The advantage of technology in the rare earth universe

The Rare Earth universe was once so large that is was quite literally a universe. Now is it more like a solar system and the planets can be counted on the fingers of both hands. However there are at least survivors for many had thought in the wake of Molycorp’s demise that it might be a case of “will the last one to leave please turn off the lights”.

The old “universe” involved many names disappearing altogether but what really happened was that there came a fork in the road and at least two of the potential routes led somewhere and those that followed the others were never seen again. One of the obvious paths, indeed the path of least resistance but maximum difficulty, was to just soldier on with one’s project. Most of those that survived (and we can number less than ten) either had significant shareholders prepared to make ongoing investment to keep the project’s moving forward or had some sort of putative offtaker.

The other path was the technology route. The grim times in the specialty metals space highlighted that classic axiom that it was the value added in technology metals that frequently took the bulk (if not all) the profits and that the mining was merely a loss-leader. The fork in the road that was the “road less travelled” was that of pursuing the technologies that might expedite extraction of the metals, be they Rare Earths or other specialty metals in demand. One thing became patently obvious from the outsized capexes in the REE space (and the outsized acid usage) and that was that something was clearly wrong with the same old, same old in processing technology. This spurred the creation of a new niche in technologies. Few companies followed this route but doing so certainly ensured their survival and now a number of new companies have appeared also hoping to exploit technologies that reduce the processing
cost, complexity and noxious environmental effect of traditional methods.

Ucore Rare Metals Inc. (TSXV: UCU | OTCQX: UURAF) has been followed by us since the high tide of the previous REE boom. It made the decision to follow the road less travelled with its MRT technology and in the process has not only survived but found a technology that works with a whole suite of specialty (and not so special) metals thus staying in the REE game but also broadening out and diversifying its potential customers. It has also enabled itself to work with “end-of-life” (read “recycling”) sources of material rather than just run-of-mine output.

Here we shall look at what this technology is and how its’ evolving at Ucore.

MRT – Let Me Boggle You with Science

This section requires you to be sitting down. The MRT platform now being utilized by Ucore is derived from the research of the founders of IBC (Dr Reed Izatt, Dr Jerald Bradshaw and Dr James Christensen) and associates who have developed and applied this technology to the separation of metal ions. In March 2015, Ucore announced that it had reached an exclusive agreement with IBC to license IBC’s MRT technology (SuperLig) within the Rare Earth industry.

MRT is a branch of Supramolecular chemistry, originally pioneered by Charles Pedersen at E.I. DuPont Laboratories in the 1960’s. That original research into the capabilities of MRT for selective binding of metal ions culminated in the awarding of the Nobel Prize for Chemistry jointly to three researchers (Lehn, Pedersen and Cram) in the development of the technology in 1987.

First some definitions may be in order. Elution, in layman’s terms, is the separation of material by washing; the process of pulverizing substances and mixing them with water in order
to separate the heavier constituents, which settle out in solution, from the lighter.

Then, Ligands, which are central to the MRT process are best described as ions or neutral molecules that bond to a central metal atom or ion. Ligands act as electron pair donors, and the central atom acts as a electron pair acceptor. Ligands have at least one donor atom with an electron pair used to form covalent bonds with the central atom.

SuperLig is essentially a customized ligand which is tethered to a solid substrate. The tether enables the ligands to act as a filter. SuperLigs trap the target element as the Pregnant Leach Solution (PLS) is flowed through the column. The raffinate exits and the target elements remain tethered to the substrate by the SuperLig. The eluate then releases the target element and leaves the Superlig ready to trap more target elements when another batch of PLS is flowed through the column. The Superligs are very resilient and remain effective through many cycles. With Rare Earths being so challenging to separate, it was rather canny of Ucore to decide to apply this technology to the Lanthanide Series using samples from Ucore’s Bokan Mountain deposit... and it was a success.

The advantages of MRT are:

- Low capital and operating costs due to high selectivity and rapid rates of reaction
- Flexible and easy operation offered by:
  - ability to treat large concentrations ranges of ions in the feed
  - efficient loading and elution profiles
  - small number of elution bed volumes
  - rapid flow rates and cycle times
  - longevity and stability of SuperLig
  - automated operation
  - Environmentally friendly operation resulting from closed-loop systems
- No contamination of processed solutions by ions transferred from SuperLig
- Waste streams treated by MRT systems contain almost none of the contaminants targeted by SuperLig
- The eluant can often be recycled
- High purity, high-concentration eluate can produce value-added products.

Applications – MRT & PGMs

IBC’s MRT-based SuperLig technology is currently already utilized extensively in metals processing, and is now being introduced into the Rare Earth separation field as a means of both selectively extracting the Rare Earths as a group from a mixed polymetallic solution and of selectively isolating and refining individual high-purity Rare Earth elements.

One of the world’s leading PGM producers, Impala Platinum, has long been a card-carrying fan of MRT with its JV with IBC to market PGM applications of MRT dating back to 1994. Below can be seen the MRT columns at Impala’s refining plant in South Africa.
Industrial applications for IBC’s SuperLig/MRT platform in the PGM space are well proven with platinum, palladium and rhodium recovery from spent automobile catalytic converters resulting in high-purity products, improved recoveries, reduced processing costs and metal lock-up. The other application has been palladium separation and purification in PGM refineries resulting in reduced processing time and costs, increased palladium separation efficiency and recovery and reduced environmental impact. It has also been applied to rhodium refining by Tanaka in Japan.

**PLS & Mixed Concentrate Preparation**

The production of a high-purity heavier REE concentrate is the key initial step in the separation of individual high-purity heavier Rare Earth salts. The resultant salts can be utilized to generate output products tailored to customer specifications. Those products include oxides, carbonates, nitrates and other salts of each of the individual Rare Earth elements. A highly purified concentrate of the heavier REEs can be considered an end product to be sold to independent Rare Earth separation facilities, or can be used as input material for an in-house individual rare earth salt separation facility.

The process through which the PLS flows can be seen in the schematic below:
A Rare Earth-enriched raffinate solution is fed through a further SuperLig extraction which is designed to separate the heavier REE’s, as a group. The heavier REE’s are then eluted from the column with a small amount of eluant and easily precipitated from the resulting concentrated solution to form the carbonate salt. Recovery rates for the HREE’s from the Bokan PLS to the salt are in excess of 99%. The remaining raffinate containing the light rare earths, as well as Yttrium, is preserved for further processing. Ucore has been working to develop a high-purity Yttrium salt as an additional output product of the MRT process.
The >99% pure HREE concentrate is a carbonate salt Rare Earth concentrate comprised of heavy rare earths ranging from Samarium (Sm) through Lutetium (Lu). The Rare Earth concentrate is easily convertible to oxide or other salt forms depending upon commercial requirements and contains the following rare earth content:

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<thead>
<tr>
<th>Carbonate</th>
<th>Sm</th>
<th>Eu</th>
<th>Gd</th>
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<tbody>
<tr>
<td>Tb</td>
<td>24.54%</td>
<td>4.00%</td>
<td>21.82%</td>
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<tr>
<td>Dy</td>
<td>25.65%</td>
<td>3.14%</td>
<td>5.96%</td>
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<td>Ho</td>
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<td>Er</td>
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<tr>
<td>Tm</td>
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<tr>
<td>Yb</td>
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<td>Lu</td>
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In the “final wash” so to speak, MRT produces a clean and high-grade heavy REE mixed concentrate, free of radioactive elements and free of commonly produced elements that interfere with traditional Solvent Extraction separation such as Al, Fe, and Fluoride. While the application of MRT to REE may be pioneering, as an industrial process MRT is a known and proven technology.

**Pilot Plant**

Ucore commissioned the construction of a pilot plant
(codenamed “SuperLig-One”) at IBC’s Utah facility (seen below). The purpose of which was to test the use of MRT for the separation of REE’s on a bulk scale. However, it then started testing other potential special metals.

The unit was capable of accepting Pregnant Leach Solution and bulk concentrates from REE feedstock locations around the world. To this end Ucore entered into agreements with several REE feedstock providers, and secured test material from a variety of locations.

The pilot plant is both modular and portable in design, capable of transport to remote testing sites as required. Columnar units within the Plant contain customized proprietary SuperLig products that are designed to selectively separate the metal being targeted. To optimize utility, the Plant will be customizable over time, with capacity for treating varying ratios of metals in different PLS feed solutions.

Stepping up in Size
The next objective is for this test unit to serve as a prototype for a full sized SuperLig separation plant (being termed a Critical Metals Facility by the company), to be located somewhere in North America, to receive PLS or concentrates from locations in the Americas and beyond. Such a plant might be around 20,000 sq ft in size with two circuits, one for Lanthanides and one for PGMs. At the moment sites in Utah, Texas, West Virginia and Alaska are being considered. It should be recalled that Alaska’s development authority had already shepherded legislation through the state’s chambers to obtain $145mn in loan guarantees for Ucore’s Bokan project and that included $10mn for a processing plant. This might tend to tip the scales towards the Alaskan option.

Another consideration though will be access to material. In both cases end-of-life material will be the initial source of feedstock with automotive recycling feeding both circuits. PGMs will be coming from exhaust catalysts (but also potentially from cracking catalysts from petroleum refineries) while the Rare Earths will come from magnets that have reached the end of their useful life (again from autos but also wind turbines etc).

**Conclusion**

Ucore is now styling itself as “resource agnostic” and seems to have struck a happy medium in bringing a mold-breaking technology to the PGM and REE spaces and yet at the same time adopting a tried and tested technology. One might call this derisked innovation. The MRT process is notable in that it uses green chemistry procedures throughout. No solvents or pernicious chemicals are used. The highly selective separations achieved with the MRT process make REE separations and recovery at high purities possible. Conservation of the Rare Earth metals has great importance, especially since large amounts, as much as 30% of these metals, remain unrecovered using conventional separation processes, such as Solvent Extraction.
Ucore holding the licensing rights for MRT originally created a whole new vertical for the company that has now barged to the front of the stage and become its raison d’etre. While those wanting to play in REE extraction technologies remain largely below the radar as private companies, Ucore has the distinction of being the only advanced non-SX technology in the Rare Earth space that is in the public eye due to its listed status. The road less travelled is turning out to be the high road.