Non-Independent Research
*SP Angel acts as Nomad and Broker

Mining Flash Note

Rainbow Rare Earths*

RBW LN **BUY**

Valuation 46p

09 November 2021

Investor meeting highlights progress at Phalaborwa and Gakara and value generation potential

Rainbow is developing the Phalaborwa direct rare earth oxide project in South Africa. The company also produces a rare earth carbonate concentrate in Burundi which is sold into Asia for further processing.

The team of expert metallurgists and seasoned mining veterans are currently working on the processing of gypsum residues from the Phalaborwa waste stacks.

Stock Data

Ticker	RBW LN
Share Price:	15.8p
Market Cap:	£81m

- Rainbow Rare Earth management hosted an analyst and major investor meeting in London yesterday.
- The team expect demand for the critical rare earths to double by 2030 due to strong demand from electric vehicles, wind farms etc…
- 91% of the value of rare earth elements is driven by demand for permanent magnets with Terbium and Dysprosium used to ensure these magnets retain their properties at high operating temperatures.
- **Phalaborwa (South Africa):** Management are focussed on testing and refining the flowsheet for the Phalaborwa project for the extraction of three rare earth oxide streams, NdPr, Tb and Dy.
- These products should be sold at market prices and may even fetch a premium in the market due to the independence of their location.
- Processing should be able to utilise surplus sulphuric acid generated from a nearby planned copper mine lowering operating costs.
- Each process stream should require just three stages for extraction with the feasibility study work expected towards the latter quarter of next year.
- Management now expect the capital cost of the project to be around $150-170m, though much work is still to be done on the cost estimation.
- **Gakara (Burundi):** The team continue to talk to the government of Burundi on the reopening of the mine and resumption of exports. Other mines in the country were also stopped pending renegotiation of the mining convention.
- Management expect the mining convention to be renegotiated and for the Gakara mine to reopen early next year.
- The value of the concentrate stockpile should have increased substantially since it was blocked by the ban on REE concentrate exports helping with the working capital cost of the restart.
- **Valuation:** We are raising our valuation to 46p from 43p on the rise in rare earth prices though this is largely offset by the increase in our capital cost assumption to $170m.
- We have also raised our discount rate to 12% to reflect the impact of the stoppage in Burundi and have raised the discount we apply to NdPr prices to 20% from 10%. We have also raised our discount to Tb and Dy prices to 30% from 25%.

Research

John Meyer
+44 20 3470 0490
john.meyer@spangel.co.uk
Simon Beardsmore
+44 20 3470 0484
simon.beardsmore@spangel.co.uk
Sergey Raevskiy
+44 20 3470 0474
sergey.raevskiy @spangel.co.uk
Joe Rowbottom
+44 20 3470 0486
joe.rowbottom@spangel.co.uk

Sales

Richard Parlons
+44 20 3470 0472
richard.parlons@spangel.co.uk
Grant Barker
+44 20 3470 0471
grant.barker@spangel.co.uk
Rob Rees
+44 20 3470 0535
rob.rees@spangel.co.uk
Abigail Wayne
+44 20 3470 0534
abigail.wayne@spangel.co.uk

Conclusion: Rainbow is one of three rare earth producers to have supplied rare earth concentrates in recent years. We expect the company to realise substantial additional value as it progresses towards restarting the Gakara mine and development of the Phalaborwa process plant.

Phalaborwa: Assumptions

OPEX costs:
Mining $1/t due to low cost hydraulic mining of gypsum stacks
Processing cost $40/t to REE concentrate
Recovery rate 85%
Royalty 5%
Transport (REE oxides) $200/t
G&A $5mpa
Capex $170m
NPV $183m – assuming a 12% Discount on the NPV
assumes Nd/Pr oxide extraction only,
assumes a 20% discount applied to current rare earth oxide prices.
assumes $40/t processing cost – very approximate guestimate

Value 21 pence / share – NdPr

NPV $298m – assuming a 12% Discount on the NPV
assumes Nd/Pr and Tb/Dy oxide extraction
assumes a 30% discount applied to Tb/Dy rare earth oxide prices
assumes $45/t processing cost – very approximate guestimate

Value 34 pence / share – Nd/Pr + Tb/Dy

If Rainbow also extracts Tb and Dy oxides at Phalaborwa and we apply a hefty 25% discount to current Td and Dy prices then we estimate a valuation of 40p per share for Phalaborwa.

Gakara: Assumptions

OPEX costs:
Mining $126/t – narrow vein mining gives higher costs per tonne
Processing cost $85/t – to REE concentrate
Recovery rate 85%
Royalty 4%
Transport (REE oxides) $200/t
G&A $3mpa
Capex $10m – new equipment to lower high mining costs and new plant to raise throughput including Dense Media Separation process

NPV $76m – REE carbonate concentrate sales

assumes a 12% discount rate

assumes 30% pay-ability on REE concentrate sales

Value 12 pence per share

Previously published on 29 September 2021

The Gakara rare earth mine benefits from possibly the highest-grade REE ore in the world. Unfortunately, the mine suffers from high operating costs associated with inefficiencies of mining narrow veins.

Management are restructuring the mining fleet and its operation and have restored positive cash flow albeit on a relatively modest scale.

Expanding the mine and the processing plant should result in further operational efficiencies requiring a further $10m in capital depending on how far management choose to go with this.

Mining and exports are currently suspended out of Burundi pending discussions with the new minister of mines.

K-Technologies 'K-Tech'

Rainbow Rare Earths has entered into an exclusive intellectual property licencing agreement with K-Technologies in Florida to use its rare earths separation technology in Southern Africa.

K-Tech has developed a continuous ion exchange and continuous ion chromatography processes to separate rare earth elements into specific rare earth oxides or carbonates in phosphogypsum applications.

The technology should work with Rainbow's Phalaborwa project requiring fewer stages and greater flexibility for significantly lower capital and operating expenditure savings.

The process does not use toxic and highly flammable solvents and diluents as required for Solvent Extraction.

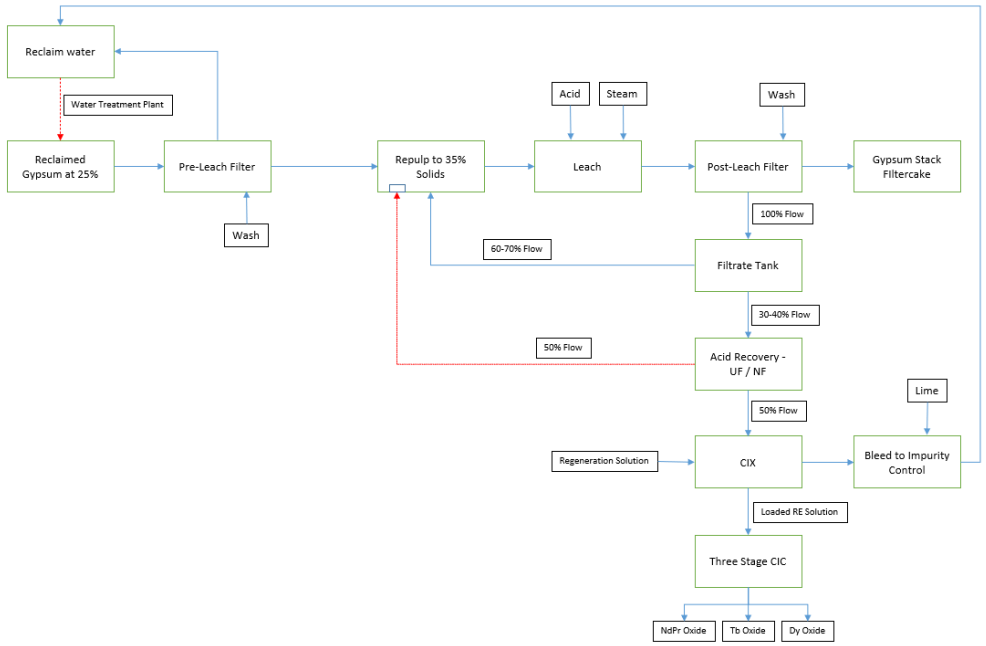
Bench and pilot plant scale testing:

K-Tech has performed successful bench and pilot plant scale testing in rare earth separations from leach solutions and with the technology successfully applied in commercial applications and industries including the sugar, lysine, base metals, potassium, and phosphate chemicals industries, as well as various biological and specialty chemical applications.

The Technology targets individual rare earths in solution and therefore the requirement to separate a full spectrum of rare earth oxides is removed, creating substantial efficiencies in a processing circuit.

Phalaborwa is likely to extract Neodymium Nd, Praseodymium Pr, Dysprosium Dy and Terbium Tb as metal oxides accounting for much of the value of the contained minerals.

Processing flow sheet



Source: Rainbow Rare Earths, K-Technologies

K-Tech technology

The K-Tech process uses continuous ion exchange developed from the batch ion exchange technology used in the 1940s as part of the Manhattan project in the US. The original process used cation exchange in a sulfonated polystyrene/divinylbenzene column. Further development of the continuous ion exchange technology led K-Tech to develop a continuous ion chromatography process enabling the extraction of individual rare earth elements with a much simpler separation process than is conventionally used with Solvent Extraction 'SX' separation processes.

K-Tech have successfully piloted at bench scale and pilot scale plants using phosphor gypsum residues in Florida for the separation of RE oxides and large-scale pilot work on the separation of uranium and Thorium from phosphogypsum in North Africa.

The continuous ion exchange and ion chromatography works with multiple precipitation steps to produce separated RE Oxides and Carbonates using a reduced flow over an ion-exchange resin with the resin lasting for around +/- five years. The extended longevity of the resin is another positive from a cost perspective.

Th process will enable Rainbow to target the extraction of the key REE oxides with NdPr as a single oxide along with Tb and Dy while leaving the other metals behind in the gypsum residue.

Other rare earths may be simply extracted at a later date from this gypsum residue stacks if demand and pricing make this attractive.

The K-Tech process has far fewer steps than other REE extraction processes and is environmentally preferable when compared with other technologies due to its use of less aggressive acid and hazardous kerosene used in more conventional separation processes.

This should result in significant savings in capital and operating costs from the huge reduction in the number of steps required to separate the individual RE

oxides compared to conventional SX separation processes' as used in China etc.

Technology deal:

Rainbow has agreed a licensing fee of US$5.5m to be paid for each project where this technology is applied in the SADEC region (Southern Africa).

The exclusive licencing deal is for an initial 4 years and should then extend assuming Rainbow does not sit on the technology

The technology applies for the life of the project enabling the $5.5m one-off fee amortised over the life of the project.

Phalaborwa

Phalaborwa – High-grade NdPr readily extractable from gypsum stacks

Phalaborwa is a large REE resource hosted in 38.3mt of phospo-gypsum residue stacks which are stacked close to the former Sasol process plant which produced phosphoric acid from concentrated hard rock phosphate. Phalaborwa's average TREO 'Total Rare Earth Oxide' grade of 0.43% is higher than the current dominant source of REE production, ionic clay deposits in China, which typically have a grade between 0.05% - 0.2%.

The residue stacks have been processed and further reprocessed enriching their REE content with each process raising the rare earth grade within the gypsum residue.

This makes the REE material in the gypsum stacks particularly amenable for processing into a value-added concentrate as it now sits in economic concentrations. The gypsum stacks now contain relatively high concentrations of Nd, Pr, Tb and Dy, with rare earths already in a cracked chemical form within the gypsum residue. This is a significant benefit for Rainbow, given lower processing costs and minimal cost of handling.

The Nd and Pr percentage within the rare earth basked is at +/- 29.1% and amongst the highest in the world.

Geologically, The Phalaborwa Carbonatite Complex has been extensively studied given the high level of economic interest in the deposit, and is comprised of a large alkaline igneous ring, with an outer ring comprised of pegmatite and surrounded by a pyroxene zone. The Complex has been previously mined for copper sulphides, magnetite, baddeleyite, apatite and uranoan thorianite in this area. The main complex is an elongated pipe-like body with widths of about 6.5km north to south, and about 2.5km east to west. The country rock is Archean granite gneiss, while the pipe-like bodies include feldspathic pyroxenite, peralkaline syenite, peralkaline quartz syenite, peralkaline granite and trachyte.

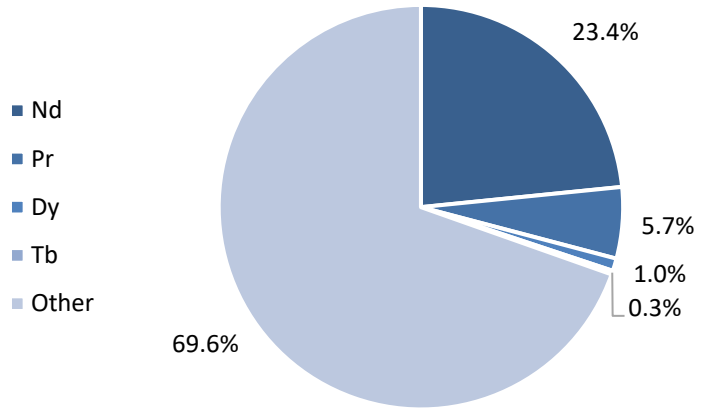
Phalaborwa Mineral Resource Estimate, 2021

			Contribution of TREO by oxide (%)					Grade	
	Tonnes (mt)	TREO (%)	Nd	Pr	Dy	Tb	Other	Th (ppm)	U (ppm)
Stack A	27.4	0.42	23.3	5.7	1.0	0.4	69.6	49.0	1.8
Stack B	10.9	0.46	23.6	5.7	1.0	0.3	69.4	44.1	2.0
Total	38.3	0.43	23.4	5.7	1.0	0.3	69.6	47.6	1.8

Source: SP Angel, Company

Given Phalaborwa's high REE basket-weighting towards NdPr, the mine and indeed the company is set to benefit from higher weighted-average basket prices and therefore higher margins. As a result, REE distribution favouring Nd, Pr, Tb and Dy (95% of Phalaborwa basket value) helps drive robust project economics.

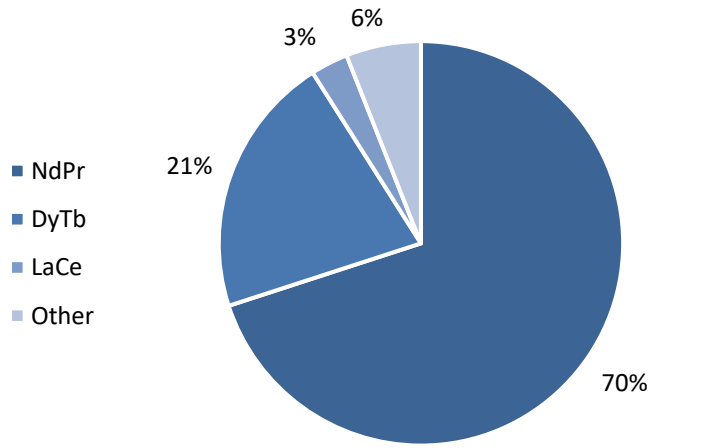
Contribution of TREO by oxide at Phalaborwa (%)



Source: SP Angel, Company

Annual production of REEs was 170,000t in 2018, according to the USGS. A breakdown of global REO production shows lower value elements such as Lanthanum (~20,000 tonnes exported from China in 2019) being produced at a much larger scale than higher value elements such as Praseodymium (72 tonnes exported from China in 2019). Demand for Nd and Pr are expected to grow from 20% to 40% (until 2035) and from 7% to 11% of the total REE demand, respectively. La and Ce constitute ~20% and 40% of the total REE demand, respectively, and their shares are expected to decrease.

Phalaborwa in-situ metal value (%)



Source: SP Angel, Company

Phalaborwa has particularly low levels of radioactive elements compared to industry peers and other phosphate gypsum residues, and thus should not require the complex processing and associated costs in order to remove higher levels of radioactive elements. Such low levels of radioactivity are also likely to

benefit Rainbow from an ESG perspective, with the project deemed favourable by off takers.

Phosphoric acid production at Phalaborwa ceased ~9 years ago when Sasol, the South African state coal to liquids and chemicals company was forced to give up the mine in an anti-competition ruling on it's phosphoric acid production business. Sasol was piloting REE extraction from the gypsum residue at that time though REE demand was very much lower and less financially rewarding. The pilot plant has sat idle ever since. Sasol were looking at the potential extraction of a different suite of rare earths when they ran the pilot plant to that being considered today.

Rainbow Rare earth projects grade and basket weighting vs other notable projects

Project	Jurisdiction	Owner	TREO (%	Nd_2O_3 (ppm)	Pr_6O_{11} (ppm)	NdPr (%)	Dy_2O_3 (ppm)	Tb_4O_7 (ppm)
Phalaborwa	**South Africa**	**Rainbow RE**	**0.45%**	**1,044**	**270**	**29.2%**	**43**	**15**
Gakara	**Burundi**	**Rainbow RE**	**13.5%**	**20,616**	**6,286**	**19.9%**	**105**	**42**
Longonjo	Angola	Pensana	1.4%	2,460	710	22.2%	80	20
Ngualla	Tanzania	Peak Resources	4.8%	7,920	2,290	21.3%	40	20
Norra Karr	Sweden	Leading Edge	0.55%	603	155	13.8%	253	38
Makuutu	Uganda	IonicRE	0.08%	188	44	29.0%	30	5
Mount Weld	Australia	Lynas	7.90%	14,319	4,014	23.2%	382	102
Nolan's Bore	Australia	Arafura Resources	2.60%	5,326	1,533	26.4%	78	21
Lofdal	Namibia	Namibia Critical Met.	0.32%	140	41	5.7%	230	31
Fox Trot	Canada	Search Minerals	1.11%	1,576	423	18.0%	199	-

Source: SP Angel, Company filings

Superior metallurgy and low mining cost result in lowest opex in peer group

The gypsum at Phalaborwa is already in a 'cracked' chemical form as the gypsum residues have already been treated with sulphuric acid which enabled the Sasol pilot plant to directly produce a mixed rare-earth carbonate without the need for an initial REE concentrate. The creation of the gypsum through the phosphoric acid production further concentrated the REE's and enables Rainbow to bypass processing stages associated with conventional REE processing where a concentrate is produced and then 'cracked' in order to produce a mixed REE carbonate or mixed REE oxide.

Initial metallurgical test work undertaken by ANSTO Minerals in May 2021 confirmed low-cost leaching without pre-treatment yielding recoveries of rare earths of over 70% were achieved within 24 hours. Rainbow now expects to improve recoveries and recovery rates through further optimisation of the ongoing test work.

Importantly, the gypsum stacks can undergo direct leaching with low-cost sulphuric acid at ambient temperatures, with the content of H_2SO_4 significantly lower than used for hard rock deposits.

The resultant pregnant leach solution, after acid recovery, will be a suitable feedstock for purification and separation of the valuable rare earths. Once leached, rare earths can be precipitated into a mixed rare earth carbonate for further refining offsite or precipitated individually by incorporation of the K-Tech separation technology which requires far fewer steps to separate individual REE oxides than the conventional REE extraction route resulting in much lower capex and opex for the project into single rare earth oxide products. Rainbow's PEA currently seeks to optimise the downstream processing and separation in order to optimise the flow sheet.

The simple processing reaffirms the Phalaborwa project's low capital intensity, with test work results to date supporting expectations that a simplified processing sheet can be developed and optimised from the original Sasol flow sheet to recover the rare earths without the high cost, energy and reagent intensive mining, crushing, milling, primary beneficiation, cracking and uranium/thorium removal costs associated with a typical rare earth project.

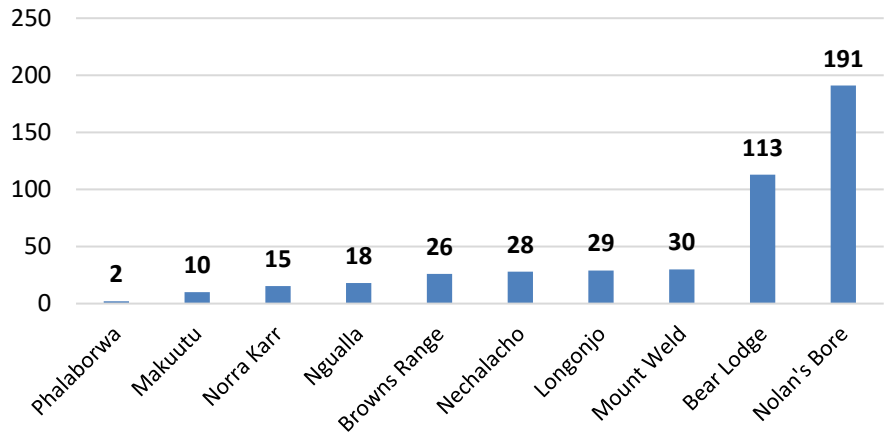
Given the gypsum is already at surface, the mining cost is expected to be a fraction of that of conventional REE projects. We estimate a mining cost of just $1/t *(compared to $240/t at Avalon Rare Metals Thor Lake Project and $245/t at Rare Element Resources Bear Lodge Project)*. As a result, we forecast Phalaborwa's operating costs to be among the lowest in the peer group. We expect Rainbow to use hydraulic mining at Phalaborwa to wash the gypsum residues due into the process plant. This will comprise of high-pressure jets of water dislodging the gypsum residues from their stacks with the ore pumped to the processing plant for treatment.

Brownfield site reduces permitting risk and lowers capex

Phalaborwa is situated in an established mining town adjacent to Foskor's mine which produced phosphate from hard rock mining for over 50 years in South Africa. The mining pedigree of the area ensures a skilled workforce near the site. The site is well serviced by road, rail, power and other key facilities which Rainbow are able to utilise. The local production of sulphuric acid also improves the financial metrics of the project, given that the acid is a key reagent in the processing circuit. Rainbow will not need to ship vast quantities of sulphuric acid to site which would add both considerable cost and pose a heightened environmental risk to the project.

The Phalaborwa project is unique in that the downstream processing will take place on site, providing further savings associated with shipping concentrates and administration costs with building a facility at a new location. The project as a whole is permitted as a chemical facility, avoiding extensive permitting. While all other permits are in place including water and land use, Rainbow may still require a permit for replacing the depleted gypsum residue.

Low uranium/thorium content improves ESG credentials and lowers processing costs (U_3O_8 ppm)



Source: SP Angel, Company

Gakara

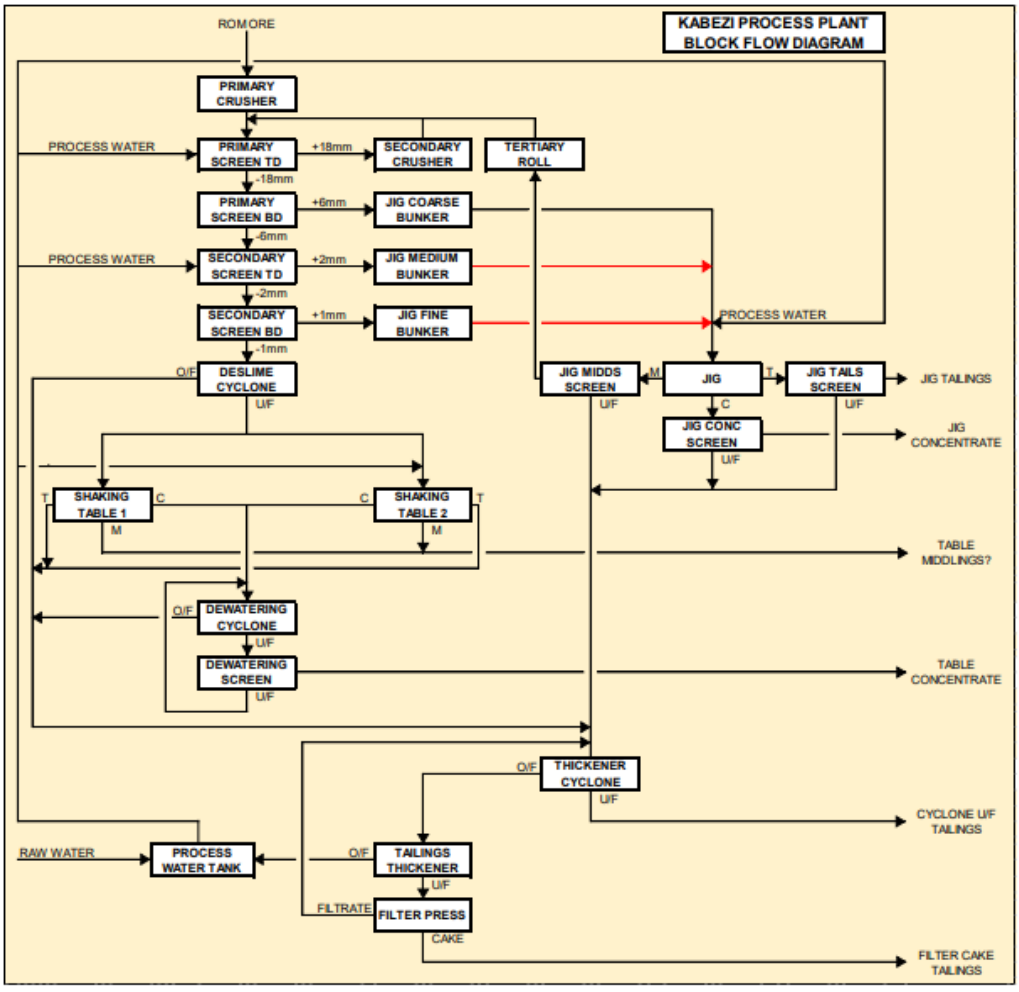
Overview

The Gakara REE Project is in the Bujumbura Province in Western Burundi approximately 20 km south-southeast of Bujumbura. Modern facilities, goods and services are available from Bujumbura, with the area served by daily commercial flights from Nairobi and Kigali. Rainbow has a current exploration target of 262-375kt at 7-12% TREO from vein hosted mineralization and 252-342kt at 1.0-1.5% TREO from breccias at Gakara.

Given the superb grades and early success trial mining, Gakara was Rainbow's flagship asset and sole focus until the signing of the Phalaborwa earn-in agreement in November 2020, which represented a shift in focus in the short and medium term to the latter project. Rainbow remains in discussions with the Burundi government to resume mining operations at the Gakara project.

Near term cash flow from Phalaborwa could allow RBW to drill, define and ramp up a bulk operation at Gakara with less short-term production pressure' pressure.

Gakara processing pilot plant flowsheet



Source: SP Angel, Company

Previous trial mining demonstrates feasibility of low-cost gravity separation

Trial mining and processing at site demonstrated a proof of concept for Rainbow, with the Gakara mine operating as the only dedicated African producer of rare earth concentrates for many years.

Mining at Gakara has been done using relatively small excavators to extract high-grade mineralisation from a near-surface stockwork vein system.

Rainbow has been looking to modernise optimise the mining method at Gakara. The team have been using a large excavator waste material at low cost, whilst high-grade veins are selectively mined by a smaller excavators to minimise mineralisation loss and dilution.

Initially, trial mining and exploration bulk samples were processed through a 5 tonnes per hour pilot gravity separation plant which exceeded 73% recovery of the contained TREOs producing a concentrate grade greater than 54% TREO.

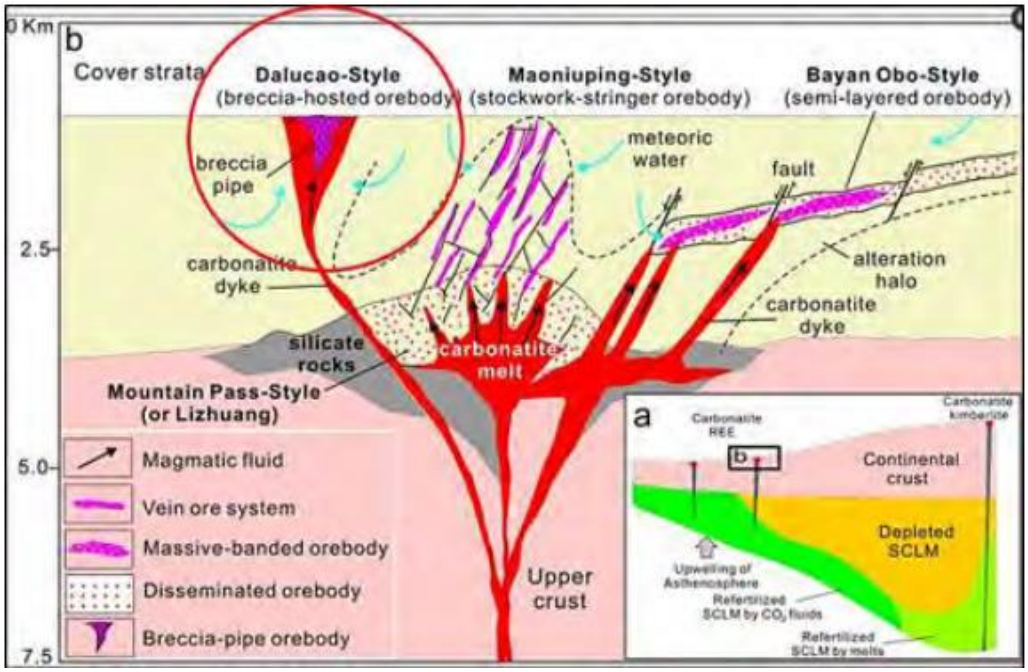
Processing consists of gravity separation using the existing pilot plant infrastructure with no reagents to produce a +/54% TREO concentrate of which 19.5% is NdPr.

The capital intensity at Gakara is low due to the grade, mineralogy and metallurgy of the project. The high-grade concentrate is produced with a simple crushing circuit, jig and 2 shaking tables, which can be rapidly scaled up in line with increased mining levels. Low levels of thorium and uranium means that the tailings at Gakara are totally benign, and Rainbow have no need implement circuits to the processing flow sheet in order to remove uranium and thorium for radioactive tailings deposition (unlike Mt Weld, Longonjo). This drives down the capital intensity and lowers the opex of the project relative to peers.

Geology shows Gakara project among world's highest REE grade

Gakara's vein-hosted rare earth project is among the world's highest grade from a TREO position. Neodymium and Praseodymium represent 19.5% of the mass of the product, and ~88% of the value, given the high value of these elements.

Schematic model of carbonatite REE mineralisation, including "breccia style mineralisation"



Source: SP Angel, Company

The Project is situated within the northeast trending Kibaran Fold Belt which stretches across Burundi from the eastern DRC to western Tanzania. The Belt consists of a highly deformed sequence of Mesoproterozoic granites, granitoids and amphibolite-greenschist facies metasedimentary and metavolcanic rocks, referred to as the Burundi Supergroup.

REE mineralisation at Gakara is related to carbonatitic and/or peralkaline magmas emplacement. Technical studies indicate that carbonatites and the associated REE mineralisation have been dated around 600-700 Ma.

Geophysical and structural analysis confirmed the presence of at least three large carbonatites, distributed along a major NNE-trending structure. The southern-most carbonatite has a diameter of approximately 2.6km, underlying a large proportion of the mapped and mined REE-bearing veins. Vein hosted mineralisation occurs as centimetre to decimetre vein stockworks which are mainly coarse grained, locally brecciated, metasomatised bastnaesite and monazite.

Project ownership structures

Phalaborwa

Rainbow has the option to acquire 70% of the Phalaborwa Rare Earths Project for a total consideration of US$750,000, in a combination of cash and shares paid by Rainbow to Bosveld in three equal tranches over twelve months. The first two payments have been made and the third is due in December 2021 for cash or shares at Bosveld's discretion.

On completion of the pre-feasibility study, 70% of the Project will held by Rainbow and 30% by Bosveld, with a mechanism included to allow for Rainbow's Joint Venture ownership to vary from 60% to 85%, dependent on results of the PFS.

The profit tax rate in South Africa is 27%, with no royalty in line with South African legislation.

Gakara

Rainbow owns 90% of Gakara with the state of Burundi owning the remaining 10%. The corporate tax standard rare in Burundi is 30%, with a minimum tax of 1% turnover if taxable profits is less than turnover divided by 30. Companies can benefit from a profit discount tax discount of 2% if an investor employs between 50 and 200 Burundians. This is scaled up to 5% if investor employs more than 200 Burundians for a period of at least six months.

NdPr Market Outlook

Price outlook

Chinese Praseodymium-Neodymium (NdPr) oxide prices have rallied strongly since March 2020, rising nearly 116% since August last year and 48% year-to-date to currently sit at ten-year highs of over $93,000/t (August 2021).

Rare earth demand growth is becoming increasingly driven by two key megatrends currently upending industrial metal markets – the EV revolution and the emergence of wind power as a dominant source of clean energy.

The rapid demand growth forecast compared to committed rare earth oxide production is expected to bring the market into deficit as early as 2024-2025 according to Argus Media.

Over the past 10 years, demand for Rare Earth Permanent Magnets has tripled in China has tripled. The outlook remains robust- with Curtin-IMCOA forecasting growth rates as high as 20-50% pa.

China NdPr Oxide Price ($/t)

Source: SP Angel, Bloomberg

After growing at a CAGR of 6.4% from 2015 through 2019, the value of global magnet rare earth oxide consumption will rise five-fold by 2030 from $2.98bn in 2020 $15.65bn in 2029, according to Adamas Intelligence.

NdPr prices are also forecast to increase at a CAGR of 9.9% through 2030 due to the supply side struggling to keep up with rapidly growing demand.

The enhanced intrinsic properties of rare earth permanent magnets in both motor efficiency and weight saving potential mean that we expect NdPr demand to grow in line with increased EV & wind turbine output, with demand to expected to increase five-fold by 2030.

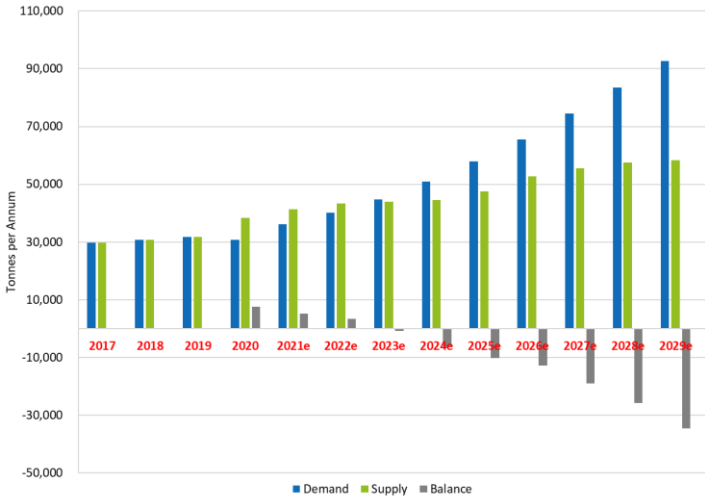
Demand

Rare earth-based permanent magnets used by the wind energy and EV industries are primarily NdFeB (Neodymium-Iron-Boron) alloy, also comprised of minor concentrations of praseodymium, dysprosium, terbium, copper and cobalt. NdFeB permanent magnet alloy is the strongest magnetic material in terms maximum energy product.

The exponential rise of EV sales and offshore wind development is vastly increasing demand for NdFeB magnets, with demand for such magnets driven almost exclusively by traction motors and generators to date. **Wind turbines consume 600-830kg of REO per Megawatt**, while each new **EV requires between 1-2kg of NdPr.**

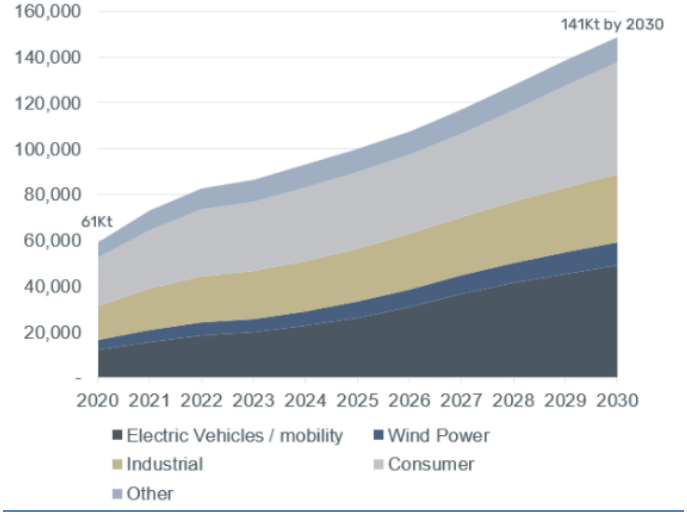
Supporting minor metals concentrations for permanent magnet offers a market opportunity for high-grade projects with a favorable rare-earths basket weighted towards NdPr such as Rainbow's Phalaborwa project, with NdPr making up 29.2% of the basket weighting of TREO and ~70% of the overall basket value.

NdPr Forecast Market Balance (tpa)



Source: SP Angel, UBS, Company Filings

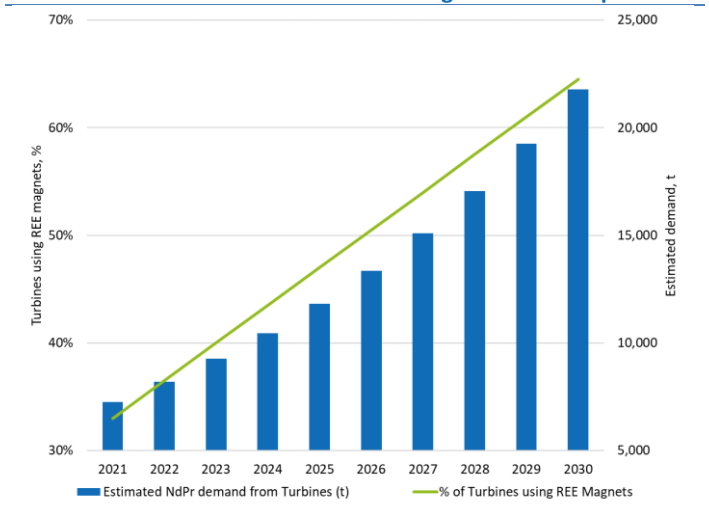
Anticipated Global REO Magnet Demand Growth (kt)



Source: Adamas Intelligence

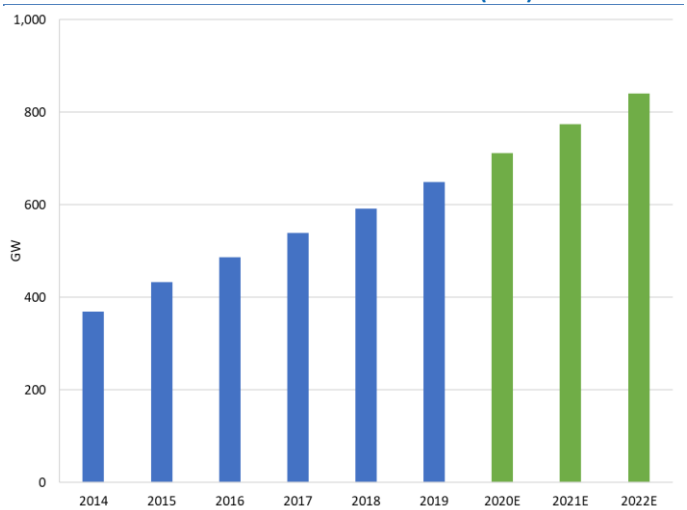
By 2025, EV sales across the world are set to increase tenfold to 11 million, as environmentally conscious consumers capitalize on government-led subsidies in key markets such as China, Germany and the UK. Europe attracted €60bn in investments for EVs in 2019, compared to China's €17.1bn in the same year. Volkswagen aims to invest €33bn into EVs over the next four years – in order to have 75 battery powered models on the road by 2029.

NdPr Demand from turbines & increasing turbine REE uptake



Source: SP Angel

Global cumulative wind turbine installation (GW)



Source: GWEC

The offshore wind market has grown on average by almost 25% every year since 2013, led by new projects in European waters. EU officials are keen to harness this momentum, with offshore wind expected to be the main beneficiary of the European Green Deal, and €25bn is to be invested over the next two years. The total energy generating capacity in Europe's seas currently stand at 23GW, however under a European commission strategy the EU would achieve a capacity of 60GW by 2030 and 300GW by 2050.

Gearless permanent-magnet turbines, also known as direct-drive are more reliable and require less maintenance. They also contain the highest amount of Rare Earth Oxides, with each 3MW direct-drive wind turbine using around 1.7t of NdFeB magnets. While future growth forecasts are currently focused on EV and turbines given the global shift to such technology, it is also crucial to note that the enhanced intrinsic properties of rare earth permanent magnets are supporting the global miniaturisation trend, with developers favoring the weight saving potential for mass adoption of robotics, drones, e-VTOL and passenger drones, e-bikes, scooters, and automotive accessories.

Supply

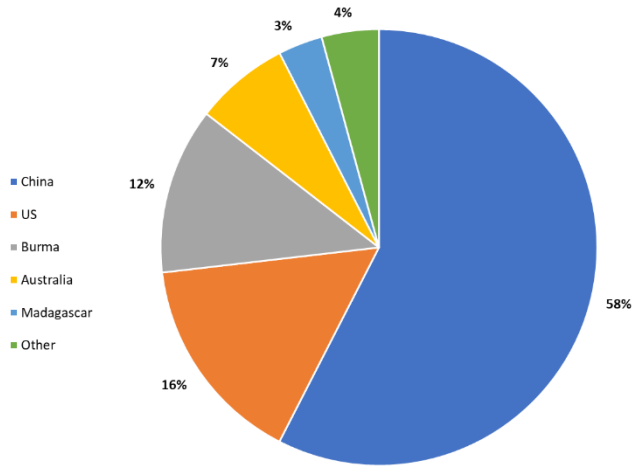
China's dominance in the rare earths industry is well-documented and has long been identified by other countries as an overreliance of a strategic material, and a resulting source of geopolitical tension. Roskill estimate Chinese TREO mine production of 110kt in 2020, representing over 55% of global output- although this is expected to be much higher due to illegal production.

Production at both the mining and refining stages in China is controlled by quotas assigned to six state-owned enterprises. Illegal production of NdPr occurs in addition to the quoted material, with estimates varying on the scale of illegal production. Some market participants estimate that illegal Chinese rare earth production brings Chinese produced rare earths to over 90% of the global total.

In 2020, China's rare earth imports jumped 74% in the first half of the year compared with the same period in 2019. Despite this, Beijing only raised the rare earth mining quota for the year by 6% to 140,000t – far from enough to still meet demand.

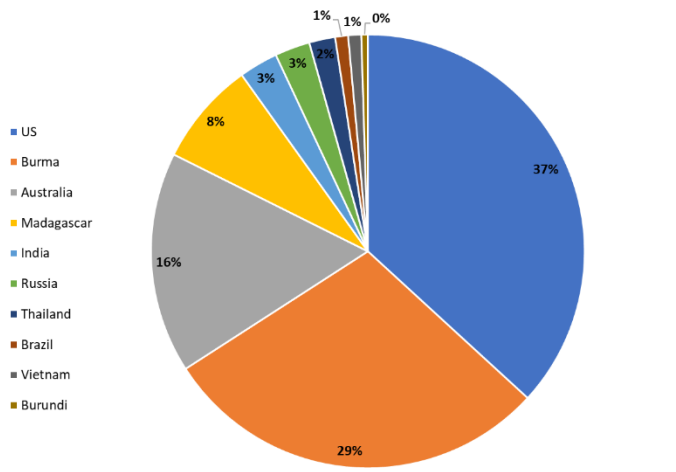
China's Industry and Information Technology Ministry (MIIT) raised the first batch of 2021 production quotas to 84,000t, up by 27% from 66,000t in the same batch in 2020. Beijing has also allocated 81,000t quotas for smelting and separation products in the first batch of this year, up by 27% from 63,500t in 2020. The rise in quotas is in response to stronger demand from major downstream sectors.

World REE Mine production, 2020



Source: USGS. Chinese production does not include illegal mining.

World REE Mine production (Excl. China), 2020



Source: USGS

With China continuing to restrict supply through its production quota system, additional supply is expected to be developed in Australia, North America and Africa in order to meet projected demand over the next decade. Additionally, China will seek additional supply outside the mainland to support their *Made in China 2025* strategy.

Adamas forecast **annual NdPr oxide shortages of 16,000 tonnes by 2030**, as a result of a lack of new primary and secondary supply sources from 2022 onwards- roughly three-times Lynas' annual output. Annual NdFeB shortages of 48,000t are expected by 2030, constrained by an expected under-supply of neodymium, praseodymium and dysprosium oxide from 2022 onward – the amount needed for some 25 to 30 million EV traction motors.

China's dominance in rare earth mining and processing has led to calls from other world powers for the emergence of a new rare earth supply chain to reduce reliance on China- with companies with projects in Africa and North America set to benefit. Biden's climate envoy commented *"It's absolutely correct there is a cornering of the market with lithium and other rare earths*," Governments including the US, Canada, UK and Australia have all publicly expressed concerns over the dominance of Chinese supply, and that a consistent supply of rare earths is of future strategic as well as economic importance to Western economies.

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