August 2022

Technical Report on the Phalaborwa Processing Flowsheet Development

This technical note serves to support the Technical Report on the Phalaborwa Processing Flowsheet Development released in February 2022 with additional information employed to finalise the Preliminary Economic Assessment ("PEA") study phase.

Rainbow Rare Earths Limited ("Rainbow") initiated a phased test work programme at ANSTO Minerals in Australia to develop a technically and economically feasible rare-earth extraction flowsheet for processing the phosphogypsum stacks located at Phalaborwa, in South Africa (the "Project").

The ANSTO Minerals test work programme was supported by various other studies and test campaigns at a number of facilities. The key programmes, in addition to those previously reported, can be summarised as follows:

- Thickening test work at Roytec Global, South Africa.
- K-Technologies Inc. ("K-Tech") bench work programme.

The initial test work programme at ANSTO Minerals was designed as a two phased programme with the phase 1 programme completed in July 2021, leading to the following key decisions and conclusions:

- Phosphogypsum will be hydraulically reclaimed from the stacks and pumped to the processing facility.
- In order to manage the leach slurry density and allow for reagent recycling, pre- and post-leach filtration steps will be included.
- Significant fluoride levels in the pregnant leach solution ("PLS") due to the targeted dissolution of the rare earth rich calcium aluminium fluoride phase.
- Fluoride removal and or control to be considered in the phase 2 test work programme.
- Sulphuric acid selected as the lixiviant of choice due to cost, materials of construction, availability in the region and targeted dissolution of the rare earth rich calcium fluoride phase without significant gypsum dissolution.
- Although ambient leach conditions yielded acceptable results over a 24-hour leach period a moderate temperature adjustment may impact positively on capital reduction and risk mitigation and will be further considered during the phase 2 test work programme.

The phase 2 programme, completed in June 2022, included a number of trade-off and project optimisation studies and covered the following milestones:

- Pre-leach impurity control.
- Leach parameter optimisation.
- Improvement of PLS quantity and quality.

Key decisions, conclusions and next steps identified from the phase 2 programme included:

- Pre-leach impurity control is critical in the final flowsheet and all future work will be completed with washed phosphogypsum, reflecting the pre-wash that will occur with the hydraulic reclamation of the stacks.
- Sulphuric acid leach parameters have been established and confirmed.
- PLS recycling or other counter current leaching systems is important to improve downstream PLS volumes and grade in conjunction with fluoride control strategies – this work has been conducted in conjunction with K-Tech as described further below.

Thickening test work at Roytec Global

The previously reported filtration studies have now been supported by settling and preliminary rheology studies at Roytec Global.

A composite sample, similar in nature to the tested composite at ANSTO Minerals, was leached employing elevated temperature sulphuric acid leaching.

The sample was then provided to Roytec Global to perform preliminary thickening tests, with the following key findings:

- Material performed better than expected in terms of settling behaviour and underflow solids density achievable.
- The inclusion of thickeners in the flowsheet will have a positive impact on filter requirements and sizing.
- The use of high-rate thickeners in the counter current leach circuit confirmed efficient leach performance without intermediate filtration.

Production of separated rare earth oxides

In order to purify and separate the target rare earth elements and produce final products for sale, various technologies have been investigated by Rainbow.

K-Tech has been selected as the best fit partner, to employ their technology, for the development of a downstream solution for Phalaborwa.

K-Tech rare earth purification and separation flowsheet development test work

K-Tech delivered a desktop study in late December 2021. The report covered PLS stream concentration, purification and separation of the targeted rare earth elements namely neodymium, praseodymium, dysprosium and terbium up to final separated oxides.

K-Tech also considered various alternative options to support the front-end leach circuit. Key findings are summarised as follows:

- It is critical to reduce PLS volumes and improve rare earth grades in the PLS to ensure a feasible long-term processing solution.
- Product options that can be considered range from NdPr oxide, Dy oxide, Tb oxide, low cerium mixed rare earth carbonate or a low cerium Nd/Pr/Dy/Tb product. The balance of the rare earths can be stored for future use.
- The estimated capital cost ("capex") and operating cost ("opex") can be significantly improved if the PLS volume can be reduced to the 40-60 m^3/h range feeding the K-Tech process.
- A desktop nano filtration ("NF") study was completed by Chimerical in South Africa. This study indicated that up to 65% of the sulphuric acid can be recycled and the resultant PLS flow reduced to 220 m^3/h.
- The desktop K-Tech study included a duplicate NF system to further reduce the volumes predicted by Chimerical. K-Tech is confident that further upgrading using NF should be possible based on their commercial experience.
- K-Tech forecasts good purity levels for the oxide products in the range of 99.5 to 99.9%, pending final test work.
- A conservative single pass circuit recovery of 80% for the oxide products was assumed, but K-Tech is confident that this could be improved once final test work is concluded. It is noted that

the PEA design will be based on recycled streams that will improve overall CIX and CIC recovery closer to 99% for the target products.

- It might be possible to employ a cheaper carbonate intermediate product and tailor the product suite to phases of project implementation with deferred capex and opex impacts. Rainbow could produce a cerium depleted mixed rare earth carbonate product with lower capex and opex (and a lower sales price as this would be sold to a rare earth separation plant) as a starter project with a phased move to the refined products.
- K-Tech supports a pre-wash prior to the leach as currently planned for Phalaborwa.
- K-Tech supports the use of the existing gypsum stack water, post neutralisation, as process water for large portion of the process (adding to the ESG credentials of the Phalaborwa project), with the exception of high purity water requirements for certain aspects in the continuous ion exchange ("CIX") and continuous ion chromatography ("CIC") sections. The high purity requirements are low in terms of overall volumes.
- K-Tech can also consider their water treatment technology that can remove impurities and generate saleable products, and not just a mixed waste that requires storage, with improved operating costs.
- K-Tech recommended the following to further optimise the capex and opex of the Project:
    - Investigate counter current leaching to improve PLS tenor and reduce volumes.
    - PLS recycle to improve PLS volumes.
    - Alternative concentration technique that can negate the use of NF altogether or significantly reduce the size of the NF circuit required.
    - Consider various water treatment options.
    - Kick-off a bench testing campaign to improve on the desk top study and firm up assumptions that form the basis of the desk top study.

A detailed test work programme addressing the above recommendations and testing the K-Tech CIX and CIC technology has been progressed significantly to date.

Whilst this bench work programme is still in progress with further optimisation initiatives being tested, results to date have delivered a technically and economically viable process flowsheet which will form the basis of the PEA being developed by Rainbow for the Project. This work is currently supported by a phase 3 test programme at ANSTO Minerals.

Key findings can be summarised as follows:

- A pre-wash, which occurs due to the hydraulic reclamation processing method, has been confirmed by K-Tech as critical to impurity control in the leach system.
- Previous leach work at ANSTO, as well as mineralogical studies, confirmed that fluoride can be leached whilst supressing rare earth dissolution. This methodology was tested and supported by K-Tech as a means to employ K-Tech patented and demonstrated technology for fluoride removal prior to subsequent rare earth leaching. The bench programme has demonstrated that fluoride can be separated from the phosphogypsum stream, with negligible impact on the overall rare earth extraction and acid consumption, employing conventional CIX technology.
- Importantly, only commercially available ion exchange resins have been tested with good yet un-optimised results – further optimisation work is ongoing which may deliver further cost benefits compared to the base case being employed for the PEA study phase.
- A counter current leach circuit has been tested to improve and stabilise overall rare earth extraction and ensure that the fluoride impact can be controlled. This allows for overall water

balance simplification resulting in a higher degree of acid recycling and reduced operating costs.

- Various, proven, rare earths precipitation techniques have been tested which have been shown to improve acid recycling and significantly reduce PLS flows to the downstream CIX/CIC circuit compared with NF. This negates the use of nano filtration as the primary means of acid recycling and PLS grade concentration with resultant reduction of both capex and opex.

All the latest process optimisation results have been incorporated into the current PEA study that culminated in the simplified block flow diagram ("BFD") depicted below as Figure 1.

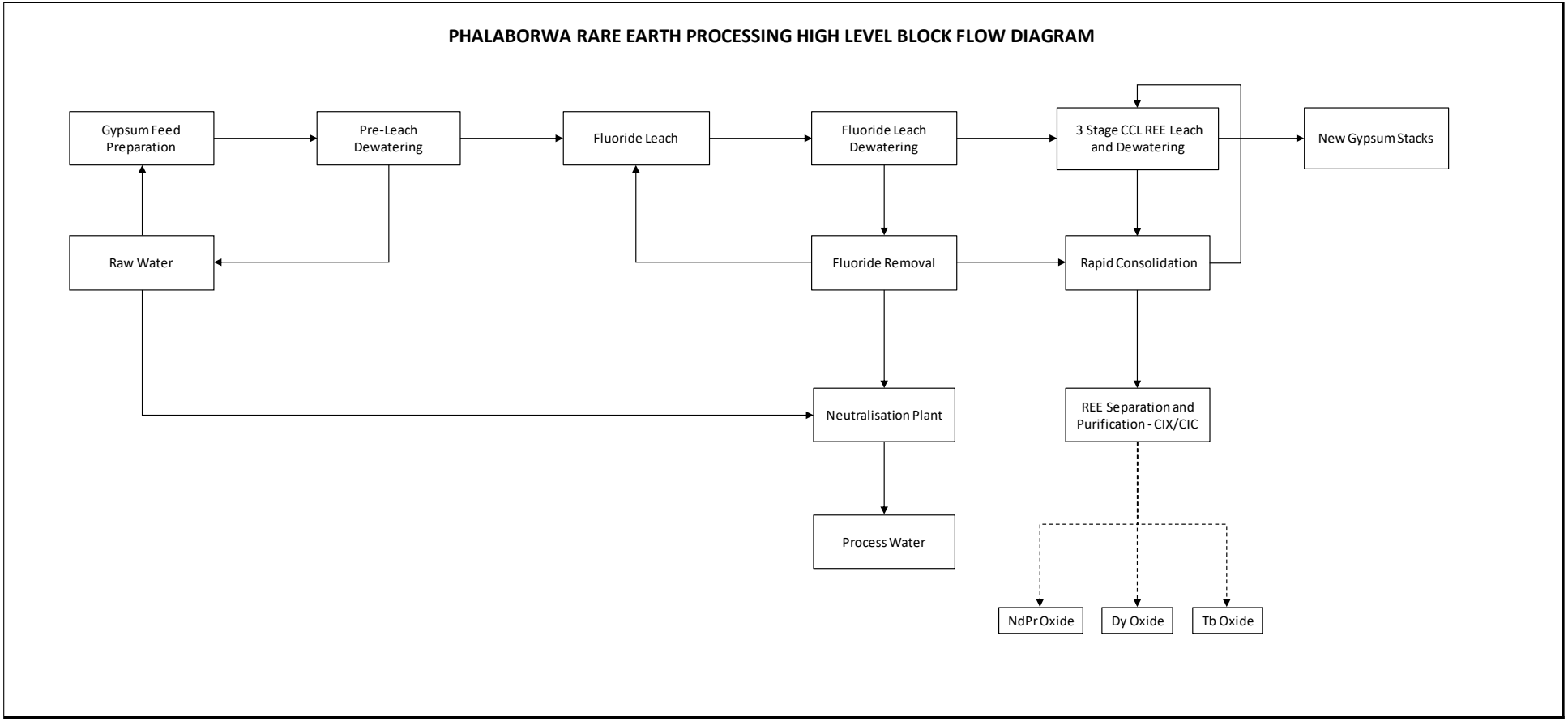

Figure 1: Simplified block flow diagram for PEA study

The following information relates to the above BFD:

- Phosphogypsum will be reclaimed hydraulically from the existing stacks and pumped to the processing facility. This process allows for a wash action on the reclaimed gypsum and the pre-processing dewatering will allow for a water balance break. It will also remove soluble impurities prior to the leach process. This has been conclusively proved in the latest test work programmes.
- During the phase 1 and 2 ANSTO test work programmes, supported by the K-Tech test programme, a fluoride leach regime was established that allows for the removal of fluoride from the gypsum stream, thereby allowing rare earth grades in the PLS to be maximised.
- The PLS from this section can then be processed using K-Tech patented technology for the sequestration of the fluoride and the production of reagents that can be employed in the process to reduce overall operating costs.
- The fluoride leached phosphogypsum progresses to the rare earth counter current leach system ("CCL") for the extraction of the target rare earth elements from the gypsum.
- The CCL system consists of multiple leach and solid-liquid separation stages for the efficient recovery of the rare earth elements and allows for successful recycling of the various acid streams to optimise the overall processing costs and solution balance.
- With PLS recycling the CCL system serves as a primary PLS volume reduction system and allows for upgrading of the PLS rare earth solution tenor.
- The PLS stream from the CCL circuit is then treated in a rapid consolidation section where the rare earths are concentrated with primary impurity rejection and a high degree of lixiviant recycling to the CCL circuit.
- The rapid consolidation circuit significantly reduces the feed flow to the downstream CIX and CIC circuits, resulting in significant capex and opex savings.
- Various recycling streams will ensure a high degree of overall rare earth recovery in the circuit, with overall recovery of 65% to 70% of the contained rare earths from the gypsum stacks.
- A neutralisation plant will process raw stack water rendering it suitable as general process water. This approach will also in due time reduce major impurities in the raw water system on site with a positive site wide environmental impact.
- Various final stacking options are being considered, in conjunction with by-product sales of high-quality gypsum, to offset on site long term gypsum stacking requirements.

Rainbow and K-Tech consider the process development work to date to be innovative and have the potential for wider application than solely the Phalaborwa Project. As a result they are jointly applying for international patents. The patent application process requires Rainbow to release abbreviated technical information at present – further technical details will be released as part of the overall patent process.

Glossary of terms

Cake washing	Wash water applied to filtered solid to remove impurities or target solution
Continuous ion chromatography ("CIC")	Rare earth separation as individual groups or elements in continuous fashion.
Continuous ion exchange ("CIX")	Extract the rare earths from the PLS stream and produce a concentrated rare earth solution
Filter cake	Solid product produced as a result of filtration
Leach circuit	System of tanks where a valuable element is recovered
Lixiviant	A liquid medium in hydrometallurgy used to selectively extract the desired metal from a mineral
m^3/h	Measurement of flow in cubic meters per hour
Nano filtration	Pressure driven filtration through a membrane
Neutralised stack water	Gypsum stack water that has been treated with a neutralising agent like lime
Phosphogypsum	Gypsum produced as a result of phosphoric acid production
Ppm	Parts per million
Pregnant Leach Solution ("PLS")	A solution that contain the extracted valuable metal
Water neutralisation	Water treatment employing lime or limestone
wt.%	Measurement of composition based on mass, weight percentage