$
Mass of Loaded Strip Liquor (g) = 317.24
Density of strip (g/mL) = 1.09
Cal Strip Volume (L) = 0.29
Strip Feed liquor [U_3O_8] (g/L) = 30.3
Free acidity (g/L)= 0.0
Starting pH = 4.25
Set Test pH = 7.5

% addition at 30 (min) = 37 6.215 mL
Stirring Duration (min) = 120
Total Time (min)= 120
Precipitation Temp (°C) = 30
1 h thief slurry vol(mL) = 5

Conditions to neutralise Acid

Required- Moles NH4OH (mol/L)= 0.00
calc Stoich Volume NH4OH (mL)= 0.00

Conditions to precipitate U_3O_8 (pH 7.5)

Required- Moles NH4OH (mol/L)= 0.11
calc [NH4OH] (M) = 13.36 25% NH3
Strength NH3 (g/L)= 228
calc Stoich Volume NH4OH (mL)= 8.3
Required % Stoichiometric = 120
Actual Volume NH4OH (mL)= 17.0
% Total Stoichiometric added = 205

Final Conditions

PF volume (L) = 0.24
Water repulp volume (L) = 0.41
Drying Temperature (oC) = 160
ADU Dry Weight (g) = 9.11
Wet wt (g) =
Moisture (%) =

Calculated Reagent Consumptions

NH_3 to precipitate Uranium (kg NH_3/ kg U_3O_8) = 0.44

Note: Repulp wash and 2 displacement-Filtered through 0.45um paper- slow
Note: Drying temperature usually 110°C for ADU

	Analyses				Digestion Precipitate		**Precipitated**	
Element	Strip Liquor Feed mg/L	PF 1 hr Thief mg/L	PF Final mg/L	Wash Total mg/L	wt.%	% of U	liquor %	solid %
Ag	10	1	1	1	0.02	0.03	78	
As	10	1	1	1	0.01	0.01	78	31
B	10	10	10	10	0.01	0.01		31
Ba	10	1	1	1	0.01	0.01	78	31
Ca	28	1	4.4	1	0.1	0.1	82	112
Cd	1	1	1	1	0.01	0.01		
Cr	1	1	1		0.01	0.01	18	
Fe	6	1	1	1	0.02	0.02	63	92
Hg					0.01	0.01		
K	10	10	13	10	0.1	0.1		
Mg	2	1	1	1	0.01	0.01		
Mo	1	1	1	1	0.01	0.01		
Na	10	1.5	2.7	1.7	0.01	0.01	54	31
Na+K					0.1	0.1		
P	4	1	1	1	0.01	0.01	44	78
PO4					0.03	0.04		
Pb	10	1	1	1	0.01	0.01	78	31
S	31800	34100	36500	1060	1	1		
Se	10	1	1	1	0.01	0.01	78	
Si	5	5	5	5	0.05	0.06		
SiO2					0.1	0.1		
Th	1	1	1	1	0.01	0.01		
Ti	10	1	1	1	0.01	0.01	78	31
U	25700	1	1	1	79	100	100	97
V	10	1	1	1	0.01	0.01	78	31
Zr	10	1	1	1	0.01	0.01	78	31
F					0.007	0.009		
Cl					0.31	**0.39**		