FACT SHEET

DONALD RARE EARTH & MINERAL SANDS PROJECT

March 2023

FINE MINERALS PROCESSING

The main technical issue which has been associated, historically, with the development of fine-grained or WIM-style mineral sands deposits, has related to processing and the achievement of commercial recoveries of the fine, valuable, heavy minerals (HM). Astron has played a major role in the development of technologies to enable the achievement of commercial levels of recovery of the valuable minerals to both concentrate and the final products. Astron's test and pilot scale work has achieved levels of ore recovery to valuable mineral at levels similar to conventional, coarse grained deposits. The major impediment to the commercialisation of what are, in the case of the Donald ore reserve, large and scalable deposits with a multi-mineral product streams, has been resolved enabling planning to progress with a confidence that commercial level recoveries and defined product quality attributes can be achieved.

Concentrate and final product recovery improvements have resulted from a long-term commitment from industry participants, such as Astron, with the assistance of specialist industry technical consultants and metallurgical equipment manufacturers, including Mineral Technologies, the global leader in mineral sands processing.

.

Context

The Donald Rare Earth and Mineral Sands Project tenements were initially discovered by CRA Exploration in the 1980s as part of a regional exploration programme in Victoria. Following extensive resource delineation, CRA undertook pilot scale concentration trials of the fine grained HM, using flotation. At the time, the use of flotation was not just inefficient, but also costly, requiring significant up-front investment and high usage of water. Recognising the challenges associated with the processing of fine grained heavy minerals, and in the context of other corporate priorities at the time in the early 2000's, Rio Tinto (as CRA had become) relinquished its Wimmera mineral sands tenements (WIM).

Historically, according to geological classification, anything finer than 38 microns was classified as slimes or extremely fine particles suspended in water indefinitely. As such it was expected that they would be lost in processing. While traditional coarse-grained heavy mineral has a grain size ranging from 75 microns to 250 microns, the Donald heavy mineral concentrate (HMC) grain size ranges between 90 and 20 microns at a median particle diameter (D-50) of 57 microns. The valuable components of the HMC, notably the zircon and rare earth minerals, are at finer end of this range. For example, the Donald Project rare earth product stream has a D-50 of 40 microns.

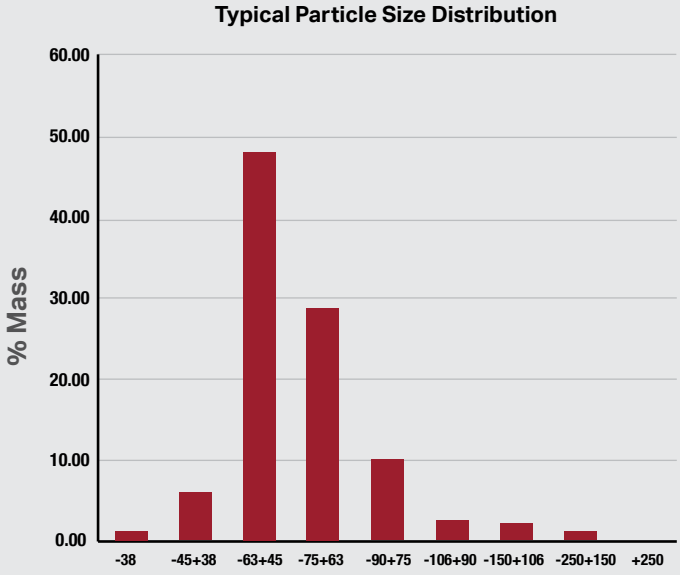

Figure 1. HMC Size Distribution

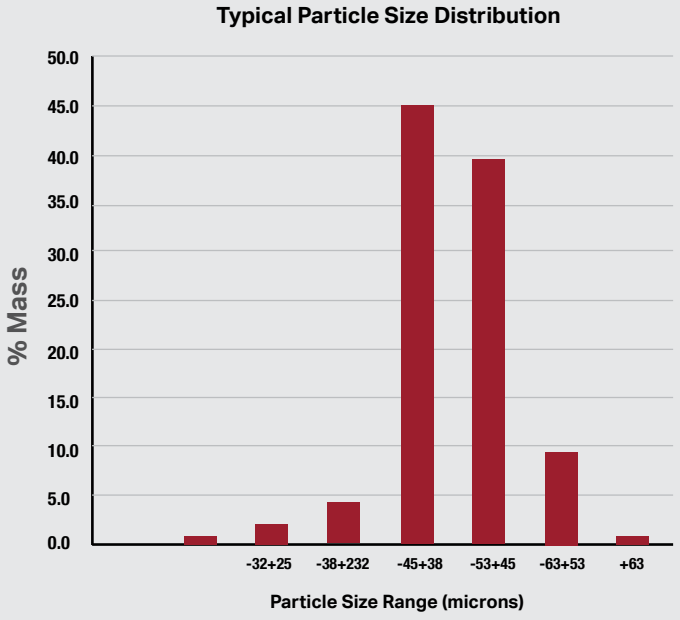

Figure 2. Rare Earth Element Concentrate Distribution

CONTACT US:

admin@donaldmineralsands.com.au | Careers: jobs@donaldmineralsands.com.au

www.astronlimited.com.au

FACT SHEET

DONALD RARE EARTH & MINERAL SANDS PROJECT

March 2023

FINE MINERALS PROCESSING

Spiral Technology Evolution – Unlocking Fine Mineral Recoveries to HMC

Gravity spiral technologies for the separation of heavy mineral separation have been well understood and widely used in the mineral sands sector for more than 40 years. The spirals to be used for the Donald Project have, however, required extensive R&D work and testing to ensure a spiral design and operating performance that can deal with the unique challenges of separating the fine, valuable HM found from the non-valuable gangue in WIM-style deposits.

Initial Development of Fine Spirals Leading to Successful Piloting of Fine Mineral Separation

Historical wet concentrator plant pilot work, 2005.

In 2004, Mineral Technologies Ltd, an Australian subsidiary of a specialist global minerals processing group, was commissioned by Astron to undertake work using spirals for the concentration of fine-grained heavy minerals. The test work made use of ore recovered from a test pit at Astron's Donald tenements in regional Victoria. Through this work, Mineral Technologies developed the first spirals suitable for the concentration of fine-grained minerals. The spirals developed were named FM-01s ("FM" standing for fine minerals, and "01" representing the technical breakthrough associated with this form of spiral). The FM-01s had unique characteristics, such as shallower spiral contours which enabled them to generate better separation outcomes for the valuable, higher specific gravity heavy minerals from the lighter gangue or waste material, including quartz.

In 2005, the successful pre-concentration of Donald ore was undertaken in a pilot plant, consisting of a trommel/vibrating screen to remove oversize material, de-sliming cyclones to remove slimes (particles lower than that for the valuable heavy mineral component) and two stages of FM-01 spirals to produce a pre-concentrate containing 19.9% HM, with an overall HM recovery of 84.8%, and a zircon recovery of 91.2%.

The HMC (which in the case of the Donald orebody contains both rare earth minerals and heavy mineral sands) was then processed in a concentrate upgrade circuit, consisting of two stages of wet high intensity magnetic separation (WHIMS) to produce magnetic and non-magnetic concentrates, and a five-stage spiral separator/wet shaking table circuit to upgrade the non-magnetic concentrate to an HMC containing greater than 90% HM. While the test-work confirmed that fine mineral recoveries at commercial scale could be achieved, there was scope for improvement.

Further Test work and Refinement of Separation Processes

In association with Mineral Technologies, Astron continued to work on the means to enhance the recovery of the fine valuable heavy mineral. By 2015, it was recognised that intermediary WHIMS circuits could be by-passed by spiral separation and with adequate feed-preparation. Laboratory-scale test work confirmed the production of a 90% HMC grade, containing rare earth minerals, zircon and titanium minerals, at recoveries of 92.6%, 94.6% and 60.4% respectively.

In 2018, this flowsheet configuration was tested at pilot scale. A further test-pit excavation enabled the processing of 1,000 tonnes of ore through a pilot concentrator plant (scaled at 1:121), using full-scale spirals. Recovery of valuable heavy mineral (VHM) was achieved at a 85% and 95% HMC grade respectively, confirming earlier laboratory-scale test results. The test work demonstrated that the initial challenges associated with achieving commercial recovery levels of fine minerals to concentrate had been resolved.

Utilising the experience in developing spiral technologies for fine-grained minerals, Mineral Technologies has adapted this knowledge into its MG-12 (medium grade) spirals. The MG-12s, as the newer generation of spirals yielded better results for fine mineral separation than the FM-01s. Testing using the Donald ore demonstrated that MG-12 spirals could enable a reduction in the number of spiral separation stages from 5 to 4, leading to a smaller plant footprint, and in turn capital expenditure and operational cost savings.

As a result of this technological development and test work, conducted over two decades, Astron developed a fit-for-purpose flowsheet that will be able to achieve commercial level mineral recovery yields, comparable to coarse-grained mineral sands operations. Further, as the test work was done on a small, batch-scale basis, it can be expected that a processing configuration at scale and run on a continuous basis should achieve higher recoveries than the test and pilot scale results. The extensive test work and technology investment has been a major component of Astron's work to de-risk major components of the Donald Project.

Donald Wet Concentrator Pilot Plant, Mineral Technologies, QLD 2018.

CONTACT US:

admin@donaldmineralsands.com.au | Careers: jobs@donaldmineralsands.com.au

www.astronlimited.com.au

FACT SHEET

DONALD RARE EARTH & MINERAL SANDS PROJECT

March 2023

FINE MINERALS PROCESSING

Rare Earth Flotation – Enabling the Production of High Grade Final Products

While concentration of ore to HMC was resolved with the development of the FM-01 and MG-12 spirals (with the knowledge gained from this work now incorporated into spiral designs able to be used for both fine and coarse grained deposits), the final separation from HMC to final products of zircon, titanium and rare earth element concentrate posed additional technical challenges.

The main technical issues were associated with the recovery of the rare earths minerals within the HMC. Unlike traditional separation methods, such as electro-magnetic and electro-static separators which separate minerals sands into zircon (non-magnetic and non-conductive) and titania-bearing products (magnetic in different degrees) the fact that monazite and xenotime are both partly-magnetic and partly-conductive, makes their separation from the mineral sands component difficult. Using conventional electro-static and electro-magnetic separation would result in monazite and xenotime "reporting" across the entire final product mix. This would, in effect, degrade the quality of the final mineral sands products. In particular, the zircon stream could be associated with unacceptably elevated levels of radioactivity from the rare earth minerals.

This led to the trial of flotation techniques in a two-stage process of separation of the raw HMC. Astron had adopted flotation for mineral separation purposes in 2016, when a flowsheet comprising sequential flotation of zircon and rare earth minerals leaving the residual titania-bearing minerals was developed and tested. While this flowsheet demonstrated acceptable recoveries, the ultimate separation of zircon and rare earth minerals still presented challenges which entailed, at that stage, the use of additional separation stages. It was determined that, in a commercial production setting, this would require significantly more process equipment with the commensurate adverse implications for both capital and operating costs.

In 2020, Astron, with the assistance of Mineral Technologies, commissioned flotation specialists, AMML, to study the flotation of rare earth minerals from the HMC. In total, six flotation tests were undertaken at laboratory scale, all of which demonstrated recoveries of over 90% of a rare earth element concentrate (REEC). One flotation test, with a longer attrition period, resulted in a rare earth recovery level of over 95%.

This flotation approach was tested at pilot scale. In 2021, 8 tonnes of HMC produced from Donald ore was separated into a REEC and a zircon and titanium HMC. The REEC produced had a total rare earth oxide (TREO) of over 60%, and Nd/Pr of over 20% of the rare earth basket. Very high recoveries of the rare earth minerals meant that the subsequent zircon and titanium products were not 'contaminated' by the rare earth element radioactivity. This work provided Astron with the confidence that it could commercially produce both an REEC and an RE-free mineral sands HMC which would be most suitable for sale and further processing by third parties to final products.

Donald rare earth flotation pilot plant, nagrom, WA, 2020.

In pilot scale test work, following the flotation of REEC, the residual HMC had a natural radioactivity of approximately 6 becquerel/gram (Bq/g). This radiation level is acceptable in end product usages for zircon, including tile manufacture, and is within the regulatory limits in Victoria allowable for the transportation of materials with elevated background radiation levels. The separation of the HMC into the zircon and titanium products uses conventional electromagnetic and electrostatic separation techniques in a simplified flowsheet with high, commercially viable recoveries to final products.

Summary

- Extensive test work associated with fine grained mineral sands over close to two decades, conducted by Astron and specialist consultants, has enabled Astron's mineral separation process to be enhanced and simplified, with the confidence that the processes tested are applicable in a commercial production setting.
- The hybrid processes to be used in relation to spirals and rare earth flotation are well-understood, widely adopted and present relatively little technical risk.
- Correspondingly, Astron has a high level of confidence that, for Phase 1 of the Donald Project, it will be able to produce a rare earth element concentrate and a mineral sands heavy mineral concentrate, with ready market application and acceptance.
- The results from test work also provide confidence that, in subsequent phases of the Donald Project, Astron can move to the processing of HMC into final products, while the company also investigates its options and the economic case for an involvement in the processing of the rare earth concentrate stream

CONTACT US:

admin@donaldmineralsands.com.au | Careers: jobs@donaldmineralsands.com.au

www.astronlimited.com.au