8th Uranium Event

ALTA 2012 URANIUM CONFERENCE

MAY 31-JUNE 1 2012
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PERTH, AUSTRALIA

ALTA Metallurgical Services
Melbourne, Victoria,
Australia

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SX/IX

COMPARISON OF VARIOUS REAGENTS FOR STRIPPING URANIUM-LOADED ALAMINE® 336

By

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ABSTRACT

Alamine® 336 is commonly used as the extraction via solvent extaction of uranyl sulphate from sulphuric acid leach liquors. Various stripping reagents, such as ammonium sulphate/ammonia, sulphuric acid, sodium carbonate, and sodium chloride, could be employed for the stripping of uranium from the loaded solvent. The most common stripping medium is ammonium sulphate, with ammonia (gas or aqueous solution) being used for pH control during stripping. Environmental and transport considerations associated with the use of ammonia have recently sparked the interest in alternative stripping reagents. A basic comparison of the various stripping reagents with regards to their performance, reagent consumption and costs, and waste generation is discussed.

SOLVENT EXTRACTION OF URANIUM AND ITS SEPARATION FROM VANADIUM IN ALKALINE SOLUTIONS

By

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ABSTRACT

Until now, no solvent extraction system has been found suitable to recover uranium from alkaline carbonate leach solutions. Quaternary ammonium salt could extract uranium effectively, but third phase formation prevents its practical applications. In this paper, isodecanol was used as the phase modifier for Aliquat 336 in Shellsol D70 to extract uranium from a carbonate leach solution effectively without third phase formation. After a single contact, more than 98% u was extracted using 3% (w/v) Aliquat 336 and 3% (w/v) isodecanol in Shellsol D70 from a carbonate leach solution containing 95 mg/L U, 25 mg/L V at pH about 10.3. It was found that the separation factor of uranium over vanadium increased with the pH and reached maxium of 280 at pH 11, indicating a good separation of the two metals with the developed organic system for the carbonate leach solution. The presence of chloride could significantly affect the uranium extraction with the organic system. In order to obtain high uranium extraction, chloride concentration should be controlled at less than 1 g/L in the aqueous phase. The co-extracted vanadium was scrubbed effectively from the loaded organic solution at pH 11 using 50 g/L Na_2CO_3 solution. Over 90% uranium was stripped from the loaded organic soluiton in a single contact using an acidic solution containing 150 g/L ammonium sulphate at pH clsoe to zero.

DEVELOPMENT OF THE METRIX^{TM} RESIN IN PULP SYSTEM FOR EXTRACTING URANIUM FROM HYPERSALINE ACIDIC SOLUTIONS

By

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ABSTRACT

Interest in recovering uranium from process solutions with high salinity has increased significantly in recent years. Because conventional uranium recovery processes are negatively affected by high chloride concentrations, this interest has prompted a high level of activity, from research organisations and resin manufactures alike, to develop new uranium recovery processes or resins that can function in hypersaline solutions.

Bateman and Mintek have been pursuing a program of research into using ion exchange, and particularly resin in pulp, for uranium recovery for some time, and have recently focused this research on the application of this technology to leach solutions with high concentrations of chloride. The research, conducted both in the laboratory and demonstration plant, has developed a uranium recovery process with the following key features:

- a commercially available resin is used
- it is suitable for application directly to process slurries
- no distinct iron removal step is required
- commercially available equipment is used
- conventional eluant solutions such as sulphuric acid can be used
- an eluate suitable for direct uranium precipitation can be produced

STRONG ACID VERSUS AMMONIA STRIP IN URANIUM SX CIRCUITS

By

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ABSTRACT

Solvent extraction is used in many acid leach uranium circuits to upgrade and purify the uranium bearing solution prior to final product precipitation. A number of strip options are available to recover the uranium from the loaded organic. This paper compares strong acid strip against ammonia strip on the basis of typical capital and operating costs for both the solvent extraction circuit and downstream uranium processing, and also considers other related issues. The aim is to provide an objective comparative assessment of these options that could be used as a qualitative guide in process selection or improvement.

URANIUM SOLVENT EXTRACTION PLANT DESIGNS – WHERE DOES COPPER COME INTO IT?

By

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ABSTRACT

There are fundamental differences in the chemistry of the uranium and copper solvent extraction processes, that drive the two far apart in terms of the number of operations and the number of different stages in each operation.

Copper can be as simple as two extract and one strip mixer settlers; while a complex uranium circuit can have: extraction, wash, scrub, strip, regeneration and re-protonation, with up to fifteen or more mixer-settler units.

The circuit selection for copper can be modelled well without recourse to detailed isotherm generation and pilot plant operation. The same cannot be said for uranium where the possible alternate stripping chemistries can drive the need for extensive piloting and isotherm generation.

There have been many advances in the design and application of mixer-settlers in copper SX. Most of these advances can be directly implemented in new uranium SX projects to improve the plant performance over older designs.

The new uranium SX plants will have mixer-settlers predominantly that look the same as copper SX units. Their circuits will incorporate the necessary process steps but also the latest copper SX developments in entrainment, contamination management, fire risk management and layout.

APPLICATION OF WINTRAY EXTRACTION COLUMN TO A DIRECT URANIUM SOLVENT EXTRACTION PROCESS

By

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ABSTRACT

Large-scale uranium hydrometallurgical processing with low grade uranium ore has been carried out, not by the direct solvent extraction (DSX) method, but by the ion exchange (IX) + solvent extraction (SX) method (Eluex). This is because the DSX method with mixer-settlers requires a much higher investment cost than Eluex, and the DSX method with a conventional column cannot be operated at a high A/O (ratio of aqueous flow rate to the organic flow rate) values. However, a number of WINTRAY® (hereinafter referred to as "the WINTRAY") extraction columns, developed by JGC for use in stage-type extraction columns, have been constructed in the petrochemical and coal chemical industries, and their high throughput, high efficiency and high resistance to scum have been demonstrated. The application areas have been extended from the hydrocarbon field to non-ferrous hydrometallurgy. This time, the uranium extraction test with a rectangular WINTRAY column (width of 100 mm, depth of 40 mm and effective extraction height of 4.9 m) from low uranium concentration (300 ppm) PLS by Alamine 336 + Iso-decanol + SHELLSOL D70 was conducted at MINTEK in the Republic of South Africa. A uranium extraction percentage of 95% was obtained at A (PLS) / O (10%Alamine) = 15, and with twice extraction, a uranium extraction percentage of more than 99% was achieved at A/O=20. Although the PLS was like muddy water, by being spiked with a high content of silica and nitrate ions and having a suspended solid concentration of 80–180 ppm, stable operation was maintained at total flux of 70 $m^3/m^2/hr$, and it was not affected by the small amount of scum that accumulated near the liquid-liquid interface at the bottom of the column. A loaded solvent with a high uranium concentration can be directly produced from the PLS of 300 ppm uranium by an industrial-size WINTRAY column. Also, by utilizing the loaded solvent generated by the WINTRAY extraction test, stripping tests using a batch countercurrent scheme were conducted at a laboratory in MINTEK to obtain design data on the stripping system using a mixer-settler cascade. The results of tests were utilized for scaling up the plant to industrial size and for a ballpark cost comparison between WINTRAY DSX process and conventional Eluex process, and confirmed that the WINTRAY DSX process can dramatically reduce CAPEX (capital expenditure) and OPEX (operating expenditure), compared with the Eluex process.

ADVANCES IN BATEMAN PULSED COLUMN DESIGN AND APPLICATION FOR URANIUM SOLVENT EXTRACTION

By

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ABSTRACT

Bateman Pulsed Columns (BPC) are installed in three uranium solvent extraction plants in Australia and South Africa. The industrial columns were designed from scale-up of pilot test work for each site using authentic solutions and actual process conditions.

Recent in-house development work has demonstrated that the geometry of the column internals can be changed to provide better dispersion of the dispersed phase at reduced pulsation intensity and consequently improved mass transfer with decreased axial mixing. In addition, a set of correlations have been developed for standard internals to predict maximum flux and pulsation intensity (amplitude*frequency) at maximum flux and holdup (fraction of column volume occupied by dispersed phase), for a given phase ratio and with the desired phase continuity – organic or aqueous.

The development work has the following implications for the design of BPC for Uranium solvent extraction:

- Modified internals geometry, can reduce height and cost of BPC
- For cases requiring higher phase ratios the modified internals improve mass transfer and reduces height and cost of BPC by decreasing back-mixing
- Predicts the flux and pulsation intensity in pilot columns based on physical properties of the solutions and therefore allows for better design of pilot tests resulting in fewer tests with smaller requirements of volumes of solutions
- In some cases the predictions can be used to design columns and improve the accuracy of cost estimation for industrial columns without any pilot tests. A limited amount of laboratory test work will, however, be necessary
- Column internals in an installed BPC can be retrofitted in order to improve performance as a consequence of changes in feed composition

URANIUM RECOVERY USING DEHPA/ALAMINE 336 MIXED REAGENT

By

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USX saline: big picture

- Chloride negatively affects uranium solvent extraction.
- Desalination costs **energy** and **money**.
- Can we use untreated sea or bore water?
- Can we increase recycle streams?

-*Save money, preserve fresh water for irrigation*

HIGH CONC. ELUATE CONCENTRATION FROM LIQUORS CONTAINING HIGH CHLORIDE CONCENTRATIONS

By

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URANIUM ORE LEACHING

THE USE OF AMMONIUM CARBONATE AS LIXIVIANT IN URANIUM LEACHING

By

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ABSTRACT

Ammonium carbonate is not commonly used in industrial uranium leaching, although it has benefits such as selectivity, little or no attack on silicaceous materials, good opportunities for reagent recycling, and straightforward and selective recovery of uranium values. It has found application in *in-situ* leaching, however.

When radioactive materials are handled in hot cells, it is desirable to have the simplest possible process resulting in no or minimal waste. Ammonium carbonate as lixiviant was studied for the selective recovery of uranium from a simulated residue for eventual application in the recovery of uranium from radioactive residues. The study also compared oxygen and hydrogen peroxide as oxidants. It was found that the leaching reaction is rapid at 50 °C and above, especially when hydrogen peroxide is used as lixiviant.

The reagent decomposes to ammonia, carbon dioxide, and water at rather low temperatures. This can, however, be put to good effect by allowing simple recovery of the reagent, thus closing possible effluent loops and minimizing wastes, with attendant environmental benefits. The conditions for obtaining an easily filtered product were determined.

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PROJECT DEVELOPMENT

METALLURGICAL DEVELOPMENT OF THE SAMPHIRE URANIUM PROJECT

By

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ABSTRACT

The UraniumSA Samphire Project is located 20km southwest of Whyalla on the Eastern Eyre Peninsula, South Australia. The project has a total inferred resource of 19,000t (42M lbs) contained U_3O_8 hosted in fluvial sediments of the Eocene Kanaka Beds. Formation water is hyper saline typically containing >30,000 ppm TDS and was recognized at discovery as a potentially limiting factor for the development of the resource. This paper presents the metallurgical development of the project; particularly issues involved in extracting uranium from the hyper saline formation waters and outlines the advances which have been made.

Laboratory ore characterisation, including mineralogy and physical properties of the ore, coupled with the geological characteristics of the host units indicate the uranium mineralisation is potentially amenable to in-situ recovery. Bottle roll tests conducted with ore and seawater under alkali and acid conditions favoured the acid leach media and demonstrated uranium recoveries up to 90% in reasonable timeframes, with low acid consumption and minimal generation of iron or other species.

A 2010 desktop study confirmed that chelating ion exchange resins had potential for uranium recovery from acidic hyper saline solutions. Preliminary testing of potential resins produced excellent results with uranium loadings up to 30 g U/l w.s.r. achieved. ANSTO were contracted during 2011 to conduct bottle roll and column leach tests of a bulk ore sample using sea water/sulphuric acid and to perform loading testwork on candidate resins using the resulting pregnant solutions. ANSTO subsequently conducted proof of concept testwork with two of the resins and produced an 84% uranium product.

The best four resins from the 2011 work program were further investigated at ANSTO via column loading and column elution and a high purity final uranium product was produced.

PILOT PLANT TREATMENT OF ORE FROM TORO ENERGY'S WILUNA PROJECT

By

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LEACHING OF KVANEFJELD CONCENTRATE

By

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ABSTRACT

Greenland Minerals and Energy owns the Kvanefjeld uranium and rare earth element project in southern Greenland. The project has completed a Pre-Feasibility study which shows an economically viable project to produce substantial quantities of uranium oxide and rare earth oxide intermediate products. This Pre-Feasibility study was released in April 2012 with Feasibility activities already initiated to take the project through to commercialisation.

Testwork has shown that silica dissolution and re-precipitation can be controlled during the leaching of Kvanefjeld concentrate. Extended residence times and high temperature are important for silica control. In addition, the rate of acid addition must be slow enough to allow silica to precipitate faster than it leaches.

High acid addition is needed to produce high extractions of values with atmospheric leaching. Monazite is noted as being a refractory mineral in the process, which reduces light rare earth extraction.

Acid baking is highly effective for extraction of light rare earth elements. High temperature of 290℃ is needed to breakdown the monazite mineral in addition to steenstrupine. Heavy rare earth and uranium extractions were observed to be lower than atmospheric leaching. This could be improved with further testwork focusing on increasing the acid dose or retaining more acid in acid bake process.

High acid conditions are known to leach the alkaline mineral steenstrupine effectively however acid baking is needed to extract values from monazite. However mineralogical investigations suggest that monazite may not be an important host of light rare earth elements across the entire deposit. Some ore types produced very high recoveries of light rare earths with atmospheric leaching with only modest decreases in heavy rare earth recoveries. The main concentrate sample tested produced the lowest light rare earth extractions and therefore also has the highest monazite content. The atmospheric leaching test appears to act as an accurate proxy for the identification of monazite across the orebody.

ENVIRONMENTAL ASPECTS OF URANIUM PROJECTS

By

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ABSTRACT

The management of environmental aspects in uranium projects is in many ways no different to the management of environmental aspects in any heavy metal mining project. But there are important differences that need to be borne in mind if permitting issues and long term legacy issues are to be minimized. These differences include public perception of radioactivity and radioactive materials, the fact that uranium has daughter elements that themselves pose environmental hazards by virtue of their toxicity and longevity and the need to measure the effectiveness of controls through both dose as well as concentration. This paper highlights the author's experience with environmental management on a number of well known uranium mines and covers the management of stockpiles, heap leach facilities, waste dumps, tailings and effluent containment facilities as well as the mining area, plant area and transport routes. Experiences gained from consulting to these operations have been summarised to provide pointers to potential environmental management requirements for new projects.

TO GAMMA OR NOT TO GAMMA
A SOUTH TEXAS CASE STUDY OF URANIUM DETECTION METHODS

By

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Outline

What is the challenge?

- Accuracy of Gamma logging in areas of Uranium disequilibrium
- Cost and time taken to obtain core
- Questions on the accuracy of sampling resolution
- Uncertainty of cost vs. benefit of core vs. PFN vs. GR

What is the investigation?

- Detailed spatial & statistical analysis of South Texas core, PFN & GR data

Results

- Which method was the least wrong?
- Confirmation of some expectations
- Further investigation

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URANIUM HEAP LEACHING FORUM

HEAP LEACHING PHILOSOPHY WITH SPECIFIC REFERENCE TO URANIUM ORES

By

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ABSTRACT

Many uranium expansion and exploration projects currently under development involve ore bodies of modest grade and/or size, making heap leaching the extraction process of choice, either for the entire ore body or in combination with agitated leaching of higher-grade materials.

The paper summarises the key decisions that are required for the process design of uranium heap leaching circuits. Uranium ores typically exhibit notable variability in a single deposit and hence require extensive characterisation of samples representing the various locations. Developments which are expected to be highly relevant to the future economics of uranium heap leaching are sorting based on X-Ray fluorescence, and the inclusion of a scrubbing step for certain ores. The use of high pressure grinding rolls (HPGR) and optimisation of blasting techniques require further research to quantify their potential benefits.

Some discussion is offered on how the use of compression and hydraulic conductivity tests can improve the confidence of scale-up from column or crib leach tests, by avoiding overly compacted regions of insufficient voidage and of excessive saturation which become stagnant and hence diffusion-controlled.

Developments which promise to advance the understanding of heap leaching in general include in-heap instrumentation, radiographic studies of particulate beds, and mathematical modelling.

THE CRITICAL ROLE OF GANGUE ELEMENT CHEMISTRY IN HEAP AND AGITATED TANK LEACHING OF URANIUM ORES

By

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Presented by

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ABSTRACT

In the uranium leach processes employing sulfuric acid as the lixiviant, only a relatively small quantity of acid is gainfully employed in extracting uranium from the host ore. The remainder of the acid is consumed by the gangue constituent elements. Many new projects that are being considered today have gangue acid consumptions in excess of 95%. Many of the gangue elements that are solubilised by the acid report to the leachate where they build up in concentration in a closed flow sheet. The impact of this may in some case be deleterious to the extraction of uranium, whilst in others there have been some benefits identified when leaching in high solute concentration solutions. The roles played by these elements have been investigated in both heap and tank leach testwork, and are presented in this paper. Discussion of the effect of gangue chemistry focuses on the impact of the gangue elements on the economics of the process and the flowsheet implications.

URANIUM HEAP LEACH MODELING

By

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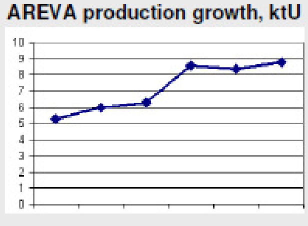
A sustained production growth

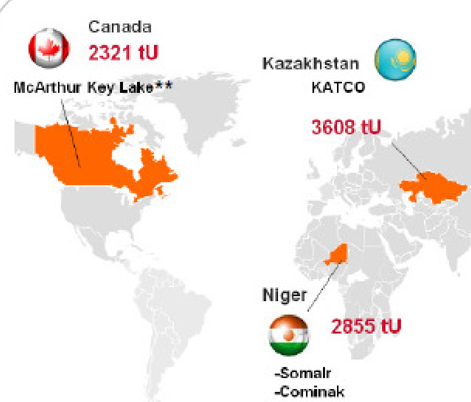
N# 2
world producer in 2011

8790* tones of uranium in 2011

+ **9%** since 2010 (despite closure of McClean Lake mine)

AREVA production growth, ktU





3 countries with 4 operating mines in 2011

*Accessible share of production, includes 6tU produced in France
** Operated by CAMECO

EARLY STAGE METALLURGICAL EVALUATION OF A COMPLEX LOW-GRADE URANIUM PROJECT

By

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ABSTRACT

The development of complex low-grade mineral deposits is becoming an increasingly important target for resource companies. These deposits often present marginal economic opportunities, which are highly dependent on the development of low-cost and efficient processing strategies and the utilisation of by-products to become a viable development target. For exploration-focused companies this presents a critical investment decision stage early in project development on whether to pursue potentially expensive resource definition or look for other targets.

The development of the Häggån project, Sweden, has presented a target requiring careful technical evaluation through the early development stages. The project represents a low-grade complex uranium resource, with significant vanadium, molybdenum, nickel and zinc credits. A process of mineralogical characterisation and multi-directional scoping metallurgical test work has been presented, focused on providing the basis to make a confident investment decision to progress the project to pre-feasibility evaluation. Implementation of this process has allowed the development of conceptual flowsheets targeted at efficient recovery of value metals and the rejection of technically ineffective options based on an understanding of the material and its behaviour.

URANIUM RECOVERY AS A BY-PRODUCT AT TALVIVAARA MINE

By

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ABSTRACT

The Talvivaara Mine, located near the City of Sotkamo in Finland, is the first bioheapleaching operation for nickel production in the world. Production of nickel along with the by-products of zinc, cobalt and copper as metal sulphides started in October 2008 at the Talvivaara mine.

The ore also contains a low concentration of uranium. Talvivaara and Cameco are working together to design, construct and commission a uranium extraction plant to recover the uranium from their production leach solution. Outotec is the main technology supplier for the solvent extraction and precipitation process areas.

The pregnant leach solution (PLS) from the existing metals recovery plant will enter the uranium plant with a uranium concentration of approximately 20 ppm. A novel solvent extraction process will be used to selectively extract the uranium from the PLS into an organic solution. Sodium carbonate will be used to strip the uranium from the organic phase back into an aqueous phase. The yellowcake will be precipitated from the aqueous phase with hydrogen peroxide, settled in a thickener and then dried before being packaged in steel drums.

The low uranium concentration in the PLS, the high volume throughput and environmental considerations were the primary factors in designing the processes and selecting the major equipment. The design engineering is complete, the building is under construction, all the major equipment has been ordered and installation of the equipment has started. Commissioning of the new uranium plant will start in early August of 2012. The plant will produce 350 tonnes of uranium per year, when the full nickel production is reached..

The process for obtaining all the permits and approvals to operate the uranium extraction plant from the European Commission, the Government of Finland, the Finland nuclear regulator (STUK - Radiation and Nuclear Safety Authority) and the Finnish environmental authorities is underway and is expected to be completed by the end of the second quarter of 2012.

DEVELOPMENT OF THE LETLHAKANE URANIUM PROJECT, BOTSWANA

By

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