Developments in Uranium Solution Mining in Australia

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SUMMARY

The last five years have seen rapid developments in uranium solution mining in Australia, with one deposit brought into production (Beverley, 1,000 tpa U_3O_8) and another close to receiving development approval (Honeymoon, 500 expanding to 1,000 tpa U_3O_8 proposed). The deposits were discovered during extensive exploration of the Frome Basin in South Australia in the early 1970s and were mothballed from 1983 to 1996 due to Government policies. Uranium mineralisation at Beverley, Honeymoon and other related prospects is hosted in unconsolidated coarse grained quartz sands which are sealed in buried palaeovalleys. Both projects have successfully trialled acid leaching methods and have confirmed high permeability and confinement of the target sands. At Beverley an ion exchange process has been adopted, whereas at Honeymoon solvent extraction has been trialled and is proposed for future production. Australian production economics compare favourably with US counterparts and are likely to be within the lower quartile of world costs.

1. INTRODUCTION

From the late 1960s until early1983, there was intensive activity in the Frome Embayment Region of South Australia aimed at identifying economic sedimentary uranium deposits (Figure 1) (Curtis et al. 1990). The philosophy and geological model was based on the extensive deposits of the inward draining Powder River Basin in Wyoming. It was considered that erosion of uranium rich granites at the margins may have resulted in economic sedimentary deposits between the margins and Lake Frome (Brunt, 1978). By the early 1980s, a number of economic prospects had been identified and two in particular, at Honeymoon and Beverley, were well advanced. Coincident with this exploration success was the development, predominantly in the USA, of solution mining or insitu leach (ISL) techniques for uranium recovery. The size, geology and hydrology of these Australian deposits seemed well suited to the ISL technique and pilot testing was carried out at Honeymoon. This in turn led to the decision to install a nominal 250,000 lbs U_3O_8/year demonstration plant at Honeymoon. Although built, the plant was never operated due to a change in Government at that time.

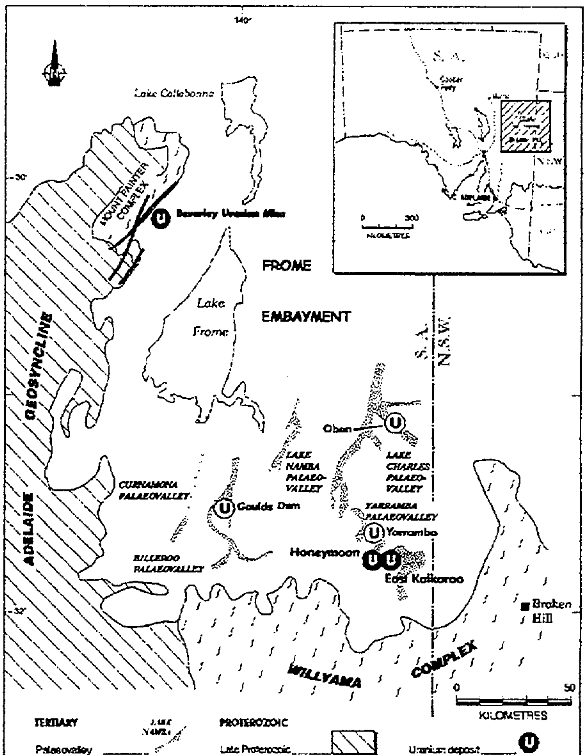


Figure 1 Location of South Australian sedimentary uranium deposits

In 1996, following a change in Government in Australia there was renewed activity. The Beverley project was by then owned by Heathgate Resources Pty Ltd, a subsidiary of the privately owned US corporation, General Atomics. The Honeymoon project, with associated prospects at Yarramba and Goulds Dam was acquired by Canadian public company, Southern Cross Resources Inc (SXR) in 1997.

Both companies committed substantial resources to development plans and approvals including demonstration operations and Environmental Impact Statements (EIS).

Considerable technical expertise and personnel were committed from the US, although it was recognised that extensive modifications would be necessary due to Australian conditions.

2. WHAT IS ISL?

The basic parameters and characteristics of ISL are well known in the mining industry. ISL involves pumping liquids through an ore zone to recover the valuable mineral component without physically moving the rock or sand in which it occurs. This avoids many aspects of conventional mining including surface disturbance, tailings dams and stock piles, rehabilitation on a large scale and the safety concerns of underground operations or heavy mobile equipment.

For the technique to be used, however, there are basic geological and hydrological parameters that must be in place. The orebody must be permeable to the liquid, preferably bounded (horizontally and vertically) by impermeable rock and must be located below the natural water table. Control of the liquid and the groundwater are vital to ensure that there is no contamination away from the orebody. ISL is a closed loop system which produces a small bleed stream (1-2% of the volume being circulated).

For uranium, the technique is used on deposits of the "Roll Front" type (Figure 2) which are found in sand and sandstone areas in continental Asia, the USA and Australia. Depending on the chemistry of the ore and its surrounding sandstone, oxygen is used in a carbonate (alkaline) or sulphate (acid) medium and the uranium is dissolved from the ore by successive leaching passes on a continuous basis. ISL has been called "water well mining" and this reflects the screened and cased water wells set up in alternate patterns of "injectors", "extractors" and "monitors" that are used in the technique. Submersible electric pumps are used to lift loaded solution from the extraction wells and pump it through the extractive metallurgical plant where the uranium is removed. Spent solution is then recharged with oxidant as needed and pumped down the injector wells in a continuous manner. It is essential that the leachate solution is limited to the orebody and this is achieved by careful wellfield planning, with an excess of volume pumped out of the zone compared to the circulation input. Extensive horizontal and vertical monitoring bore patterns are used.

It should be stressed that the orebody is the primary determinant of whether ISL can be used and the characteristics of that ISL operation. Besides the needs listed earlier, with respect to water table and permeable rocks substantially surrounded by those that are impermeable, the orebody must meet ore grade, thickness, amenable mineralogy and recovery criteria to allow economic extraction. ISL is capable of up to 80% extraction of uranium from an ore zone which contains coffinite or uraninite as the uranium mineral type. It is essential therefore that these characteristics are proven, understood and trialled before commercial operation is undertaken.

ISL has a number of inherent advantages over conventional open cut operations. These include the ability to extract from smaller orebodies economically, the low labour requirements and inherent lower worker radiation exposures, the lack of ore exposure and extensive rehabilitation, and as previously stated, the avoidance of tailings and extensive surface disturbance and infrastructure.

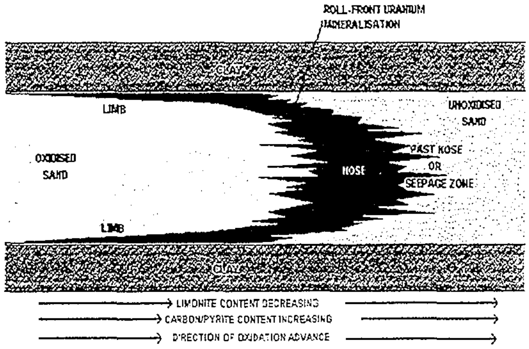


Figure 2 Schematic section through Roll Front uranium mineralisation

3. IMPORTANT FACTORS IN ISL

There are two distinct types of chemical regimes used for ISL mining and two extraction techniques used in the plants to which the ISL solution is fed. Being a closed loop continuous system it is vital that these process routes are compatible and meet the process requirements. Normal practice in the US, where the sandstone deposits usually contain limestone, is to use alkaline (or carbonate) leaching in which sodium carbonate is added (with oxygen) to the solution being injected. Operated at alkaline (high pH) conditions, this technique avoids gypsum formation and consequent blinding of the orebody. Alkaline (carbonate) leaching is inherently slower than alternative acid techniques.

Where such limestone considerations are not present, as in Australia, the alternative acid (or sulphate) leaching technique is used. Sulphuric acid (with oxygen and or an oxidant) is used to achieve a pH of 2.5-2.8 and leaching rates are appreciably higher than for alkaline conditions. Acid leaching is particularly suited to the saline conditions experienced in Australia but solution chemistry must be tempered by the need to avoid possible gypsum formation (Bush, 1999).

The technique for uranium extraction in the plant is largely a question of the level of chloride ion in the solution. In order to extract uranium from the circulating solution either ion exchange (IX) resins or solvent extraction (SX) must be used. Present technology and commercially proven ion exchange resins have an extraction performance and longevity which is very dependent on the salt level in the liquid. It is probable that IX can only be economically used in solutions of about 3,000 ppm chloride or below. This was the primary reason for the selection, trialling and subsequently successful use of IX for the Beverley project levels (Heathgate Resources Pty Ltd, 2001).

Above this level, SX must be used as at Honeymoon where typical TDS is 20,000 ppm. There are also no commercially proven resins that will work in alkaline conditions at such TDS.

Plant Extraction Method	ISL Operating Method	
	Acid (sulphate) Leach	**Alkaline (carbonate) Leach**
IX	Effective to 3,000 ppm Cl.	Effective to 3,000 ppm Cl.
SX	Operable at high chlorides.	Solvents unavailable.

Figure 3 ISL Uranium Production and Recovery (below)

As can be seen from the table, the process decisions at Honeymoon and Beverley are determined by the chloride groundwater levels and the orebody characteristics. Honeymoon must use SX whilst Beverley has been able to start up on IX.

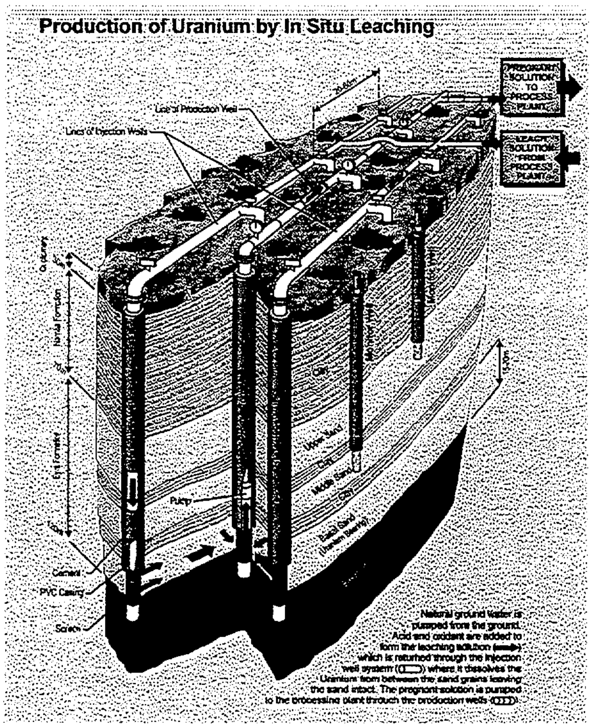
4. ISL IN AUSTRALIA

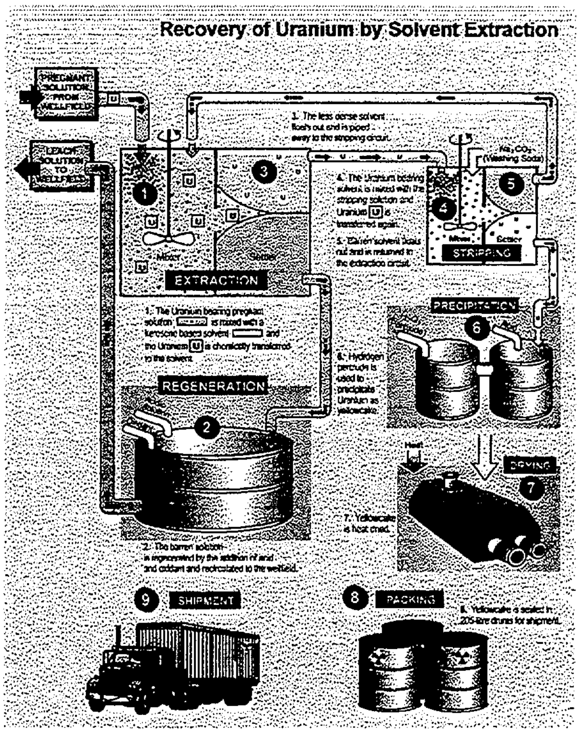
Beverley

Heathgate Resources Pty Ltd, founded in 1990 as a subsidiary of General Atomics of the US, obtained the mothballed Beverley project in that year. Following a change in Federal Government policy in 1996, an active assessment, permitting, trials and negotiation programme was put in place with the aim of establishing a commercial mining operation. Approval of the EIS environmental and mining proposals was achieved in March 1999 and development began. After the expenditure of at least A$50m for capital and development, the project, at a nominal production rate of 1,000 tonnes annually of U_3O_8 yellowcake, was officially opened in February 2001. The project, with over 60 employees, is positively contributing to the local, Aboriginal and State economies and is performing to expectations in production and environmental standards.

Honeymoon

The Honeymoon project involves development of the Honeymoon and East Kalkaroo ore bodies which occur in the Yarramba palaeovalley (Bampton et al. 2001). SXR was established in 1997 as a public Canadian company specifically formed to acquire the uranium infrastructure and geological assets of Mt Isa Mines Ltd and Sedimentary Holdings in the





Lake Frome region of South Australia. A programme was developed to progress the project to commercial status. This programme included refurbishment of existing facilities; operation of a demonstration plant; extensive investigations involved in the environmental approval process; marketing and Government measures; and expansion of the geological knowledge base and ground position. Operation of the field leach trial was carried out successfully between April 1998 and August 2000. The EIS public document was released for review in June 2000 with the resulting Response Document released in November 2000. In February 2001 the Federal Minister for the Environment & Heritage gave conditional approval to the project, whilst requiring some additional work be undertaken before full approval would be forthcoming. This field, modelling and office work was in the areas of geological stratigraphy, pump test hydrology, hydrological and geological modelling and bleed stream chemical modelling. The work was completed in July 2001 and at the time of writing, the company is awaiting a decision by the Minister.

A schematic of the planned Honeymoon project is shown as Figure 3. The operation, using solvent extraction in groundwater of considerably higher salinity than at Beverley, would have approval for an annual projection of about 1,000 tpa of U_3O_8. The actual initial production rate will depend upon market and capital considerations following Government approval (Bush, 2000 and Bampton et al. 2001).

5. ECONOMICS AND COMPARISON WITH US ISL OPERATIONS

Both South Australian projects have been developed on the basis of being low operating cost uranium producers, whose costs are in the lowest quartile of their competitive counterparts on a global basis. This is most important in the market context of the 1990s and 2000s, when uranium prices are at historically low levels and there are some continuing questions as to future demand by the nuclear power industry. A comparison is made therefore between the two South Australian projects and the latest (and largest) US ISL operation at Rio Algom's Smith Ranch project in Wyoming (Stout et al. 1997, Freeman et al 1999 and Norris et al 2000). The Honeymoon data is for the 1,000 tpa planned operation, whilst the Beverley and Smith Ranch information is from their publications and technical talks. This is not a comprehensive comparison but concentrates upon those parameters which illustrate the differences in the operations.

FACTOR	SMITH RANCH USA	BEVERLEY AUSTRALIA	HONEYMOON AUSTRALIA
Orebody Character			
Average Grade (% U_3O_8)	0.10	0.18	0.16
Total Resource (mt U_3O_8)	23,000	21,000	6,000
Depth typical (m)	150–300	100	110
Permeability	Moderate	Very High	High-Very High
Aquifer Water Quality (g/l TDS)	500	3,000-13,000	17,000-20,000
Area Size km^2	5+	1.4	0.3
Orebody Contents: $CaCO_3$ %	up to 20	<1	<1
Pyrite %	1-2	<0.5	<1
Ore Zone Type	Sandstone	Sand	Sand
Wellfield Operations			
Production Rate/Injector Well (l/s)	1.25	6	5
Pregnant Liquor U (ppm)	50-80	150-200	75 Planned
Extractors for 1,000 tpa U_3O_8	170	42	88
Leach Method Used	Alkaline	Acid	Acid
Oxidant Added	O_2	H_2O_2	O_2/$NaClO_3$
Modifying Agent Added	CO_2 gas	H_2SO_4	H_2SO_4
Groundwater Restoration	Required	Not Needed	Not Needed
Groundwater Usage	Potable	Marginal - grazing	Unusable for grazing
Bleed Stream Disposal	Deep Wells	Re-injected	Re-injected
Solution pH	6.5-6.8	2.5-3.0	2.5-2.8
Typical Well Life	5-8 years	About 18 months	9-18 months
Reserve (lbs U_3O_8 per pattern)	11,500	>30,000	30,000
Infrastructure			
Operational Mode	Near Town	Remote Fly In/Out	Remote Drive In/Out
Housing	Not Needed	Camp	Camp
Power Supply	Local Grid	Gas Generated	Diesel Generated (?)
Airstrip	Not Needed	Necessary	In Place
Access Roads	Sealed	Unsealed	Unsealed
Water Supply	Potable Aquifer	Great Aust Basin	RO Plant
Crewing Needs for 1,000 tpa U_3O_8	75	About 60	About 50
Trialling/Permitting Time	8 years	3.5 years	4 years anticipated
Plant Characteristics			
Recovery Method	IX	IX, SX later (?)	SX

6. CONCLUSION

The rate of development of techniques and projects in South Australia has been rapid over the last five years. Uranium solution mining (ISL) appears destined to be an economic, significant and growing supplier of uranium yellowcake product. There is a distinct Australian knowledge base growing up in the technical and approval methods and policies needed to sustain that growth.

7. ACKNOWLEDGEMENTS

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REFERENCES

Ackland, M.C. 1997, *The Honeymoon Project - Australia's First In Situ Leach Uranium Project*, Australian Nuclear Association Conference, Canberra.

Ackland, M.C. 1997, "The Honeymoon Project: On the Brink of Realisation", *Proceedings of the 22nd Annual Symposium*, Uranium Institute, pp119-125, London.

Bampton, K.F. et al 2001, "Geology of the Honeymoon Uranium Project", web proceedings AusIMM, submitted, Illawarra.

Brunt, D.A. 1998, "ISL Uranium Mining – the key elements", *Australian Uranium Summit*, Adelaide.

Brunt, D.A. 1978, *Uranium in Tertiary Stream Channels, Lake Frome Area South Australia*, Proceedings AusIMM No.266, pp79-90, Melbourne.

Bush, P.D. 2000, " Development considerations for the Honeymoon ISL Uranium Project", *Uranium 2001 - Process Metallurgy of Uranium*, pp 257-279, Saskatoon.

Bush, P.D. 1999, "Water Management for the Honeymoon ISL Operation", *Proceedings of the WAMMO 1999 Conference*, Australian Mineral Foundation, Perth.

Curtis, J.L. et al 1990, "Tertiary palaeochannel uranium deposits of South Australia", *Geology of the Mineral Deposits of Australia and Papua New Guinea* (Ed. Hughes, F.E.), pp1631-1638, The Australian Institute of Mining and Metallurgy, Melbourne.

Freeman, M.D. et al 1999, "The Smith Ranch Project – a 1990s In Situ Uranium Mine", *Proceedings of the 24th Annual Symposium of the Uranium Institute*, London.

Graham, J.J. 2000, "The Beverley Mine Update and a Supplier's view of the Uranium Market", Resources Week 2000, Adelaide.

Graham, J.J. 1998, *The Role of the Beverley ISL Uranium Mine in Today's Market*, 2nd Australian Uranium Summit, Adelaide.

Heathgate Resources Pty Ltd 2001, URL: http://heathgateresources.com.au.

Hore-Lacy, I. 2001, "In-Situ Leach (ISL) Mining of Uranium", *Uranium Information Centre Briefing Paper 40*, Melbourne.

Norris, J.D. et al 2000, "Uranium recovery by in-situ leach, the Smith Ranch Project", *Uranium 2000 – Process Metallurgy of Uranium*, pp311-319, Saskatoon.

Southern Cross Resources Australia Pty Ltd 2000, *Honeymoon Uranium Project Environmental Impact Statement*, Brisbane.

Stout, R.M. et al 1997, "The Smith Ranch Uranium Project", *Proceedings of the 22nd Annual Symposium of the Uranium Institute*, London.