

# BFS positions Ngualla as one of the world's lowest cost rare earth projects

Peak Resources Limited (ASX: **PEK**) ("**Peak**" or the "**Company**") is pleased to report the results of its Bankable Feasibility Study (the "**Study**" or "**BFS**") on the Ngualla Rare Earth Project (located in Tanzania) and proposed refinery in Tees Valley (located in the UK). The BFS has delivered further significant **reductions in operating costs** and facilitated access to higher value markets as compared to the Company's project update ASX announcement "Ngualla Project Study delivers substantial Capex and Opex savings" dated 16 March 2016 ("**Project Update**").

The results of the BFS have confirmed that the Ngualla Project has the potential to become one of the **lowest cost and highest quality rare earth projects worldwide.** 

Delivery of the project is well timed to benefit from the expected strong uplift in the demand for permanent magnet motors required by the rapidly expanding electric vehicle market, which has been the main catalyst for significant increases in the price of lithium and cobalt since late 2015. Neodymium and praseodymium are expected to generate 90% of Ngualla's future revenue.

Please note all cost are in US\$ unless otherwise stated.

## **Highlights of the BFS:**

- Operating cost of US\$ 34.20/kg NdPr\* Oxide, demonstrating potential to be the world's lowest cost fully integrated rare earth development project
- Annual operating costs reduced by \$35 million per annum from the PFS
- Pre Tax NPV<sub>10</sub> of \$676 million
- Post Tax NPV<sub>10</sub> of \$445 million
- Pre Tax NPV<sub>8</sub> of \$930 million
- Post Tax NPV<sub>8</sub> of \$633 million
- Pre Tax IRR of 25% and Post Tax IRR of 21%
- High degree of confidence in the ore body and mine plan, with 92% classified as Proved Ore Reserves under JORC 2012
- 30 year life, low cost, open pit mining, conventional multi-stage processing plant and refinery delivering free cash flow of \$104 million per annum (post tax and royalties)
- Proven and demonstrated extraction processes targeting NdPr products using extensive operational and marketing expertise from Peak's team of rare earth industry specialists

<sup>\*</sup>  $NdPr = Nd_2O_3 / Pr_6O_{11}$  Mixed Oxide  $2N - min 75\% Nd_2O_3$ 



Completion of the BFS by Peak's team of experienced rare earth industry experts in conjunction with global engineering firm Amec Foster Wheeler, including the extensive pilot planting of Ngualla ore, has delivered a study from which all stakeholders can have confidence in the deliverability and operability of the planned mining, beneficiation and refining processes.

The Study envisages production over a 30 year mine life based on the weathered Bastnaesite Zone mineralisation, which comprises only 22% of the Total Ngualla Mineral Resource estimate at a 1% rare earth oxide (REO) lower grade cut (for details see Appendix). The annual output target is:

- 2,420 tonnes of Neodymium and Praseodymium rare earth oxide (2N min 75% Nd<sub>2</sub>O<sub>3</sub>)
- 530 tonnes of mixed Samarium, Europium and Gadolinium rare earth carbonate
- 3,005 tonnes of Cerium carbonate and 6,940 tonnes of Lanthanum carbonate

Please note production, costs and financial analysis are reported on a 100% owned basis (Peak currently own 75% of the Ngualla Project). Production targets and schedules are based on the Ore Reserve and stated Material Assumptions as set out in the Company's ASX Announcement "Ngualla Rare Earth Project – Updated Ore Reserve" dated 12 April 2017 and within the BFS Executive Summary released together with this announcement.

**Managing Director, Darren Townsend commented:** *"I would like to congratulate the Peak and AMEC Foster Wheeler teams and our other consultants on the delivery of a robust and comprehensive BFS. Our stakeholders can take comfort that the Study has been completed under the leadership of our Chief Operating Officer, Rocky Smith and Technical Director, Dave Hammond and is based on the Peak team's significant rare earth operating and marketing experience combined with extensive pilot planting. With the further US \$14 million per annum (14%) reduction in operating cost compared to the Project Update and a total reduction in operating costs of US \$35 million per annum compared to the Company's Preliminary Feasibility Study dated March 2014. The Ngualla Project has the potential to be one of the world's lowest operating cost/kg NdPr fully integrated rare earth producers and we believe is perfectly positioned for the expected increase in magnet metal prices driven by the forecast enormous growth in e-mobility and low carbon technologies."* 

**AMEC Foster Wheeler Director of Mining Australasia, Greg Hayes commented:** "I would like to thank the Peak and AMEC Foster Wheeler teams for their professionalism in delivering this high quality Study. Peak has taken advantage of perfect timing to complete the BFS during a period of depressed commodity prices and as a result were able to access some of the best talent in our organisation and within the various pilot plant laboratories"



## The BFS Highlights "Physicals drive economics"

Ngualla's favourable project economics are in part driven by the high NdPr grade and advantageous mineralogy of the rare earth deposit itself, together with the development of an extraction and purification process that targets the higher value rare earths whilst rejecting the majority of the lower value cerium. The location of the refinery in proximity to sources of inexpensive bulk reagents and existing utilities is also a key driver of lower Opex.

With the alignment of products and value drivers to the high demand magnet metal market the project is in a favourable position in terms of marketing and future demand for its products which will represent less than 5% of total world demand.



## RESULTING IN A LIFE OF PROJECT CONSOLIDATED OPERATING COST OF

## US \$34.20/kg<sup>#</sup> NdPr

is the breakeven point for positive cash flow. Considering today's spot pricing of US \$42.55/kg and understanding the projections and the drivers for the market outlook of increased demand for NdPr, Peak aims to take advantage of the expected increase in pricing as new permanent magnet technology applications arrive on the factory floors.

*# OCBRITDA = Operating cost before royalties, interest, tax, depreciation and amortisation* 



#### **CAPEX INTENSITY OF**

## US \$4.96/kg NdPr

The Ngualla Project has the potential to have the lowest Capex intensity per unit output of NdPr over its mine life compared to other fully integrated development projects.

## Peak Resources: Number 1 amongst its peers



## The BFS Highlights "Physicals drive economics"



#### AND A TOTAL PRE-PRODUCTION CAPEX OF

## US \$356 million

for Ngualla and the UK refinery combined. This has the potential to be the lowest Capex among its peers for a fully integrated producer. We highlight the fact that the BFS now includes a third solvent extraction circuit which will improve margins by separating cerium and lanthanum.

#### WITH A MINE LIFE OF



#### **30 Years**

based on an Ore Reserve of 18.5Mt grading 4.80% REO, containing 887,000t REO, of which 92% is the highest Proved JORC category (8% being Probable), with a favourable mineralogy, easy to mine and able to be processed to a high grade concentrate. This combination makes Ngualla one of the best NdPr deposits worldwide.

We believe the three most important measures of the Ngualla Project are, in order:

- 1) Opex intensity per unit of NdPr output;
- 2) Capex intensity per unit of NdPr output; and
- 3) Total Capex (inclusive of producing fully separated rare earth oxides).

The Ngualla Project has the potential to be a world leading, fully integrated rare earth development project based on each of these measures.

We believe, as a result of the low Opex position, the Ngualla Project is financially more robust and will be able to handle periods of softness in rare earth prices. We see this as an important distinguishing feature of the Ngualla. Based on our assumptions of expected pricing, as set out in the BFS Executive Summary released together with this announcement, which are driven off anticipated strong demand for e-mobility and low carbon technologies, Ngualla is predicted to generate US\$ 104 million dollars per annum in free cash flow (post tax and royalties) with an IRR of 21% (post tax).

#### Peak Resources: Number 1 amongst its peers



## The BFS Results "The Economic Highlights"

PRE TAX & ROYALITIES NPV10	POST TAX & ROYALITIES NPV10
US \$676 million	US \$445 million
PRE TAX & ROYALITIES NPV <sub>8</sub>	POST TAX & ROYALITIES NPV <sub>8</sub>
US \$930 million	US \$633 million
PRE TAX IRR	POST TAX IRR
25%	21%
AVERAGE ANNUAL REVENUE	AVERAGE ANNUAL OPERATING COST
US \$228 million	US \$83 million
AVERAGE ANNUAL CASH FLOW	PRE-PRODUCTION CAPEX
US \$104 million pa.	US \$356 million

**Notes:** See Table 1 for BFS price assumptions. BFS financial highlights are reported on a 100% owned basis. The production target and schedule on which the financial information is based is in turn based on the Ore Reserve and stated Material Assumptions in ASX Announcement "Ngualla Rare Earth Project – Updated Ore Reserve" dated 12 April 2017 and those summarised in the BFS Executive Summary released together with this announcement.

Rare earth price assumptions on which the financial evaluation is based are derived from forecasts by independent industry experts and are as stated in Section 12 of the BFS Executive Summary.

Peak will require new funding for its 75% share in the Ngualla Project in order to achieve the stated financial outcomes, which will result in some dilution of existing shares, the quantum of which will depend on the final debt to equity ratio of the financing package that is yet to be arranged.

#### Peak Resources: Number 1 amongst its peers



## **Key Study Outcomes**

Table 1: Key Study Outcomes. Note all costs are in US dollars unless otherwise denoted.

PRODUCTION ASSUMPTIONS	
Life of Mine	30 Years
Average Life of Mine REO Grade	4.80%
Life of Mine Strip Ratio (Waste:Ore)	1.77
Average Mill Throughput	624,000 tpa
Average REO Mineral Concentrate Production	28,300 tpa
Average NdPr Mixed Oxide 2N Production	2,420 tpa
Average La Oxide Equivalent Production (final product: 6,940 tpa Carbonate)	3,650 tpa
Average Ce Oxide Equivalent Production (final product: 3,005 tpa Carbonate)	1,660 tpa
Average SEG and Mixed Heavy Oxide Equivalent (final product: 530 tpa Carbonate)	280 tpa
OPERATING COSTS	
Average Operating Cost to Mine Gate	US\$ 46m p.a
Average Tees Valley Refinery Operating Cost to Final Product	US\$ 37m p.a
Total Consolidated Operating Cost to Final Product	US\$ 83 m p.a
Total Consolidated Operating Cost/kg	
(NdPr Mixed Oxide 2N <sup>#</sup> )	US\$ 34.20/kg
CAPITAL COSTS (including growth and contingency)	
Ngualla (Mine and Process)	US\$ 52 million
Ngualla (Infrastructure)	US\$ 134 million
Tees Valley Refinery	US\$ 152 million
Owners Costs	US \$18 million
Total Capital Pre-Production	US\$ 356 million
Average Consolidated Sustaining Capital per annum	US\$ 5 million
FINANCIAL METRICS	
Consolidated Total Revenue over life of mine	US\$ 6.76 billion
Consolidated Average Annual Revenue	US\$ 228 m p.a
Total Consolidated (Post Tax) Cash Generation over life of mine	US\$ 3.01 billion
Annual Average Consolidated (Post Tax) Cash flow	US\$ 104 m p.a
Average Annual EBITDA	US\$ 145 m p.a
NPV <sub>8</sub> - Pre Tax and Royalties	US\$ 930 million
NPV <sub>8</sub> - Post Tax and Royalties	US\$ 633 million
NPV <sub>10</sub> - Pre Tax and Royalties	US\$ 676 million
NPV <sub>10</sub> - Post Tax and Royalties	US\$ 445 million
IRR - Pre Tax and Royalties	25%
IRR - Post Tax and Royalties	21%
Operating Margin	64%
Payback Period (from start of Operations)	5 years
Average LOM Product Prices:	
– NdPr Mixed Oxide 2N Min 75% Nd <sub>2</sub> O <sub>3</sub>	US\$ 85.00/kg
<ul> <li>Lanthanum rare earth oxide equivalent</li> </ul>	US\$ 4.41/kg
<ul> <li>Cerium rare earth oxide equivalent</li> </ul>	US\$ 2.25/kg
<ul> <li>– SEG and Mixed Heavy oxide equivalent</li> </ul>	US\$ 8.00/kg

Figures above are on a 100% Project basis (Peak holds 75%). #2N= 99% purity. Average annual statistics are at steady state, post ramp-up.



Further details on project metrics and material assumptions are set out in the ASX Announcement "Ngualla Rare Earth Project – Updated Ore Reserve" dated 12 April 2017 and those summarised in the BFS Executive Summary released together with this announcement.

### Leverage to Neodymium and Praseodymium price

As can be seen in the context of the three NdPr price sensitivity graphs in Figures 1 to 3 following, the Ngualla Project is highly leveraged to the price of Neodymium and Praseodymium, the main constituents of the high growth rare earth permanent magnet market driving e-mobility and other low carbon technologies.

The Company has focused on the higher value and in demand magnet metals through a processing technology that targets these metals, which are expected to generate 90% of the Ngualla Project's revenue.

Overall, we believe the outlook for demand for NdPr continues to be very positive. In 2016 the majority of Chinese producers were unprofitable, suggesting that recent price levels may represent a cyclical low. Furthermore, prices have already risen 9% this calendar year primarily driven by the largest Chinese producer of NdPr implementing a 6% price increase in February 2017 (see Figure 4 showing recent positive price movements).

We believe we are seeing the green shoots of the resurgence of the rare earth market and look forward to monitoring the effect of increasing levels of demand and positive actions in China to reduce illegal production.



Figure 1: Pre Tax NPV<sub>10</sub> vs NdPr Price





Figure 2: Ngualla Project average life of mine post ramp-up free cash flow (post tax and royalties) vs NdPr price

Figure 3: Ngualla Project Pre Tax IRR vs NdPr price





Figure 4: Increasing NdPr Price Trend in 2017



Source: Asian Metal



### **Next Steps**

The completion of the BFS and the recent receipt of the Environmental Certificate for Ngualla are important achievements in the development of the project. With both these key milestones now complete the Company is able to ramp up its discussions with potential offtake, debt financiers and strategic partners for the Ngualla Project with an aim to move into Front End Engineering and Design once appropriate funding partner(s) is/are identified. The focus of discussions will be on strategic partners, export credit agencies, trading houses and NdPr customers with a particular focus on drive train manufacturers for e-mobility.

In parallel, the Company will move forward with an application for a mining license at Ngualla. It is the Company's aim to have the project ready for execution in time to be exposed to the predicted increase in Neodymium and Praseodymium prices driven by e-mobility and low carbon technologies.

J. [\_\_\_\_\_

For and on behalf of Peak Resources Limited. **Darren Townsend** Managing Director



## **Compliance statements**

Information and documentation which forms the basis of the BFS in relation to Mineral Resources and Ore Reserves have previously been reported as detailed within the BFS Executive Summary released together with this announcement. The Company confirms that it is not aware of any new information or data that materially affects the information included in the relevant market announcements and, in the case of the Company's February 2016 Ngualla Mineral Resources and the April 2017 Ngualla Ore Reserves that all material assumptions and technical parameters underpinning the estimates in the relevant market announcement continue to apply and have not materially changed. The Company confirms that the form and context in which the Competent Person's findings are presented have not been materially modified from the original market announcements.

## **Cautionary statements and risk factors**

The contents of this announcement reflect various technical and economic conditions at the time of writing. Given the nature of the resources industry, these conditions can change significantly over relatively short periods of time. Consequently, actual results may vary from those detailed in this announcement.

Some statements in this announcement regarding estimates or future events are forward-looking statements. They include indications of, and guidance on, future earnings, cash flow, costs and financial performance. Forward-looking statements include, but are not limited to, statements preceded by words such as "planned", "expected", "projected", "estimated", "may", "scheduled", "intends", "anticipates", "believes", "potential", "predict", "foresee", "proposed", "aim", "target", "opportunity", "could", "nominal", "conceptual" and similar expressions. Forward-looking statements, opinions and estimates included in this announcement are based on assumptions and contingencies which are subject to change without notice, as are statements about market and industry trends, which are based on interpretations of current market conditions. Please also refer to the additional sensitivity factors described in the Project Economics section of the attached report.

Forward-looking statements are provided as a general guide only and should not be relied on as a guarantee of future performance. Forward-looking statements may be affected by a range of variables that could cause actual results to differ from estimated results, and may cause the Company's actual performance and financial results in future periods to materially differ from any projections of future performance or results expressed or implied by such forward-looking statements. So there can be no assurance that actual outcomes will not materially differ from these forward-looking statements.



These statements are subject to significant risks and uncertainties that include but are not limited to those inherent in mine development and production, geological, mining, metallurgical and processing technical problems, the inability to obtain and maintain mine licenses, permits and other regulatory approvals required in connection with mining and processing operations, competition for among other things, capital, acquisitions of reserves, undeveloped lands and skilled personnel, incorrect assessments of the value of projects and acquisitions, changes in commodity prices and exchange rate, currency and interest rate fluctuations and other adverse economic conditions, the potential inability to market and sell products, various events which could disrupt operations and/or the transportation of mineral products, including labour stoppages and severe weather conditions, the demand for and availability of transportation services, environmental, native title, heritage, taxation and other legal problems, the potential inability to secure adequate financing and management's potential inability to anticipate and manage the foregoing factors and risks. There can be no assurance that forward-looking statements will prove to be correct.

Where the Company expresses or implies an expectation or belief as to future events or results, such expectation or belief is expressed in good faith and on a reasonable basis. No representation or warranty, express or implied, is made by the Company that the matters stated in this announcement will in fact be achieved or prove to be correct.

Except for statutory liability which cannot be excluded, the Company, its officers, employees and advisers expressly disclaim any responsibility for the accuracy or completeness of the material contained in this announcement and exclude all liability whatsoever (including in negligence) for any loss or damage which may be suffered by any person as a consequence of any information in this announcement or any error or omission there from.

This announcement does not take into account the individual investment objectives, financial or tax situation or particular needs of any person. It does not contain financial advice. You should consider seeking independent legal, financial and taxation advice in relation to the contents of this announcement.

Except as required by applicable law, the Company does not undertake any obligation to release publicly any revisions to any forward-looking statement to reflect events or circumstances after the date of this announcement, or to reflect the occurrence of unanticipated events, except as may be required under applicable securities laws.



#### **Competent Person Statements**

The information in this announcement that relates to Ore Reserve estimates was based on information compiled by Ryan Locke, a Principal Consultant with Orelogy Consulting Pty Ltd, Orelogy are an independent consultant to Peak Resources. Ryan Locke, who is a Member of the Australasian Institute of Mining and Metallurgy, has sufficient experience that is relevant to the style of mineralization and type of deposit under consideration and to the activity being undertaken to qualify as a competent Person as defined in the 2012 edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. Ryan Locke consents to the inclusion in this announcement of the matters based on his information in the form and context in which it appears.

The information in this announcement that relates to the Mineral Resource Estimates is based on work conducted by Rod Brown of SRK Consulting (Australasia) Pty Ltd, and the work conducted by Peak Resources, which SRK has reviewed. Rod Brown takes responsibility for the Mineral Resource Estimate. Rod Brown is a Member of The Australasian Institute of Mining and Metallurgy and has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration, and to the activities undertaken, to qualify as Competent Person in terms of the Australasian Code for the Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code, 2012 edition).Rod Brown consents to the inclusion of such information in this announcement in the form and context in which it appears.

The information in this announcement that relates to Exploration Results is based on information compiled and/or reviewed by David Hammond, who is a Member of The Australasian Institute of Mining and Metallurgy. David Hammond is the Technical Director of the Company. He has sufficient experience which is relevant to the style of mineralisation and type of deposit under consideration and the activity which he is undertaking to qualify as a Competent Person in terms of the 2012 Edition of the Australasian Code for the Reporting of Exploration Results, Mineral Resources and Ore Reserves. David Hammond consents to the inclusion in this announcement of the matters based on his information in the form and contest in which it appears.

The information in this announcement that relates to metallurgical test work results is based on information compiled and / or reviewed by Gavin Beer who is a Member of the Australasian Institute of Mining and Metallurgy and a chartered Professional. Gavin Beer is a Consultant Metallurgist to the Company and has sufficient experience relevant to the activity which he is undertaking to be recognized as competent to compile and report such information. Gavin Beer consents to the inclusion in this announcement of the matters based on his information in the form and context in which it appears.

The information in this announcement that relates to infrastructure, project execution and cost estimating is based on information compiled and/or reviewed by Lucas Stanfield who is a Member of the Australasian Institute of Mining and Metallurgy. Lucas Stanfield is the General Manager - Development for Peak Resources Limited and is a Mining Engineer with sufficient experience relevant to the activity which he is undertaking to be recognized as competent to compile and report such information. Lucas Stanfield consents to the inclusion in this announcement of the matters based on his information in the form and context in which it appears.



**Bankable Feasibility Study** Executive Summary Ngualla Rare Earth Project

April 2017



## is the number you need to remember



Praseodymium

UNDERSTOOD - DE-RISKED - COMPETITIVE - MANAGEABLE - READY TO BE DELIVERED!

**ENABLING LOW CARBON TECHNOLOGIES** 

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# **1. INTRODUCTION**

Peak Resources Limited ('Peak' or the 'Company') has completed a Bankable Feasibility Study ('BFS' or 'Study') with Tier One Consultants led by Amec Foster Wheeler for its 75% owned Ngualla Project. The Study components consist of a mine and a multi-stage processing plant on-site at Ngualla in Tanzania and a rare earth refinery in the Tees Valley, United Kingdom.

Peak, together with its parters Appian Natural Resources Fund ('Appian') and International Finance Corporation ('IFC'), is developing Ngualla to be a low cost next generation rare earth project with a product suite that is strongly aligned to the high value and expanding magnet metal market. With this distinctly different development approach backed by the advantages of a large high quality deposit, a bespoke metallurgical process and real world, rare earth experience, the Company is well positioned for the predicted surge in demand for magnet metals from the electrification of automobiles and the green technology sectors.

Peak has completed a comprehensive BFS in partnership with Tier One international consultants that is backed by extensive pilot plant test work, detailed engineering design and cost studies and a high confidence Mineral Resource estimate.

The focus of the Study has been to evaluate the feasibility of the development of a long life open pit mine and associated multistage processing plant on site at Ngualla in Tanzania. A base case of a subsequent rare earth refinery located in Tees Valley in the United Kingdom is presented to produce approximately 2,420 tonnes per annum of >99% purity Neodymium-Praseodymium Oxide (NdPr), plus additional refined rare earth co-products. Alternative marketing strategies being investigated by the Company also include toll treating of the processed rare earth product from Ngualla at an existing refinery or direct sale of the product.

The production rate is based on the Ore Reserve (ASX announcement dated 12th April 2017 "Ngualla Rare Earth Project - Updated Ore Reserve") released simultaneously with this report and which, together with this report, summarises the Material Assumptions. The Ore Reserve is based on the 2016 Weathered Bastnaesite Zone Mineral Resource estimate at +1% rare earth oxide cut-off grade (ASX announcement 'Higher grade Ngualla Mineral Resource contains nearly 1 million tonnes rare earth oxide' of 22nd February 2016) and the mining, processing and economic assumptions contained in the following sections of this report. 91% of the Mineral Resource estimate on which the Ore Reserve is based is classified in the Measured JORC category and 9% in the Indicated. No Inferred material is included in the Ore Reserve.



Figure 1.1: Relative value\* contributors by product type and constituent REO's.

\*Relative value of contained REO equivalent product mix based on prices assumed in the BFS for individual rare earth oxides.

# **2. MANAGING DIRECTOR'S STATEMENT**

## STATEMENT FROM THE MANAGING DIRECTOR DARREN TOWNSEND, B.ENG (MINING-HONS) EMBA

#### 11th April 2017

It is with a great deal of pride that the Peak team delivers the BFS for the Ngualla Project. This is a milestone reached only by a select few rare earth companies and is the culmination of many years of hard work. Investors can take comfort in the tier one approach Peak and its partners have used in completing the Study. It is our understanding that we are also the only company outside of China that has used experienced rare earth industry operational and marketing executives to feed their expertise into a BFS back stopped by extensive pilot planting on the whole production process.

When you combine the above with the Study being led by engineering consultants of the quality of Amec Foster Wheeler, all stakeholders should have comfort on the deliverability and operability of the planned mining, processing and refining solution that the Ngualla Project represents.

You will note as you read on in this document how the superior physical attributes of the Ngualla orebody combined with the unique advantages of the Tees Valley refinery location positions Peak to be one of the world's lowest operating and capital cost rare earth developers.

The Peak team has delivered on the one thing it can control – operating cost. We have further reduced our annual operating cost from US\$118 million per annum, as stated in the Preliminary Feasibility Study dated March 2014, to US\$ 97 million per annum, in the Project Update dated March 2016 an now to US\$83 million per annum as set out in the BFS. This 30% or US\$35 million per annum reduction is outstanding and makes the Ngualla Project one of the world's lowest cost rare earth projects.

With an operating cost of US\$34.20/kg NdPr oxide this means if we were to equity finance the project we could produce in excess of US \$ 20 million per annum margin on the NdPr oxide product alone at today's low spot prices.

We believe that the information set out above makes Peak the go to investment for exposure to the exciting rare earth magnet market that is underpinned by high growth applications such as e-mobility and low carbon technologies.

## **The Asset** • **The Market** • **The Team**

Peak Resources - more than the sum of its parts and the first choice for investment in the rare earth space.

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# **3. BFS HIGHLIGHTS**

## Permanent magnets made up 79% of the rare earth market by value in 2015<sup>#</sup>. Of this, the two key rare earths Neodymium and Praseodymium made up 85%.

Peak's Ngualla Project is one of the highest grade undeveloped Neodymium/Praseodymium (NdPr) deposits in the world. With its 30 year mine life and simple open cut, low strip ratio mining and bastnaesite mineralogy it is blessed with significant natural advantages. Peak has demonstrated through extensive pilot planting a flow sheet that is able to reject 70% of the loss making cerium oxide (which makes up 48% of the total rare earths to be refined) prior to the addition of any expensive chemical reagents into our process. As a result this means 90% of Peak's predicted future revenue is to be from NdPr, which is perfectly aligned to the highest value component of the rare earth market that is being driven by demand from e-mobility and low carbon technologies.

To put the results from the BFS into context it is important for us to show you how Ngualla compares with other projects. A benchmarking exercise has been completed using data from **Adamas Intelligence.** Initially we started with 58 global junior rare earth projects and this number was reduced to 29 projects due to availability of quality data to be able to perform a detailed, comprehensive and professional comparison.

The following methodology has been applied. The white indicator on the following dials show for the specific KPI the closest perceived competitor of Peak Resources. This competitor is a light rare earth project, has low or moderate radioactivity levels in its ore body, undertakes full separation to produce separated oxides and has either a project status of Preliminary-Feasibility ('PFS'), Definitive Feasibility Study ('DFS') or Bankable Feasibility Study ('BFS'). The ghosted white indicator shows all the projects which are not perceived as a direct competitor due to disqualifying elements such as:

- Projects only at PEA (Preliminary Economic Assessment or Scoping) stage or earlier have immature cost data and information which is not comparable with the quality of a PFS or BFS project status.
- Heavy rare earth projects which are by nature not comparable with light rare earth projects.
- Projects with high radioactivity levels in their mineralisation
- Low margin projects that aim to sell a low value intermediate or mixed rare earth product as opposed to a final purified product that is readily tradeable in the world's rare earth markets

# Professor Dudley Kingsnorth (IMCOA) 2016

# 3. BFS HIGHLIGHTS (continued)



#### RESULTING IN A TOTAL LIFE OF PROJECT OPEX INTENSITY (US\$/KG NdPr Oxide) OF

## US\$ 34.20<sup>#</sup>/kg NdPr<sup>\*</sup>

is the breakeven point for positive cash flow. Considering today's (8 April 2017) spot pricing FOB China of US\$42.55/kg and understanding the projections and the drivers for the market outlook of increased demand for NdPr, Peak aims to take advantage of the expected increase in pricing as new permanent magnet technology applications arrive on the factory floors.

<sup>#</sup> OCBRITDA = Operating cost before royalties, interest, tax, depreciation and amortisation \* NdPr = Nd<sub>2</sub>O<sub>3</sub> /Pr<sub>6</sub>O<sub>11</sub> Mixed Oxide 2N – min 75% Nd<sub>2</sub>O<sub>3</sub>



## CAPEX INTENSITY OF US\$ 4.96/kg NdPr

The Ngualla Project has the potential to have the lowest Capex intensity per unit output of NdPr over Life of Mine compared to other fully integrated development projects.



## AND A TOTAL PRE-PRODUCTION CAPEX OF

## US\$ 356 million

for Ngualla and Tees Valley refinery combined. This has the potential to be the lowest Capex among its peers for a fully integrated producer. We highlight the fact that the BFS now includes a third solvent extraction circuit which will improve margins by separating cerium and lanthanum.





## 'PHYSICALS DRIVE ECONOMICS' PEAK RESOURCES: NUMBER 1 AMONG ITS PEERS

Compared to other rare earth projects, Ngualla has lower capital investment requirements and, thanks to a unique combination of favourable physical attributes and the improved processing route selected, enviably low operating costs that will make it cost competitive with Chinese production.

Ngualla's favourable project economics are in part driven by the high PrNd grade and favourable mineralogy of the rare earth deposit itself, combined with the development of an extraction and purification process that targets the higher value rare earths. This combined with the location of the refinery in proximity to the source of inexpensive reagents and utilities helps drive low Opex.

With the alignment of products and value drivers to the high demand magnet metal market, the project is also in a favourable position in terms of marketing and future demand for its products.



with a Mine Life of **30 Years** 

based on an Ore Reserve of 18.5Mt grading 4.80% REO, containing 887,000t REO, of which 92% is the highest Proved JORC category (8% being Probable), with a favourable mineralogy, easy to mine and able to be processed to a high grade concentrate. This combination makes Ngualla one of the best NdPr deposits worldwide.

We believe the three most important measures of the Ngualla Project are, in order:

- 1) Opex intensity per unit of NdPr output;
- 2) Capex intensity per unit of NdPr output; and
- 3) Total Capex (inclusive of producing fully separated rare earth oxides).

The Ngualla Project has the potential to be a world leading, fully integrated rare earth development project based on each of these measures.

We believe, as a result of the low Opex position, the Ngualla Project is financially more robust and will be able to handle periods of softness in rare earth prices. We see this as an important distinguishing feature of the Ngualla. Based on our assumptions of expected pricing, as set out in this BFS Executive Summary, which are driven off anticipated strong demand for e-mobility and low carbon technologies, Ngualla is predicted to generate US\$ 104 million dollars per annum in free cash flow (post tax and royalties) with an IRR of 21% (post tax).

# 3. BFS HIGHLIGHTS (continued)

# US\$ 676 million

## POST TAX & ROYALTIES NPV10 US\$ 445 million

## PRE TAX & ROYALTIES NPV<sub>8</sub> US\$ 930 million

## POST TAX & ROYALTIES NPV<sub>8</sub> US\$ 633 million

## PRE TAX IRR

25%

POST TAX IRR

## AVERAGE ANNUAL REVENUE

US\$ 228 million

## AVERAGE ANNUAL OPERATING COST US\$ 83 million

## AVERAGE ANNUAL CASH FLOW US\$ 104 million pa

# PRE-PRODUCTION CAPEX USS 356 million

**Notes:** See Table 12.1 for BFS price assumptions. BFS financial highlights are reported on a 100% owned basis. The production target and schedule on which the financial information is based is in turn based on the Ore Reserve and stated Material Assumptions in ASX Announcement "Ngualla Rare Earth Project – Updated Ore Reserve" dated 12 April 2017 and those summarised in this BFS Executive Summary.

Rare earth price assumptions on which the financial evaluation is based are derived from forecasts by independent industry experts and are as stated in Section 12 of this BFS Executive Summary.

Peak will require new funding for its 75% share in the Ngualla Project in order to achieve the stated financial outcomes, which will result in some dilution of existing shares, the quantum of which will depend on the final debt to equity ratio of the financing package that is yet to be arranged.



ENABLING LOW CARBON TECHNOLOGIES

# **4. COMPANY PROFILE**



#### Peak Resources is focused on delivering an integrated rare earth project

The Company's 75%-owned project combines mining and multi-stage processing at Ngualla in Tanzania, with downstream refining at a solvent extraction separation plant in the UK to produce a range of rare earth products. Approximately 90% of the value of the final product is associated with a high-purity neodymium and praseodymium oxide.

#### Ngualla is one of the world's largest NdPr deposits

The Ngualla deposit is located in Tanzania, 147 kilometres from the city of Mbeya. It is one of the world's largest NdPr deposits, with total mineral resource containing 4.6Mt of REO. The deposit is host to a thick blanket of weathered, high-grade mineralisation from surface. The Weathered Bastnaesite Zone Mineral Resource estimate at a cut-off of 1.0% REO is 21.3Mt grading 4.75% REO, containing 1,010,000t REO, of which 89% is in the Measured category.

#### Tanzanian operations to produce 28,300tpa of beneficiated REO mineral concentrate grading 45% REO

The Company plans to process 624,000tpa of dry ore through a multi-stage flotation-based beneficiation process to produce 28,300tpa of high-value, 45% REO concentrate containing 12,700tpa of REO.

## UK-based rare earth refinery to produce final products

8

Having investigated a number of different flowsheets and following positive trials on actual mineralisation from Ngualla, the Project will use an alkali roast processing route to produce a rare earth solution feed to a solvent extraction-based separation process. In this, the material is firstly roasted with alkali, then washed and filtered before being leached using a low-strength hydrochloric acid, a process that selectively targets Nd and Pr. The project benefits from the low rate of acid consumption, owing to the absence of acid consuming carbonate and phosphate in the mineralisation and the relatively low levels of iron in the concentrate. Final products from the project are planned to be:

- 2,420 tonnes of neodymium and praseodymium rare earth oxide (2N min 75% Nd<sub>2</sub>O<sub>3</sub>),
- 530 tonnes of mixed SEG and Mixed Heavy rare earth carbonate,
- 3,005 tonnes of cerium carbonate and 6,940 tonnes per annum lanthanum carbonate.

## Neodymium and praseodymium exposed to high-growth permanent magnet demand

Neodymium and praseodymium are used in combination to create high-powered lightweight NdFeB permanent magnets. Prices of rare earths, including those for NdPr oxides, peaked in 2011 and have since fallen back to unsustainable levels.

Owing to the increased use of high-power magnets in electrical motors and generators, particularly in electric cars and bikes, the outlook for demand for NdPr is very positive, suggesting that current price levels should represent a cyclical low.

Peak has completed this Study using Tier One international consulting firms in partnership with its own in house team of industry experts experienced in real world rare earth operations and marketing as well as specialised metallurgical, geological, financial modelling and engineering studies.

The team is pleased to deliver a comprehensive, high quality and accurate study that is also practically deliverable and operable.

#### Ngualla is de-risked and ready to be delivered.

Table 5.1 List of BFS consultants and areas of expertise

CONSULTANT	AREA OF EXPERTISE
Amor Foctor Wheeler	Study Load Engineer LIK Refinery Engineering
	Study Lead Engineer, OK Kenner y Engineering
MDM Engineering	Ngualla Site Infrastructure and Plant Engineering
Knight Piésold	Tailings, Geotechnical and Water Management
Golder Associates	Ngualla Open Pit Geotechnical and Hydrological Studies
SRK Consulting, Australia	Mineral Resource Estimation
SGS, Perth	Beneficiation Pilot Plant and Sample Analyses
Orelogy Consulting	Ngualla Ore Reserve and Mining Studies
COWI Tanzania	Ngualla Access Road Engineering
ANSTO Minerals	Leach Recovery and Separation Pilot Plants
ALS Metallurgy	Beneficiation Pilot Plants and Mineralogy
Nagrom	Metallurgical Process Development
Independent Metallurgical Operations (IMO)	Benefication Process Development
Jenike and Johanson	Materials Handling
Align Environment and Risk Management	Environmental and Social Studies, Tanzania
Paulsam Geo-Engineering	Environmental Certificate Studies, Tanzania
WYG	Environmental Studies and Permitting, UK
Dr Wally Witt	Geology and Mineralogy
Dr Roger Townend and Associates	Mineralogy
Deloitte	Accounting and Location Studies
Steinepreis Paganin	Corporate and Legal
Clyde and Co, Tanzania	Corporate and Legal, Tanzania



ENABLING LOW CARBON TECHNOLOGIES

NGUALLA ONE OF THE WORLD'S LARGEST AND HIGHEST © UNDEVELOPED NEODYMIUM (Nd) © PRASEODYMIUM (Pr) RARE EARTH PROJECTS The rare earth Mineral Resource estimate for Ngualla was reported in accordance with the JORC 2012 Code and Guidelines by independent resource consultants SRK Consulting (Australasia) Pty Ltd (SRK) in February 2016. It was re-stated in March 2017, also by SRK, to report barite (barium sulphate, BaSO<sub>4</sub>) with no change to the rare earth Mineral Resource estimate or estimation methodology. The BFS does not contemplate the production of barite.

#### 6.1 WEATHERED BASTNAESITE ZONE MINERAL RESOURCE ESTIMATE

Included in the Total All Ngualla Mineral Resource estimate is an important high grade subset, the Weathered Bastnaesite Zone Mineral Resource, a particularly mineralogically favourable component of the greater deposit, which is targeted for initial development. The rare earth component of the Weathered Bastnaesite Zone Mineral Resource estimate is the basis of this BFS.

At a 1% REO lower grade cut-off the Mineral Resource estimate for the Weathered Bastnaesite Zone is:

# 21.3 million tonnes at 4.75% REO and 37.7% barite, for 1,010,000 tonnes of contained REO and 8.03 million tonnes of contained barite

(see Table 6.1 and Table 1 in the Appendix for JORC category classification and individual rare earth distributions).

The +1% REO Mineral Resource estimate for the Weathered Bastnaesite Zone is high confidence, with 98% classified in the JORC Measured or Indicated categories, and the majority (89%) being Measured (see Table 6.1). The Ore Reserve and production schedule for the Study is based on the Measured and Indicated portions only of the +1% REO Weathered Bastnaesite Zone Mineral Resource estimate.

Lower cut-off grade	JORC Resource Category	Tonnage (Mt)	REO (%)	Contained REO tonnes ('000)	BaSO₄ (%)
	Measured	18.9	4.75	900	37.8
40/ 050	Indicated	1.9	4.85	90	38.3
1% REO	Inferred	0.5	4.43	20	31.5
	Total	21.3	4.75	1,010	37.7

Table 6.1: Mineral Resource estimate summary – Weathered Bastnaesite Zone +1% REO\*

\* REO = total rare earth oxides including yttrium. The Weathered Bastnaesite Zone Mineral Resource >=1% REO is contained within and is a subset of the total All Resources Ngualla Mineral Resources +1% REO. See Table 1 in the Appendix for relative distributions of individual rare earths as a proportion of total REO. Figures may not sum due to rounding. Barite grade is derived from geochemical assays for barium and the assumption, supported by extensive mineralogical studies, that barium is present as barite. Figure 6.1: Plan and section of Ngualla Mineral Resource block model >1% REO across the Bastnaesite Zone showing a thick blanket of high grade mineralisation from surface.



The Mineral Resource estimation process and estimate for the Weathered Bastnaesite Zone subset and the Total All Ngualla Mineral Resource is reported in ASX announcement titled "Higher grade Ngualla Mineral Resource contains nearly 1 million tonnes rare earth oxide" of 22 February 2016. Barite was added in a revision reported in ASX announcement dated 2nd March 2017 and titled "Ngualla Mineral Resource estimate re-stated to include barite", with no change to the rare earth estimates or estimation methodology.

As at the date of this report there has been no change to the Mineral Resource estimates since these announcements.

## **6. MINERAL RESOURCES** (continued)

Barite is included in the Mineral Resource estimates as preliminary studies have suggested that there may be some future potential to produce barite as a by-product. A relatively pure barite stream reports to one of the rare earth waste streams during rare earth production. Further work is required to evaluate the economic potential of barite production and at present barite remains a potential future upside opportunity for the project.

#### **Definition and Advantages of the Weathered Bastnaesite Zone Mineralisation**

The Weathered Bastnaesite Zone Mineral Resource is defined as weathered or colluvial rare earth mineralisation containing less than 10% calcium and very low phosphorous of less than 0.3%. This higher grade mineralisation occurs from surface and extend as a thick blanket to depths of up to 140m above an undulating karstic surface.

Rare earths are contained within the fluorocarbonate mineral bastnaesite within a relatively soft barite and iron oxide-rich host rock with some guartz. Weathering processes have concentrated the rare earths and removed acid-consuming carbonate minerals. Phosphate minerals, which can also be disadvantageous in processing, are naturally absent. The mineralisation contains very low levels of uranium (15ppm) and thorium (54ppm) compared to other large rare earth deposits.

This combination of fundamental mineralogical characteristics distinguishes Ngualla from other projects and underpins the low capital and operating costs outlined in the following sections of this report.

#### **6.2 TOTAL ALL NGUALLA MINERAL RESOURCE ESTIMATE**

The Weathered Bastnaesite Zone Mineral Resource estimate reported above is included within and is a subset of the Total All Mineral Resource for the Ngualla Project, which at a 1% REO lower grade cut-off is:

#### 214.4 million tonnes at 2.15% REO and 16.6% barite. for 4.620.000 tonnes of contained REO and 35.6 million tonnes of contained barite

(See Table 6.2 for JORC category classification and Table 2 in the Appendix for individual rare earth distributions).

The Mineral Resource estimation process is described in the ASX Announcements stated. As at the date of this report there has been no change to the Mineral Resource estimates since these announcements.

Metallurgical test work has shown that rare earth mineralisation outside the Weathered Bastnaesite Zone may be processed using other conventional beneficiation and leach recovery processes. The long mine life supported by the Weathered Bastnaesite Zone provides the Company with the opportunity and time to optimise these processes, which could be brought in at a later stage in the life of the operation.

Ngualla is not only an extremely large rare earth deposit but it is also of superior quality as a result of the high rare earth grades, outcropping mineralisation with a morphology that is beneficial to mining, a mineralogy that is favourable to processing, low levels of uranium and thorium and a high proportion of the more valuable rare earths neodymium and praseodymium.

xble 0.2. Willer ar Resource estimate summary - Total All Ngualia Willer ar Resource estimate + 176 REO							
Lower cut-off grade	JORC Resource Category	Tonnage (Mt)	REO (%)	Contained REO tonnes ('000)	BaSO₄ (%)		
	Measured	86.1	2.61	2,250	20.2		
	Indicated	112.6	1.81	2,040	13.8		
1% REU	Inferred	15.7	2.15	340	17.6		
	Total	214.4	2.15	4,620	16.6		

Table 6.2: Mineral Resource estimate summary - Total All Ngualla Mineral Resource estimate +1% REO\*

\*REO = total rare earth oxides including yttrium. The weathered Bastnaesite Zone Mineral Resource +1% REO is contained within and is a subset of the total All Resources Ngualla Mineral Resources +1% REO. See Table 2 in the Appendix for relative distributions of individual rare earths as a proportion of total REO. Figures may not sum due to rounding. Barite grade is derived from geochemical assays for barium and the assumption, supported by extensive mineralogical studies, that barium is present as barite.



# 7. ORE RESERVES & MINING

#### OPEN PIT MINE LIFE OF 30 YEARS AT A LOW STRIP OF 1.77

#### ORE RESERVE OF 18.5 MILLION TONNES AT 4.80% REO

#### LOW AVERAGE TOTAL MINING RATE OF 1.7MT PER YEAR

Mining studies indicate the viability of a modest sized but long life open pit operation with a low Life of Mine (LOM) waste strip ratio of 1.77, which at the proposed production rate can provide sufficient feed for an initial project life of 30 years based solely on the Weathered Bastnaesite Zone portion of the greater Ngualla deposit.

Orelogy Consulting Pty Ltd based in Perth, Western Australia, have undertaken the previous mining studies and Ore Reserve estimate on Ngualla and consequently Peak commissioned them to complete the mining component of the Study and Ore Reserve estimate. As the mineralisation is weathered and at surface, mining will predominantly (70%) be free dig requiring minimal blasting and with low Ore to waste stripping ratios. Through the optimisation and scheduling process the mine will also produce higher grade mill feed with a higher proportion of neodymium and praseodymium in the earlier years of production.

The scope of work that formed the basis of mining component of the BFS comprised the following:

- Open Pit Optimisation
- Mine design
- Mining cost estimation
- Mining equipment and personnel requirements



#### 7.1 MINING LOSSES

Mining losses and dilution are expected to be minimal due to the thick blanket morphology of the deposit and the use of small mining equipment operating at a relatively low mining rate averaging less than 1.7Mt total material movement per annum over the life of mine. Total mining losses comprise just 6% of the total Mineral Resource available (Measured + Indicated categories of the +1% REO Weathered Bastnaesite Zone).

#### 7.2 OPEN PIT OPTIMISATION

The pit optimisation was undertaken using GEMCOM Whittle 4X software utilising the February 2016 Ngualla Mineral Resource model completed by SRK Consultants Pty Ltd. Table 7.1 provides a summary of the optimisation wall slope parameters used for this Study. Associated operating cost parameters for mining, processing, and selling can be found in Section 14. The individual rare earth oxide grades, recoveries and prices were used in preference to using an average REO grade, average total recovery and basket price. This level of detail maximises total returns by allowing the optimiser and subsequent mine schedule to focus early production on the highest grade areas of Ngualla's main value drivers of neodymium and praseodymium.

Only material from the Weathered Bastnaesite Zone Mineral Resource estimate with a REO grade above 1% was used in the optimisation. Of this material 89% is in the Measured JORC category and 9% is Indicated. The Inferred portion of the Mineral Resource was excluded from the optimisation process.

Location	Face Height	Batter Angle	Berm Width	Catch Berm Width	Catch Berm Increment	Overall Slope Angle
	(m)	(°)	(m)	(m)	(m vert)	(°)
Oxide	5.0	50	6.5	15	20	25
Oxide / Fresh	10.0	50	6.5	15	20	34
Fresh	10.0	75	8.0	15	40	43

#### Table 7.1: Optimisation wall slope parameters

The overall slope includes an allowance for a 15m wide catch berm every 20 vertical metres in oxide material and the oxide / fresh transition zone. This results in the very shallow 25° slope applied in the oxide and 34° in the oxide / fresh zone. A 23m wide ramp has been incorporated into the design suitable for a dual lane ramp based on the 65t dump truck selected.

ASX Announcement "Ngualla Rare Earth Project - Update Ore Reserve" of 12 April 2017 summarises the material assumptions used for the Ore Reserve estimation, which continue to apply.

#### 7.3 ORE RESERVE

An optimal shell was selected as the basis for the open pit mine design and subsequent LOM schedule, which is to be mined by 4 initial stages followed by the ultimate pit design. In line with previous studies, it is assumed mining is via two successive 2.5 metres mining flitches. The geotechnical parameters as defined in Table 7.1 above have been utilised in the design.

The location of the ultimate pit and the interim pit designs are shown in Figure 7.1.

# 7. ORE RESERVES & MINING (continued)

The ultimate design contains the following Ore Reserve:

- Plant Feed of 18.5 million tonnes at 4.80% REO comprising 17.0 million tonnes at 4.78% REO Proved Reserve and 1.5 million tonnes at 5.10% REO Probable Reserve category (see Table 7.2).
- The average LOM strip ratio is 1.77.
- Provides for 30 years of mill feed at a production rate output of approximately 2,420 tonnes per annum of NdPr oxide.

To further enhance the mining returns in the first years, and as project economics are not sensitive to total mining costs, the slightly lower value (lower grade) ore >1% REO is mined selectively to stockpile for later processing to allow access to higher value material earlier in the processing schedule. This can be seen in the mine schedule shown in Table 7.3, with the stockpiled material shown to be processed from Year 7 onwards.

#### Table 7.2: Ngualla Project Ore Reserve estimate

Classification	Ore Tonnes (Mt)	REO %	Contained REO tonnes
Proved	17.0	4.78	813,000
Probable	1.5	5.10	74,000
Total	18.5	4.80	887,000

See Table 7.4 for indicative REO breakdown



#### Table 7.3: Life of Mine (LOM) Material Movement and Plant Throughput

	Total LOM	Pre- strip	Year 1	Year 2	Year 3	Year 4-5	Year 6-10	Year 11-20	Year 21-31
Total (N4t)	F1 1	0.7	2.7	2.0	2.5	4.4	12.0	16.2	2.0
IOLAI (IVIL)	51.1	0.7	Z./	2.8	2.5	4.4	12.9	10.3	8.9
Waste (Mt)	32.7	0.7	1.0	1.0	1.3	2.4	10.0	11.0	5.1
Ore (Mt)	18.5	0.0	1.6	1.7	1.3	2.0	2.9	5.2	3.8
Strip Ratio (WT:OT)	1.77	N/A	0.64	0.60	1.03	1.19	3.47	2.11	1.37
Direct Ore Feed to Mill (Mt)	13.5	0.0	0.3	0.5	0.5	1.1	2.1	5.2	3.8
Ore to Stockpile (Mt)	4.9	0.0	1.3	1.2	0.7	0.9	0.8	0.0	0.0
Ore Feed from Stockpile (Mt)	4.9	0.0	0.0	0.0	0.0	0.0	0.8	1.3	2.7
Total Ore Feed (Mt)	18.5	0.0	0.4	0.5	0.5	1.1	2.9	6.5	6.5
REO grade (%) through Mill	4.80	0.00	5.01	5.17	5.58	5.63	4.97	4.68	4.61

# 7. ORE RESERVES & MINING (continued)

Figure 7.2: Perspective view of staged pit designs, Ngualla weathered Bastnaesite Zone



Table 7.4: Elements of combined REO grade

Rare earth oxides	R	EO Grade (%	6)	% of Total REO			
	Proved	Probable	All	Proved	Probable	All	
MTonnes	17.0	1.5	18.5	-	-	-	
Lanthanum	1.318	1.418	1.326	27.59	27.80	27.61	
Cerium	2.305	2.456	2.317	48.25	48.15	48.24	
Praseodymium	0.228	0.243	0.229	4.77	4.77	4.77	
Neodymium	0.788	0.838	0.792	16.49	16.43	16.49	
Samarium	0.077	0.082	0.077	1.61	1.61	1.61	
Europium	0.014	0.015	0.014	0.30	0.28	0.30	
Gadolinium	0.029	0.031	0.030	0.62	0.60	0.62	
Terbium	0.002	0.002	0.002	0.05	0.05	0.05	
Dysprosium	0.004	0.004	0.004	0.07	0.07	0.07	
Holmium	0.000	0.000	0.000	0.01	0.01	0.01	
Erbium	0.001	0.002	0.002	0.03	0.03	0.03	
Thulium	0.000	0.000	0.000	0.00	0.00	0.00	
Ytterbium	0.001	0.001	0.001	0.01	0.01	0.01	
Lutetium	0.000	0.000	0.000	0.00	0.00	0.00	
Yttrium	0.010	0.010	0.010	0.20	0.19	0.20	
Total REO	4.78	5.10	4.80	100.00	100.00	100.00	

Values may not sum up due to rounding.

# **8. PILOT PLANTS**

Peak has developed and demonstrated through extensive pilot plant operation a robust process for Ngualla's unique ore to provide confidence in the deliverability and operability of the three main processing stages – beneficiation, leach and purification/ separation (Figure 8.1). The pilot plants together cost approximately A\$ 5 million and comprehensively validate the operating and design parameters used in this Study.





#### 8.1 BENEFICIATION PILOT PLANT

A beneficiation flowsheet piloting program was conducted at ALS in Perth using a total of 56 dry tonnes of typical weathered bastnaesite mineralisation from Ngualla. The mineralisation was initially coarse crushed and homogenised to form a single bulk sample grading 5.9% REO. The bulk sample was successfully piloted at a feed rate of 250 kg/hour using the new milling and two stage flotation flowsheet developed by Peak.

The Pilot Plant accomplished the following:

- Sustained operation in steady state demonstrating the beneficiation process is both robust and reproducible on mineralisation selected to be representative of the first five years of mill feed.
- Provision of vital operating and design parameters to Amec Foster Wheeler for incorporating into the BFS.
- The production of two tonnes of concentrate grading >40% REO in preparation for piloting of the next stage Leach and Purification process at ANSTO Minerals (ANSTO) in Sydney.

#### 8.2 LEACH & PURIFICATION PILOT PLANT

The selective leach recovery process developed by Peak is a key factor in Ngualla's low operating and capital costs and allows the final products to be aligned to the high demand magnet metal rare earth market.

A pilot plant at ANSTO Minerals piloting facility near Sydney used the high grade mineral concentrate produced by the ALS Beneficiation Pilot Plant to demonstrate the new selective leach flowsheet.

- The simple but robust recovery process produces a high purity mixed product enriched in neodymium and praseodymium from the rare earth mineral concentrate.
- A dry roast process followed by selective leach and purification leads to low reagent consumption and a smaller downstream plant to produce a suitable feed to the final product separation stage.
- The process allows the use of lower cost modular designed polymer tanks.

# 8. PILOT PLANTS (continued)

#### 8.3 SEPARATION PILOT PLANT

The ability to produce high purity separated rare earth products adds significant value to Ngualla's products and allows access to wider end use markets. To this end, Peak commissioned ANSTO to prepare a feed stream for a separation Pilot Plant from a 1.3 tonne bulk sample of weathered Bastnaesite Zone mineralisation from Ngualla.

*Figure 8.3: A portion of the Leach Recovery and Purification Pilot Plant at ANSTO Minerals test facility.* 



Figure 8.4: Solvent Extraction test facility at ANSTO Minerals.



By the completion of the Pilot Plant operation, four high purity separated rare earth oxide products were successfully produced from Ngualla's mineralisation. Peak Resources is one of only a very small number of rare earth development companies to have successfully demonstrated at pilot plant level the processing of rare earth mineralisation from its project through the entire stages to final high purity separated rare earth products.

Figure 8.2: Barite pre-flotation circuit at ALS test facility in Perth, Western Australia.



Peak has designed a Multi-Stage Processing Plant that will be located on site at Ngualla to produce 28,300 tonnes per annum of rare earth concentrate grading 45% REO.

The plant comprises the following:

- A ROM pad to receive mine production and blend plant feed to predefined specifications.
- A comminution circuit incorporating primary crushing, grinding and classification.
- Beneficiation of the ground feed utilising reverse gangue flotation, regrinding and rare earth flotation to produce a high grade/low mass concentrate.
- A segmented Tailings Storage Facility (TSF) for safe disposal of waste solids and water reclaim.

The multi-stage processing plant layout and flowsheet is shown in Figures 9.1 to 9.3.

The entire flowsheet has been modelled by Amec Foster Wheeler using SysCAD software to provide a detailed mass and energy balance model. Operating and capital costs have been determined on the basis of the model outputs. The key Basis of Design parameters are given in Table 9.1.

Annual mill throughput * (dry tonnes)	556,000t
Annual rare earth concentrate production (dry tonnes)	28,000t

45.0%

Table 9.1: Processing Plant	Basis of Design	Parameters
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\*Throughput to be increased in Year 8 to 650,000t

Rare earth concentrate

grade (% REO)

#### 9.1 COMMINUTION CIRCUIT

The run of mine (ROM) feed is delivered to stockpiles allowing for blending based on grade and mineralogy. A front end loader reclaims from the stockpile and feeds directly to a ROM bin which is fitted with a static grizzly to scalp out oversize rock. Feed is withdrawn at a controlled rate from the bin by an apron feeder, which in turn transfers onto a vibrating grizzly feeder to scalp out fines. Scalper oversize is fed to a tooth rolls mineral sizer, which breaks rocks down to a notional top size of 200mm and is combined with scalper undersize on the discharge conveyor. The feed is then conveyed directly to the grinding circuit.

The crushed material is initially milled in a high aspect open circuit SAG mill, with slurry passing through discharge grates and a trommel. The trommel undersize slurry flows into a common hopper shared with the closed circuit secondary ball mill. The hopper discharge is pumped to a pack of hydrocyclones with the underflow reporting back to the secondary mill.

#### 9.2 BARITE PRE-FLOTATION CIRCUIT

The ground material is conditioned in two high intensity conditioning tanks with flotation reagents prior to being presented to barite flotation. The circuit consists of a rougher bank, with the rougher concentrate being further upgraded in two stages of cleaner flotation.

#### 9.3 BARITE PRE-FLOTATION DEWATERING AND TAILINGS DISPOSAL

The flotation concentrate from the Barite Pre-flotation is almost pure barite. In the future, this stream may be treated further to make a potentially saleable barite by-product but this is not included in the current Study; is dewatered in a high rate thickener (for water recovery) and pumped to a dedicated cell within the TSF. The flotation underflow, which is depleted in barite, contains the majority of rare earth minerals along with gangue iron and silica minerals. This stream is first dewatered in a high rate thickener and then pumped to a surge tank to provide a buffer between flotation circuits.

# 9. OVERVIEW: NGUALLA OPERTIONS (continued)

Figure 9.1: Ngualla Flowsheet



# 9. OVERVIEW: NGUALLA OPERATIONS (continued)



Figure 9.2: Ngualla plant 3D layout

#### 9.4 REGRIND AND RARE EARTH FLOTATION CIRCUIT

Slurry is pumped from the surge tank through an open circuit regrind mill in order to grind coarse particles and mechanically reactivate mineral surfaces ahead of rare earth flotation. The milled slurry is diluted with process water and heated with steam injection in conditioning tanks where flotation reagents are added prior to flotation. The Rare Earth Flotation circuit is of higher complexity than the Barite Pre-Flotation Circuit due to the comparatively difficult separation of rare earth minerals from iron minerals which require stage wise depression with starch to achieve an adequate final concentrate grade. The circuit consists of a rougher train followed by four stages of counter-current closed circuit cleaner flotation. Steam is added stage wise through the cleaner circuit in order to improve selectivity against the iron minerals.

## 9.5 CONCENTRATE AND TAILINGS DEWATERING

The final concentrate is dewatered in a high rate thickener to recover water from the overflow with the thickened slurry reporting to a filter surge tank. Slurry is then pumped through a pressure filter which operates on a batch cycle, with the filter cake discharging into the bagging facility. The bagged concentrate is then containerised for land and sea transport to the refinery.

The tailings stream from this circuit, comprising mainly of iron minerals, is dewatered in a high rate thickener to recover water and then pumped to a dedicated cell within the TSF.

The flowsheet is shown in Figure 9.1 and the plant 3D layout in Figures 9.2 and 9.3

Figure 9.3: Ngualla plant 3D layout - flotation and thickening




## **10. ENVIRONMENTAL & SOCIAL**

Peak is developing Ngualla to be a long term, environmentally and socially sustainable supplier of choice to the global high technology rare earth market. The Company's own ethics and standards in this regard, together with those of its investor partners, match the modern needs of global industry to have a responsible source of materials throughout their product supply chain. The Company aims to make this green and sustainable approach a fundamental part of its business strategy and a point of differentiation for its products compared with some other sources of rare earths.

The Company maintains highest standards of environmental, health, safety and social behaviour and aims to ensure that the development of Ngualla benefits all stakeholders including the communities in which it operates.

The project development area at Ngualla is free of any habitation, farming or grazing and there are no reserves of any kind over the area. The Company enjoys the support of the local community and government at the district, regional and national level in the development of the project.

The location of the mine and process facilities within the ring of hills that surround the carbonatite structure will enable the site to be self-contained with a low impact on surrounding areas. Water will be recycled for re-use in the plant and there will be no waste discharge from the operation.

Figure 10.1: First bucket of water accepted by villager at handover ceremony for Madodomia village water bore and pump, donated by Peak December 2015.



An assessment of the specific activity levels of the mineralisation to be mined indicates that the levels of uranium (15ppm) and thorium (54ppm) are very low and well below levels set by the International Atomic Energy Agency to be regarded as radioactive and as such there is no concern of any environmental or health and safety issues arising from safety issues.

#### 10.1. SOCIAL

Peak has established and maintained an excellent relationship with the local people, village council, local government organisations and the central government ministries. Peak is an active member of the local community, which is in full support of the development of the mine and processing plant and has actively assisted the development by providing labour, local produce, access to land and security.

Through its Community and Social Responsibility (CSR) programmes, Peak has funded, assisted with and donated to many community projects in the local area and wider region (see Figure 10.1 to 10.4). Projects are identified by the Ngwala Village Council based on the needs and priorities of their constituents. These projects are brought to Peak's attention at village meetings and developed through further discussion and consultation that includes the broader levels of local administration to ensure they are aligned with the established programs of the District and Regional government. Individual projects completed to date include the building of two new classrooms and refurbishment of several more for the Ngwala Primary School, provision of text books, school equipment and desks to three schools in the Ngwala district and the construction of nine teachers' houses. Other projects have included completion of water bores

## **10. ENVIRONMENTAL & SOCIAL** (continued)



*Figure 10.2: Local children gathering outside Ngwala Village School.* 

and pumps, provision of sporting equipment for local teams, construction of clinic waiting area and assistance with the establishment of an airstrip at Ngwala.

#### **10.2. ENVIRONMENTAL PERMITTING**

The environmental permitting of the Ngualla Rare Earth Project is complete with the Environmental Certificate (EC) received on 16 March 2017. The certificate of environmental approval was granted after the successful completion of a detailed Environmental and Social Impact Assessment Study overseen by regulators National Environment Management Council (NEMC). The study included wet and dry season baseline studies, socioeconomic reports, stakeholder consultation at local, District, Regional and National level together with a site visit and review meeting with NEMC. Widespread support for the development of the project has been received from all stakeholders.

An application for an Environmental Permit for the Tees Valley refinery is in preparation at the time of writing and will be lodged with the UK Environment Agency shortly, with approvals expected during 2017.

Peak's environmental and social consultants also assist the Company to ensure IFC's best practice standards of operation and reporting are met, standards which will also be required by international banks in areas of environmental and social responsibility and the Company's own sustainable business model.



Figure 10.3: Community Liason Officer, Mariam Mwaiswelo, Managing Director, Darren Townsend and Project Manager, Patrick Ochieng outside the Ngualla teachers houses built by Peak in 2014.



Figure 10.4: Ngwala Village Football Team prepare to commence a match- kits were donated by Peak in June 2013.

#### **RARE EARTH REFINERY**

#### 11.1 CALCINING/LEACHING/ PURIFICATION

Containers of concentrate coming from the port are stored in front of Tees Valley processing to help mitigate potential Ngualla processing and transportation issues. The Recovery Circuit takes advantage of the fact that the multi-stage beneficiation process has produced a high grade/low mass rare earth concentrate and therefore has low treatment rate of less than four dry tons per hour. This results in a very modest size circuit consisting mainly of low cost fibre-reinforced plastic tanks, pumps and filters.

The received mineral concentrate (45% REO) is mixed with a common alkali prior to being fed into an indirectly fired rotary kiln. After the material is calcined it is washed with water to remove soluble fluoride and then sent on to leach circuit. The conditions of the Calciner and the Leach form the real control for the cerium/iron sequestration and the rare earth recovery.

After the leach residue is filtered out, the leach liquor is sent to Purification process to remove the majority of the remaining impurities that cause issues with downstream processes and product quality. The solids from the leach, purification and fluoride removal process are collected and forwarded into the solid waste facility. Residual brine solutions are forwarded to water treatment and then passed into the Sembcorp effluent treatment system.

#### **11.2 SOLVENT EXTRACTION**

Solvent extraction technology will be used to separate rare earths. This process starts by separating the mid and heavy rare earths, followed by separating neodymium and praseodymium and lastly separating cerium from lanthanum.

The conditions for each of the three solvent extraction units are altered to favour the elements being extracted. In all three solvent extraction units, the separated elements are concentrated and purified for the subsequent precipitation and product finishing.

## 11.3 PRODUCT PRECIPITATION / PRODUCT FINISHING

There are four different products being generated in this plant normally; mid-heavy rare earth carbonate, NdPr oxide, lanthanum carbonate, and cerium carbonate.

System for the carbonate systems will be setup as continuous precipitations, meaning multiple stages, reliable pH control, consistent temperature control, possible seeding capabilities, and correct agitation and pumping from wash thickeners to centrifuges. Thickener overflow centrate will be routed to REO scavenging recovery circuit. The NdPr oxalate batch precipitation, will be followed by calcination to a two nines oxide product. Products will be bagged in one metric tonne bags, with a plastic inside liner.

#### **11.4 ANCILLARY SERVICES**

The Tees Valley was one of over a dozen international sites that were evaluated for the fit to rare earth refinery's requirements.

#### Logistics

Access to port facilities for rare earth concentrate delivery as well as availability of a bulk supply of hydrochloric acid, other reagents and heavy vehicle access has been taken into account in the site selection criteria for the refinery.

#### **Power and Water Supply**

The power and water infrastructure to meet the Refinery's requirements has been allowed for in the site selection criteria. This will save on the need for significant capital expenditure on Peak's part for these services.

#### Effluent/Solid Waste Treatment

The solids from the leach, purification and fluoride removal process are collected and forwarded into a solid waste facility. Acidic streams generated within the Recovery and Separation circuits will be pumped to an effluent treatment plant for neutralisation; resulting in divalent precipitation and brine clarification using Best Available Techniques (BAT). Residual brine solutions are then into passed to Sembcorp water treatment.

# 11. OVERVIEW: TEES VALLEY OPERATIONS (continued)

Figure 11.1: Tees Valley flowsheet



### **11. OVERVIEW: TEES VALLEY OPERATIONS** (continued)

#### Reagents

The main reagent of hydrochloric acid will be supplied from a third party storage facility within the vicinity of the Tees Valley site. Only modest on-site storage tanks will therefore be required.

Minor liquid reagents, such as solvents, will be transported and dispensed directly from typical 1m<sup>3</sup> intermediate bulk containers.

Bulk solid reagents will be delivered by pressurised tankers and stored on site in small silos.

Minor solid reagents will be transported via 1 tonne bulk bags in shipping containers.

Approximately 110,000 tonnes of reagents will be required at the refinery per annum so the Tees Valley location within 1km of Tees port and location close to excess Chlor-Alkali capacity in Europe are key drivers for the safe and efficient operation of the refinery.

#### **11.5 OPERATIONS READINESS**

Starting a rare earth operation from the ground up requires solid planning and specific knowledge of the space. It is critical to find and hire a small number of key personnel for the overall project to effectively put together the framework of the operation. This small group of hires will be key to the successful startup and implementation of what will be a high performance organisation. These are the systems our customers will be the most interested to see fully developed and they are the backbone of the most highly effective operations.

This group will direct the actions to put in the frame work for support systems including; Operations Excellence, Quality Management Systems, Training, and Reliability Based Maintenance, Environmental/Health/ Safety, Purchasing, Human Resources and Information Technology. The goal is to bring all systems to a stage of development, so they can be used for startup and commissioning of both sites. Two vital areas of development are discussed overleaf;



Figure 11.2: 3D Layout of Tees Valley Refinery

## **11. OVERVIEW: TEES VALLEY OPERATIONS** (continued)

#### QA/QC

The QA/QC group must have a high level of capability for analyzing rare earth products and the impurities within those products. Often the difference in getting new business is related to the confidence customers have in the product certification of analysis (COA). This group will be the primary quality support for Marketing/Sales, Ngualla QA/QC, most inprocess analytical efforts at Tees Valley and Product Development. The ability to build a highly effective QA/QC team and to act as the face of the corporation on the quality front are critical to Peak's success. They will also lead company-wide Quality Management Systems, ISO 9001:2015 certification and Reach certification.

#### **Process Engineering**

Process Engineering will be an active support for root cause analysis (RCA), as it relates to Safety, Quality and Mechanical failures. The group will also have a lead role for quality management and active participation in ISO certification related to quality, environmental and safety.

Additional responsibility includes; short interval control (SIC) or "decision trees", SOP development, development of Pi data historian collections and all the development of the reports which use the Pi data to give transparent vision of operational effectiveness, including process KPI's, OEE%, down time pareto.



Figure 11.3: Concentrate handling facility.



Figure 11.4: Leaching area adjacent to effluent treatment facility.



#### **12.1 MARKETING AND SALES STRATEGY**

Overall, our governments and society are becoming more concerned about the global environmental challenges which we are facing. Compounding this is the context of the growth of emerging markets in Africa, Asia and Latin America. It is predicted that more than one billion people in Asia are in the transition of advancing from low socio-economic circumstances to a middle-income class. Subsequently the desire to increase their mobility will cause a change in their consumer behaviour. At the same time we see that these emerging markets, in particular China, but also the rest of the world, are becoming aware of the environmental toll that this growth requires and they have acknowledged alarming developments in the area of climate change, health and resources scarcity.

The majority of the predicted future growth of rare earths consumption and particular neodymium and praseodymium is already underpinned by recent and already agreed legislation and government policies and the will for decarbonisation of energy production, transport and industry.

As a result of this we see a positive sentiment in our society and a positive global shift in demand which will drive and increase the demand for rare earths and in consequence underpin the growth strategy of Peak and the identified value drivers for the Ngualla Project (90% of Peak's future revenue).

Neodymium magnets are ten times more powerful and three times lighter than traditional ferric magnet alternatives. These magnets provide much better performance under a wider range of operating conditions, so allowing effective miniaturisation and production of compact, lightweight and powerful motors which represents the overall trend in the industrial manufacturing industry.

## Peak will produce and market the following four products:

- A high purity neodymium-praseodymium oxide (99%) product 2,420 tonnes per annum (tpa)
- A combined mid-heavy rare earth carbonate product 530 tpa equivalent to 280 tpa of contained REO
- A lanthanum rare earth carbonate product 6,940 tpa equivalent to 3,650 tpa of contained REO
- A cerium rare earth carbonate product 3,005 tpa equivalent to 1,660 tpa of contained REO

The Company is targeting a modest production level of total 8,010 tpa REO equivalent (less than 5% of world demand), which makes the marketing of production more achievable than many projects that need a high production profile in order to realise an adequate return on higher capital and operating costs.

Peak has held discussions with a large number of potential offtake customers and has received strong interest from several.

Potential customers include industrial conglomerates for the neodymium-praseodymium 'magnet metal' product, rare earth refiners for the mid + heavy product, and Fluid Catalytic Cracking (FCC) and auto catalyst manufacturers for the lanthanum and cerium products.

#### **OPINION**

This opinion piece represents Peak Resource's view on the dynamics of the market (pages 30-36).

#### 12.2 NGUALLA – LEADING DEPOSIT UNDERPINNED BY A STRONG MARKET DEMAND STORY

Over the past six years, it has been difficult for investors to get excited about the rare-earth sector. With commodity prices for rare earths enduring significant declines and hitting lows in late 2016, the sector has been viewed as a high-risk, low return investment proposition.

The good news is if a project can make it in the current market environment, it will have an exceptional future.

Looking at pricing on face value, it appears as if nothing positive has happened following the surge in pricing in late 2010 and early 2011. However, digging beneath the recent commodity price performance and focussing on actual market dynamics, there is much to be optimistic about. The reality is that the demand for rare-earths, particularly neodymium and praseodymium is set to grow exponentially due to the introduction of new disruptive technologies in the e-mobility sector (electrified transport) which is benefiting from increased support by global legislators.

#### The Evolution of Disruptive Technology

When a major new disruptive technology is introduced, there is often an associated scepticism among established players, who often loudly condemn the new technology as one that, for countless reasons, won't gain momentum. Their argument is often based on the notion that if there was such a thing as 'game changing technology' and there was a market for it, they would have already developed it. Their excuse often sounds a lot like –"Been, there, done that – and it doesn't work." A classic example of this in recent times was when 10 years ago, mobile phone powerhouses Nokia and RIM predicted that Apple would remain a niche supplier of mobile technology and that their iPhone would likely fail owing to the fact it had no keyboard and came with a fully embedded content ecosystem.

In addition the iPhone was, in their eyes also overpriced. Now, 10 years later, Apple dominates the smart phone industry having sold over 1 billion iPhone units and will in 2017, likely reach the incredible milestone of accumulating US\$ 1 trillion revenues from their mobile platform IOS. Quite a ride isn't it? Where are those former industry leaders? Well, most of them have been taken over by new players looking to get their hands on their comprehensive IP portfolios.

As human history shows through multiple examples, real innovation is always led by new players with tremendous dedication, a vision and hunger to succeed and a willingness to challenge the status quo. This is what drives them and what most big corporations are lacking because their shareholders demand predictability and low-risk business models. Uncertainty and failures are their natural enemies but inevitable when it comes to true innovation.

Now you might think we've gone off track here, right? Maybe, maybe not - who knows? While we may not have the magic crystal ball to see the future, we would like to help you, as Steve Jobs, CEO of Apple once said, 'connect the dots'

We believe the fundamentals are already in place and the question is not if it will happen, but when?

#### **E-Mobility**

We, along with many in the industry, believe that we are witnessing, right now, the type of disruption discussed above with e-mobility in one of the biggest global industry sectors - automotive industry. This disruption is being led by an important and well-known challenger and innovator, Tesla, a company that does not have to defend a legacy like the established car manufacturers and instead, realise they have more to gain than to lose.

It will be crucial for the success of E-mobility globally that Tesla ultimately succeeds given the potential for the massive disruption it will cause to secure and accelerate the transformation of the global automotive industry. Its success will ensure the availability of capital which otherwise would have never been accessible, opening the door for new players to enter the market, in turn forcing the established car manufacturers to join e-mobility. Some of them will need to fight for their survival even if they are not aware of it today.

Remember the Nokia's, Motorola's and RIM's? We think the same will occur with E-mobility, and that in 10-15 years' time the world will look very different. Here we follow the thoughts of Mr Kevin Kelly and like him believe that electric mobility in combination with autonomous driving implementation will represent a technical revolution similar to the industrial revolution in the 19th century. We believe that artificial intelligence (AI) of autonomous driving will kick off a new industrial chapter where AI is combined with electric power and this will be a fundamental technology disruption significantly impacting the way we live our lives.

Importantly, and significantly for Peak, all of these new self-sustainable robotic solutions in not only mobility, but manufacturing, agriculture, logistics, and domestic services will need to be powered by engine technologies which will most likely rely on NdPr based technologies.

#### **Connecting the Dots**

So, let's connect the dots by focusing on the electric mobility market, a key demand centre for Peak's raw materials. We have selected this industry sector deliberately because of its visibility in the media, its relevance to everybody's daily lives and the fact that it is an end-consumer application which has a huge accelerated and unpredictable growth potential.

Tesla, as the leader in the e-mobility trend, is today facing the classical problem of a true innovator. Burning cash, making little or no profit and fighting against an established and highly profitable industry. The traditional automotive industry follows a predictable paradigm which demands companies only innovate as much as they need to be able to differentiate themselves from the competition while at the same time maximising shareholder value. As a result, they stick to their

Figure 12.1



SOURCES: Exane BNP Paribas; UBS

written off technologies and milk the cow as long as possible with moderate investments while selling the appearance of being innovative.

When local or national governments, politicians and regulators push too hard to promote the types of true innovation we're talking about, the automotive industry use their network and lobby groups to spread the threat that if they are forced to invest too much they will no longer be able to stay competitive and this might lead directly to local job cuts.

So that is why it is so important that Tesla succeeds in accomplishing its goal to reduce the overall cost for this technology, in particular the battery cost, which currently represents up to a third of an electric vehicle cost.

Between 2020-2025 battery cost and performance will reach competitive equilibrium with combustion engines which initiates the S-curve for electric vehicles.

#### **Massive Emobility Market Growth**

Tesla's brave push into the market has been positive for the sector having initiated an avalanche of investments of more than USD 20 billion for new, incremental lithium battery capacity committed by companies like VW, Samsung, LG Chem, BYD, Boston-Power, Foxconn, Tesla - Panasonic, Daimler. With the mega factories being built and the technical challenges being addressed, consumers can look forward to a tremendous increase in the range of electronic vehicles available for sale within the next 3-5 years.

More than +200 new electrified models from Hyundai-Kia, GM, BMW Group , Honda, VW Group, Daimler, Nissan, BYD, Ford, Toyota and others are expected to hit the dealerships by 2025. The model landscape will reach a level of diversification which will ultimately enable this technology to enter the mainstream market. This is especially the case when you see electric vehicles being designed with an emotional appeal and less with an industrial design such as the Porsche Mission e, BMW I , BMW I NEXT or the Daimlers EQ series.

When these new vehicles hit the market in the price range of US\$ 30-35,000 (which represents the price range within the majority of vehicles are sold in the US today) and at the same time offer the performance of a super sports car accelerating from 0-100km per hour in less than 3 seconds, the consumer demand proposition is in our view, a "no brainer".



The prediction is the cost of ownership of an electric car will be BELOW that of a combustion engine car by 2022!

Further supporting this rapid transition to electric mobility, it is projected by Bloomberg that by 2022 the cost of ownership of an electric vehicle will be cheaper than a combustion engine. This will signal the point of no return. Once this milestone is achieved we predict within 10 years' time combustion engines will become a nostalgic artefact.

All lights are on green, there is hardly any analyst that does not show substantial growth for the e-mobility sector, just have a look at following reports: German Bank – Lithium 101 Report, Goldman Sachs - The Low Carbon Economy or Bloomberg - Here's How Electric Cars Will Cause the Next Oil Crisis they all project annual sales volumes between 7 to 16 million vehicles in 2025. Representing a global market share of 7 to 22% at that time. Bloomberg projects even for 2040 a market share of 35% with potential annual sales of 40 million vehicles.

It is projected that by 2025 electric vehicles will reach annual sales of between 7 to 16 million vehicles.



#### Figure 12.2: The rise of electric cars

SOURCE: Data compiled by Bloomberg New Energy Finance, Marklines

#### 12.3 WHAT DOES THIS MEAN FOR NEODYMIUM AND PRASEODYMIUM?

With all of this in place, we remain puzzled that the investment community and analysts are so euphoric and engaged with commodities such as Graphite, Lithium and Cobalt (the raw materials used in lithium-ion batteries) while showing no excitement for rare earths and in particular for neodymium (Nd) and praseodymium (Pr). NdPr are the core ingredients of high-efficiency electricmotors and generators which will power not only the electric vehicles, but of a range of other clean, green and high-tech applications.

Nd and Pr are critical elements in the construction of compact, light-weight and high-efficiency permanent magnets, which are already dominant in today's electric vehicle industry.

Behind each battery is a motor and 9 times out of 10 it is an NdPr permanent magnet motor in a vehicle.

With this in mind, it is also important to understand that based on today's knowledge for each electric vehicle which is built in place of a traditional internal combustion engine (ICE) powered vehicle, there is an incremental increase in demand of 0.5 to 1kg pure NdPr oxide, depending on the model and applied power train technology. Multiply this by the projections just mentioned above, and you can clearly see the potential for rapid demand growth for NdPr. And we didn't even touch upon electric bicycles, scooters, commercial vehicles, busses, trains etc.

If you want to get the energy from your lithium battery onto the road, 90% of the time it will be going via an NdPr magnet.

Each converted car from combustion engine to an electrified vehicle represents an additional demand of 0.5 to 1kg NdPr oxide.

e-mobility is only one of several applications which represents a huge increase of the future demand of NdPr. Visit our new website and you can learn more about the other applications like:

- Direct Wind Turbines
- HFC replacement technologies like magnetocaloric technologies
- Existing industrial robotic solutions
- Future autonomous robotic solution

*E-mobility is just one of several applications* which rely on NdPr as heart of their motors.

#### **12.4 OTHER SUPPORTIVE KEY DRIVERS**

As much as we are excited about the application side of the business we understand that three additional important drivers are important for the anticipated change:

- Global environmental related legislation;
- Macroeconomic; and
- China The leading global supplier of rare earths today

We have followed the latest developments in these areas carefully and we see that implemented legislation world-wide and the overall positive sentiment in society is supportive and accelerating the transition to NdPr technologies - just look what is happening in Germany, Norway, Netherlands, and India.

Up to 50% of this increase of NdPr demand is underpinned by already approved government legislations.

In the case of government policies; tougher controls on emissions and environmental standards, growing requirements to improve energy efficiency and the will for decarbonisation of energy production, transport - and industry will positively impact the global demand to apply NdPr technologies. We agree with the new report by Adamas Intelligence, that up to 50% of this increase of demand is underpinned by legislation which is already being implemented such as the Kigali-Agreement, COP21 Paris summit and Energy 2020 (Europe).

The overall macroeconomic trend and the projected facts for 2035-2040 imply that the world needs to find new answers for old questions. It is projected that global GDP, world population, global vehicle fleet and global electricity consumption (without realisation of efficiency improvements) will double over the next 20 years. This trend will be further amplified by the trend of urbanisation and increasing numbers of mega cities – with all the associated problems that come with them.

According to BP and ExxonMobil energy outlook 2017, the global demand for mobility and electricity will double during the next 20 to 25 years. the incremental energy demand of the next 20 years is equivalent to what South and North America are consuming together today.

In October 2016 the Ministry of Industry & Information Technology of the Chinese Government released its "Rare Earth Industry Development Plan (2016-2020)" which represents the implementation The supply demand situation will soon get out of balance and China being the single main source of supply will no longer be able to satisfy the increasing global demand.

plan for the Rare Earth Industrial Standard Regulation, published on July 1, 2016. The plan covers the complete spectrum of the Chinese rare earth industry including industrial consolidation, the environmental sustainability agenda, protection of national resources, a road map for further integration into the value chain and moving away from low-tech to high-tech applications. In a nutshell, China is aiming for further downstream integration of the global rare earth industry while at the same time reducing illegal mining and international exports and improving the environmental compliance of the industry. Their agenda includes:

- A projected annual growth rate of 15% in regards of the overall domestic rare earth consumption.
- A fixed target of reducing solvent extraction REO processing capacity from 300,000 t (2015) to 200,000 t (2020) and implementing controls to limit REO production to 140,000 tpa.
- A reduction of rare earth exports from 57% of 2015 output to 30% of 2020 output.
- An improvement in the profitability of rare earth enterprises from 5.8% (2015) to 12% (2020).
- A target to make 90 % of Chinese rare earth companies compliant with energy and environmental legislation (from a base of 30% today).
- The Government to support overseas investment or collaboration in the rare earth space .
- The government indicates further industry consolidation and no new mining rights issued except to the 6 state-owned rare earth groups.

In addition to the Chinese government's rare earth agenda, China has to face the reality that from an environmental standpoint, they cannot continue to exploit their natural resources in the way they have done over the last 20 years.

"In 2016, more than 90% of China's rare earths companies were not operating profitably and lost money."

While the sole aim until now has been to elevate the national average income and the overall prosperity of their citizens, China is now facing the real issues of environmental degradation. Current methods of mining some rare-earths domestically in China are highly damaging to the environment and unsustainable into the future.

China will undergo the same phenomenon as other developed countries in combating air pollution, similarly to how London has overcome the high levels of pollution that caused the Great Smog of 1952.

Figure 12.3: A tugboat on the Thames in 1952 near Tower Bridge in heavy smog.



China is in the process of moving two thirds of their population into the middle class over the next 15 years and by doing that China has to face a reality. As soon as bellies are full and basic needs are met, Chinese citizens will no longer accept the disastrous environmental situation and the way it is impacting their daily life and health today.

Figure 12.4: Lady walks through smog in Beijing, 2016



All these elements will cause an imbalance in the NdPr supply-demand situation. It is predicted that today's 2016 annual consumption of NdPr of approx. 30 - 40,000 t will double by 2025 (see market research data and publications from Professor Dudley Kingsnorth from IMCOA or ADAMAS).

It is our view and of the Chinese themselves that China will not have enough NdPr by 2025 for its own needs. Therefore we believe the outlook for NdPr demand from 2020 and beyond is outstanding.

#### 12.5 RARE EARTH DEMAND AND PRICING OUTLOOK

Owing to the increased use of high-power magnets in electrical motors and generators, particularly in electric cars and bikes, the demand outlook for NdPr is very positive, suggesting that current price levels, where the majority of producers are losing money should represent a cyclical low.

Furthermore, in February 2017, the largest Chinese producer of NdPr implemented a price increase of 6%.

To provide context on the pricing assumptions used in the BFS the following charts are included using data from the Asian Metals Index (an independent source of actual historic pricing data). As neodymium and praseodymium are expected to generate approximately 90% of the projects revenue we have focused on these metals.

Figure 12.5: Historic Rare Earth Price Trends



SOURCE: Asian Metal, Argus Metals

Figure 12.6: Increasing NdPr Price Trend in 2017



SOURCE: Asian Metal



#### 12.6 PRICE DECK FOR THE BANKABLE FEASIBILITY STUDY

Table 12.1: Price deck for the BFS

METRIC	UNITS	VALUE \$
Average LOM Product Price – NdPr Mixed Oxide $2N$ – min 75% $Nd_2O_3$	US \$/kg	85.00
Average LOM Product Price – Lanthanum rare earth oxide 2N equivalent	US \$/kg	4.41
Average LOM Product Price – Cerium rare earth oxide 2N equivalent	US \$/kg	2.25
Average LOM Product Price – SEG and Mixed heavy rare earth oxide equivalent	US \$/kg	8.00

In determining the rare earth pricing for the BFS, Peak reviewed a range of recent published rare earth price projections from several established independent experts and analysts including IMCOA, Adamus and Hallgarten. A pricing position was selected within the projected ranges of these experts.

#### **12.7 ADDITIONAL RARE EARTH MARKET INSIGHTS**

#### **Rare Earth Markets**

Rare earths have a variety of end uses and are not equal in terms of demand, production or price. They therefore cannot be considered as a single commodity. Table 12.2 summarises some of the main applications for individual rare earths.

USE	ELEMENTS USED
Magnets	Neodymium and praseodymium are key components in permanent magnets which have widespread and growing application in 'green' and renewable energy such as wind turbines, hybrid and electric vehicles and also personal audio and electronic equipment.
Phosphors	Europium, terbium and yttrium are important in new, low energy lighting (Flourescent and LED), TV's and computer displays.
Batteries	Lanthanum is a component of nickel metal hydride (NiMH) batteries used in electris and hybrid cars and cordless power tools.
Catalysts	Cerium and lanthanum are important in the manufacture of auto and petroleum industry catalysts for pollution control and refining of oil.
Polishing	Cerium-based polishing powders are preferred for high finish applications including flat panel displays, optics, electronics, smart phones and touch screen computers.
Alloys	Cerium-rich mischmetal, yttrium and neodymium strengthen steels and super-alloys for aerospace and military applications.
Glass	Cerium and other rare earths are used as additives to colour glass and screen UV light in optical and medical applications.

Table 12.2: Overview Rare earth applications



#### 12.8 RARE EARTH DEMAND/MARKET OUTLOOK

Since the early 2000's there has been a significant increase in demand for rare earths due to the many growth areas of application.

The estimated value of the global annual rare earth oxide consumption in 2016 was approximately US\$ 2 to 3 billion. The permanent magnets business represents approx. 80% of the total value of all rare earth applications and approximately 30% by volume.

Global forecast for neodymium and praseodymium demand is presented in Table 12.3.

		CATALYSTS	GLASS	POLISHING	METALLURGY	MAGNETS	PHOSPHORS	CERAMICS	OTHERS	TOTAL
		t REO	t REO	t REO	t REO	t REO	t REO	t REO	t REO	Total
2010	Pr	0	0	100	125	4,500	750	400	50	5,925
2010	Nd	250	0	300	500	21,500	200	800	275	23,825
2011	Pr	0	0	125	110	5,100	750	400	50	6,535
2011	Nd	200	0	250	450	23,400	200	800	275	25,575
2012	Pr	0	0	125	125	5,250	600	400	50	6,550
2012	Nd	200	0	250	500	24,750	150	800	225	28,875
2012	Pr	0	0	125	125	5,600	750	400	50	7,050
2013	Nd	250	0	250	350	27,875	150	800	225	29,900
2014	Pr	0	0	150	150	6,450	800	400	65	8,015
2014	Nd	200	0	250	400	30,700	125	800	250	32,725
20150	Pr	0	0	175	150	7,250	900	375	70	8,920
20156	Nd	275	0	275	375	35,250	125	700	250	37,250
20160	Pr	0	0	200	150	8,120	900	375	200	9,945
20106	Nd	275	0	300	350	38,250	125	700	465	40,465
		CATALYSTS	GLASS	POLISHING	METALLURGY	MAGNETS	PHOSPHORS	CERAMICS	OTHERS	TOTAL
		t REO	t REO	t REO	t REO	t REO	t REO	t REO	t REO	Total
2010-2016	Pr	-	-	12%	3%	10%	3%	-1%	26%	9%
CAGR	Nd	2%	-	0%	6%	10%	-8%	-2%	9%	9%
20170	Pr	0	0	225	150	9,000	900	490	200	10,965
20176	Nd	275	0	325	350	41,575	125	750	500	43,900
20200	Pr	0	0	250	225	12,725	900	475	125	14,700
20208	Nd	300	0	350	475	54,000	125	900	500	56,650
20250	Pr	0	0	300	300	15,925	1,175	600	175	18,475
20256	Nd	400	0	600	600	75,500	125	1,200	750	79,175
		CATALYSTS	GLASS	POLISHING	METALLURGY	MAGNETS	PHOSPHORS	CERAMICS	OTHERS	TOTAL
		t REO	t REO	t REO	t REO	t REO	t REO	t REO	t REO	Total
2017-2025	Pr	-	-	4%	9%	7%	3%	3%	-2%	7%
CAGR	Nd	5%	-	8%	7%	8%	0%	6%	5%	8%

Table 12.3: Global forecast for neodymium and praseodymium demand

Pr = Praseodymium Nd = Neodymium

SOURCE: IMCOA 2016 Data

#### **KEY FEATURES:**

- US\$ 356 million Capex including growth, contingency and owners costs.
- Includes rare earth refinery.

#### **13.1 BASIS OF CAPITAL COSTS**

The capital cost estimate is based on a mine and process facilities consuming 624,000 tonnes per annum of ore, producing 2,420 tonnes per annum of high purity neodymium and praseodymium rare earth oxide. Capital costs have been estimated to a 10% level of accuracy and are based on:

- Mining: Orelogy Group Ltd estimated the open pit mining equipment requirements based on the pit optimisation and mining schedule scenarios. We have assumed mining equipment will be leased.
- Process Plants: The entire end to end mineral process capital estimate is based on updated laboratory and pilot plant test work data incorporated by Amec Foster Wheeler into process and mass balance modelling using SysCAD software. Preliminary equipment lists were developed and sized consistent with the defined level of accuracy.
- **Recovery:** Recovery estimates were derived from the recently completed piloting program These estimates have been interpreted by CDMet Consulting Pty Ltd and Amec Foster Wheeler and incorporated into the overall process mass balance. The separation plant is based on the test-work and solvent extraction pilot plant operation completed at ANSTO and Nagrom.
- Infrastructure: Amec Foster Wheeler has developed the infrastructure designs and provided the capital costs for the construction of all mine facilities, accommodation village and site project services at both sites. Knight Piésold has provided estimates for the tailings facilities at Ngualla. Ngualla power supply has been included as a heavy fuel oil power package while Tees Valley will purchase power from local providers. The required upgrade to the 80km access road has been reviewed by COWI and estimated by Amec Foster Wheeler.

#### 13.2 CAPITAL COST ESTIMATE

The total estimated capital cost including directs, indirect and contingency cost is, as detailed in the following table, US\$356 million. This figure maintains Peak's position as the only potential rare earth miner and producer of separated rare earth products with a capital requirement of under US\$500 million.

**Ngualla Mine/Processing Capex** US\$ 52 million

**Ngualla Infrastructure Capex** *US\$ 134 million* 

**Total Ngualla Capex (including contingency)** US\$ 186 million

**Total Tees Valley Capex (including contingency)** US\$ 152 million

**Owners cost** US\$ 18 million

Total Ngualla and Tees Valley Capex (including owners costs) US\$ 356 million

#### 13.3 CAPITAL COST COMPONENTS CARRIED IN OPERATING COSTS

Build, own and operate (BOO) components are those areas of the operation where a third party will at their own expense supply and operate a particular part of the operation. In turn Peak will pay a usage fee for the service or goods that are supplied. The only components in the current estimate to have been costed as BOO are the Ngualla HFO and Solar Hybrid power supply.

The cost of the Capital for the Mining fleet and equipment has been carried as a lease cost and is included in the Mining operating cost.

## 13. CAPITAL COST SUMMARY

#### **13.4 GROWTH AND CONTINGENCY**

Contingency is defined as the amount added to a cost estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional cost.

For the Study the following engineering growth and contingency figures were used:

Ngualla: US\$ 28 million (15%) Tees Valley: US\$ 23 million (15%)

The contingency provision makes allowance for such factors as:

- Planning and estimating omissions
- Minor price fluctuations
- Design developments and changes within the scope
- Variations in market conditions
- Material and labour rate accuracy

#### **13.5 EXECUTION STRATEGY**

Where practical, the processing plant will be modularised, prefabricated off site and skid mounted to allow for fast, efficient construction and installation on site.

This technique will reduce the amount of skilled labour required on-site during construction as well as improve the quality control of the equipment to ensure a smooth ramp-up period. Peak plans to undertake a number of different contracting strategies for each section of the project to reduce project costs and better control project risks. In areas such as the access road, local Tanzanian contracting companies have been approached to undertake the construction on a design and build contracting basis directly for Peak. In areas requiring greater technical ability such as the separation and recovery plants, it is envisaged that an EPC or EPCM contracting strategy will be used.



### **KEY FEATURES:**

- Lowest separated oxide unit production cost of all comparable development projects.
- Operating cost of US\$ 34.20 kg NdPr 2N high purity separated oxide.
- Low cost reagents, energy and environmental costs, resulting in total annual Opex of US\$ 83 million.

Costs are LOM after start-up.





## 14. OPERATING COST SUMMARY

(continued)

#### 14.1 MINING COSTS

The operating costs for mining and haulage were developed by Orelogy Group Ltd. The mining costs include drilling, blasting, grade control, fuel, labour, load and haul.

#### **14.2 PERSONNEL**

Personnel requirements for management, operations and maintenance have been estimated by Orelogy, Amec Foster Wheeler and Peak. All personnel costs are fully loaded and inclusive, where applicable of all taxes and statutory charges, travel and site accommodation. A breakdown of employee numbers by area is shown in Table 14.1 below.

#### **14.4 REAGENTS**

Reagent consumption is based on pilot plant test-work results and the associated updated SysCAD mass balance model.

For Ngualla, reagents rates are based on quoted prices ex-China and South Africa, with some items including costs landed in Dar es Salaam. Shipping and transport costs by road of reagents to site are included in the total reagent cost.

For Tees Valley, reagent rates are based on quoted prices delivered to UK / Europe plus transport to site. The UK site has excellent access to ChlorAlkali and by-product Hydrochloric Acid (HCl). As shown in the Figure 14.2 HCl makes up the largest single portion of the total reagent costs.

AREA	NUMBER OF PERSONNEL (NGUALLA)	NUMBER OF PERSONNEL (TEES VALLEY)
Mining	50	-
Beneficiation	112	-
Recovery	-	45
Separation	-	46
Site Services	47	38
TOTAL EMPLOYEES	209	129

#### Table 14.1: Personnel numbers by area

#### **14.3 POWER**

Electrical power consumption has been calculated across the process plants by Amec Foster Wheeler from the preliminary mechanical equipment lists including estimates for infrastructure power requirements. Power rates per kWh are based on a hybrid solar and heavy fuel oil power plant BOO package similar to other Tanzanian operations.

For Tees Valley, energy pricing is based on purchasing power and piped natural gas.

## 14. OPERATING COST SUMMARY (continued)

Figure 14.2: Annual reagent cost breakdown



#### **14.5 CONSUMABLES**

Estimated costs associated with concentrate and product packaging, replacement of mill liners, grinding media, filter cloths, demineralised water, cooling tower and boiler chemicals, natural gas (Tees Valley) and over the fence services (Tees Valley) have been provided by Amec Foster Wheeler. An allowance for site safety and other general consumables has been made by Amec Foster Wheeler, included as part of salary on costs.

#### **14.6 MAINTENANCE**

Maintenance costs for each part of the process are factored from the direct capital cost of the equipment. Factors range depending on the location of the equipment and area process conditions and averaging approximately 3% per annum.

#### 14.7 GENERAL ADMINISTRATION

General administration costs have been detailed for each site.

#### **14.8 CONCENTRATE TRANSPORT**

Concentrate transport costs based on road haulage and shipping rates and have been obtained by Peak and Amec Foster Wheeler and include transport from Ngualla to Dar es Salaam port, port loading and port clearing fees, wharfage, sea freight to UK / Europe and destination port clearing fees plus road haulage to Tees Valley. The BFS has demonstrated a technically robust, de-risked project with strong financial metrics that is well aligned to market demand. The financial evaluation of project economics at the stated assumptions in the BFS and Ore Reserve estimate are summarised in Table 15.1 and include:

- A long life and profitable project with an annual free cash flow (post tax and royalties) of US \$104 million over 30 years.
- Attractive NPV<sub>10</sub> of US \$676 million pre-tax and royalties.
- Project IRR of 25% pre-tax and royalties.

The forecast cumulative US \$3.01 billion cash flow generated (post tax and royalties) by the consolidated project over the 30 year life (Figure 15.1 below) demonstrates the strategic nature of the project to the supply of key rare earths and the potential for a long life, cash flow generating business.



Figure 15.1: Annual operational cash flow (EBITDA) over the 30 year life of the project.

#### Compliance Statements

Production, costs and financial analysis are reported on a 100% owned basis (Peak hold 75%).

The production target and schedule on which the financial information is based is in turn based on the Ore Reserve estimate and stated Material Assumptions in ASX Announcement "Ngualla Rare Earth Project – Updated Ore Reserve" of 12 April 2017 and those stated within this BFS Executive Summary report.

Price deck assumptions on which the financial evaluation is based are derived from a review of a range of forecasts by respected independent industry analysts. A pricing position was selected for the BFS within the projected ranges of these experts.

The 100% Project funding requirement is estimated at approximately US \$391 million, comprising Capex of US \$356 million and a maximum working capital requirement of US \$35 million.

Peak will require new funding for its 75% share in the Ngualla Project to achieve the stated financial outcomes, which will result in some dilution of existing shares, the quantum of which will depend on the final debt to equity ratio of the project finance package, which has yet to be arranged.

## 15. PROJECT ECONOMICS (continued)

Table 15.1: Key Study Outcomes and Assumptions

PRODUCTION ASSUMPTIONS	
Life of Mine	30 Years
Average Life of Mine REO Grade	4.80%
Life of Mine Strip Ratio (Waste: Ore)	1.77
Average Mill Throughput	624,000 tpa
Average REO Mineral Concentrate Production	28,300 tpa
Average NdPr Mixed Oxide 2N Production	2,420 tpa
Average La Oxide Equivalent Production (final product: 6,940 tpa Carbonate)	3,650 tpa
Average Ce Oxide Equivalent Production (final product: 3,005 tpa Carbonate)	1,660 tpa
Average SEG and Mixed Heavy Oxide Equivalent Production (final product: 530 tpa Carbonate)	280 tpa
OPERATING COSTS	
Average Operating Cost to Mine Gate	US\$ 46m p.a
Average Tees Valley Refinery Operating Cost to Final Product	US\$ 37m p.a
Total Consolidated Operating Cost to Final Product	US\$ 83m p.a
Total Consolidated Operating Cost/kg (NdPr Mixed Oxide 2N#)	US\$ 34.20/kg
	i
CAPITAL COSTS including growth and contingency	
Ngualla (Mine and Process)	US\$ 52 million
Ngualla (Infrastructure)	US\$ 134 million
Tees Valley Refinery	US\$ 152 million
Owners Costs	US\$ 18 million
Total Capital Pre-Production	US\$ 356 million
Average Annual Consolidated Sustaining Capital	US\$ 5 million
	ń.
FINANCIAL METRICS	
Consolidated Total Revenue	US\$ 6.76 billion
Consolidated Average Annual Revenue	US\$ 228m p.a
Total Consolidated (Post Tax) Cash Generation	US\$ 3.01billion
Annual Average Consolidated (Post Tax) Cashflow	US\$ 104 m p.a
Average Annual EBITDA	US\$ 145 m p.a
NPV <sub>8</sub> - Pre Tax and Royalties	US\$ 930 million
NPV <sub>8</sub> - Post Tax and Royalties	US\$ 633 million
NPV10 - Pre Tax and Royalties	US\$ 676 million
NPV10 - Post Tax and Royalties	US\$ 445 million
IRR - Pre Tax and Royalties	25%
IRR - Post Tax and Royalties	21%
Operating Margin	64%
Payback Period (from Start of Operations)	5 Years
CUMIMUDITY PRICE ASSUMPTIONS average LOW	
Napr Mixea Oxide 2N Min 75% Nd2O3	USS 85.00/kg

NdPr Mixed Oxide 2N Min 75% Nd <sub>2</sub> O <sub>3</sub> US\$ 85.00/k	3
Lanthanum Rare Earth Oxide Equivalent US\$ 4.41/k	3
Cerium Rare Earth Oxide Equivalent US\$ 2.25/k	3
SEG Mixed Heavy Oxide Equivalent US\$ 8.00/k	3

For further detail on project metrics and assumptions please see the sections of this report and the Ore Reserve ASX Announcement "Ngualla Rare Earth Project – Updated Ore Reserve" of 12 April 2017. Annual average statistics are at steady state, post ramp up. \*2N=99% purity

## 15. PROJECT ECONOMICS

Compared to other rare earth projects, Ngualla has lower capital investment requirements and, thanks to a unique combination of favourable physical attributes and the improved processing route selected, enviably low operating costs that will make it cost competitive with Chinese production.

Ngualla's favourable project economics are in part driven by the high NdPr grade and advantageous mineralogy of the rare earth deposit itself, together with the development of an extraction and purification process that targets the higher value rare earths whilst rejecting the majority of the lower value cerium. The location of the refinery in proximity to sources of inexpensive bulk reagents and existing utilities is also a key driver of lower Opex.

With the alignment of products and value drivers to the high demand magnet metal market the project is in a favourable position in terms of marketing and future demand for its products which will represent less than 5% of total world demand.

#### **Project Sensitivity Analysis**

Based on the sensitivity analysis, the key drivers of the Projects economics are rare earth recovery, ore grade and price of the main revenue driver, NdPr.



Key project sensitivities to NPV (+/- 10%) are as follows:



The comprehensive piloting of the beneficiation leach recovery and separation processes using bulk samples of mineralisation from Ngualla has mitigated process recovery risk. The Ore Reserve is based on a high confidence and well defined Mineral Resource estimate, 89% of which is in the highest Measured JORC 2012 category, which similarly minimises the potential for variance. The Project NPV is not particularly sensitive to capital costs due to the high cash flows expected to be generated. The remaining driver to project economics is NdPr pricing, which is underpinned by the predicted demand increase in the magnet metals as discussed in the Marketing section of this report.

Figures 15.2 to 15.4 following illustrate three key Project financial metrics:

- Average annual Free Cash Flow (post ramp up)
- NPV<sub>10</sub> and
- IRR

against changes in the BFS NdPr price assumptions flexed by +/-30%. Recent actual prices for rare earths over the last six years since January 2011 from Asian Metal are shown in Figure 12.5 on page 37. The three sensitivity graphs following illustrate robust project economics in the face of 30% variances in the BFS NdPr pricing assumptions.



Figure 15.2: Ngualla Project average life of mine post ramp-up free cash flow (post tax and royalties) vs NdPr price.

## 15. PROJECT ECONOMICS (continued)

#### Figure 15.3: Pre Tax NPV<sub>10</sub> vs NdPr Price



Figure 15.4: Ngualla Project Pre Tax IRR vs NdPr price



## **16. OVERVIEW OF THE PEAK TEAM**

### SENIOR MANAGEMENT

Peak is fortunate to have an extremely well credentialed executive team supported by a quality Board of directors and senior advisers rarely found at a company of Peak's size.

During the completion of the BFS, Peak was able to add two key appointments to the executive team who possess significant operational and commercial rare earth experience, and have extensive industry networks. Peak was able to capitalise on this know-how during the engineering design and BFS process. The current team places Peak in an enviable position versus other aspiring rare earth development projects.

Further details of the members of the executive team.



#### DARREN TOWNSEND B.ENG (MINING-HONS), EMBA

#### Managing Director, Peak Resources Limited

- Extensive East African experience incl. development of tantalum mine in Mozambique and resource drill out and permitting a niobium project in Kenya.
- Mining Engineer with 25 years' mining and corporate experience.
- Extensive experience in managing and financing ASX and TSX listed companies.
- Commercial experience generating and consummating Company transforming multi jurisdictional deals.



#### DAVE HAMMOND M.SC, DIC, B.SC (HONS), MAUSIMM

Technical Director, Peak Resources Limited and COO Tanzania

- Extensive experience working and operating in Tanzania since 2010.
- Exploration Manager with 25+ years' technical and management leading teams in Africa and Australia.
- Formerly held senior roles with De Grey Mining Ltd and Sons of Gwalia. Previously with Billiton/Gencor in Africa.



#### **GRAEME SCOTT FCCA (UK)**

#### **CFO & Company Secretary**

- Has spent the last 12 years working in the resources sector in CFO and Company Secretarial roles for both ASX and TSX listed companies.
- Previous experience at senior managment level with multinational blue chip companies.
- More than 20 years' experience in professional and corporate roles in both Australia and the UK.



#### MICHAEL PRASSAS GM Sales, Marketing &

Business Development

- Former Global Account Manager Automotive Catalysis /Sales Manager of Rare Earth Systems for Solvay, responsible for sales of Rare Earth Mixed Oxides in Europe and Africa.
- Over 15 years' experience in sales and business development.
- Management skills include budget responsibility, project management, building stakeholder relationships and competing priorities in deadline-driven environments.



#### ROCKY SMITH B.SC (CHEM)

#### **COO Project Development**

- Previously Managing Director of Molycorp's Mountain Pass Rare Earth Complex from 2009 to 2015.
- Achievements include the delivery of successful expansions resulting in a 230% increase in production capacity over a three year period as well as managing of operation budget in excess of US\$150 million.
- Chemist with over 35 years' operations and senior management experience in the mineral processing and chemical engineering sectors.

## **16. OVERVIEW OF THE PEAK TEAM**

(continued)

#### DIRECTORS



#### PETER HAROLD B.APPSC (CHEM), AFAICD

Non-Executive Chairman, Peak Resources Limited

- Currently Managing Director of Panoramic Resources. Previous senior roles with Spectrum Rare Earths, Shell Australia, Australian Consolidated Minerals Limited and Normandy Mining Limited.
- Chemist with almost 30 years' operational and corporate experience in the minerals industry specialising in financing, marketing and business development.



#### JOHN JETTER B.LAW, B.ECON, INSEAD

#### Non-Executive Director, Peak Resources Limited

- Experience in negotiating and executing rare earth off-take agreements.
- Extensive international finance and M&A experience.
- Former Managing Director, CEO and head of investment banking of JP Morgan in Germany and Austria, and a member of the European Advisory Council of JP Morgan in London.



#### PAUL RUPIA MPA, BOA (POLITICS)

#### Special Advisor to Peak Resources Limited

- Has served in the Government of Tanzania at senior levels as Chief Secretary in the President's Office, Secretary to the Cabinet, Head of Civil Service, Principal Secretary in the Ministry of Foreign Affairs, Permanent Representative of Tanzania to the United Nations, Ambassador to Ethiopia and Deputy High Commissioner in the United Kingdom.
- Currently Chairman of DCB Commercial Bank Plc since 2002.



#### JONATHAN MURRAY B.LAWS AND COMMERCE Non-Executive Director.

Peak Resources Limited

- Partner at independent corporate law firm Steinepreis Paganin, Bachelor of Law and Commerce (majoring in accounting).
- Specialising in equity capital raisings, acquisitions and divestments, governance and corporate compliance.



#### KIBUTA ONGWAMUHANA B.LAW, M.LAW, PHD

#### Non-Exective Director, PR NG Minerals Limited

- Leading Tanzanian legal practitioner who specialises in taxation and corporate law.
- Managing partner of the legal firm, Ako Law in Dar es Salaam and an Advocate of the High Court and Court of Appeal as well as legal consultant to a number of government, non-government and private business organisations.

In addition the Project is also able to call upon the extensive experience and expertise within the teams of Peak's strategic partners in the Project; Appian and IFC (refer Section 18 Strategic Partners for further details).

#### **17.1 RARE EARTH PROJECT EXPANSION**

The large size of the Weathered Bastnaesite Zone Mineral Resource and the long life of the operation offer opportunities for the expansion of production once markets for Ngualla's products are established. With the Weathered Bastnaesite Zone comprising just 22% of the Total rare earth Mineral Resources at Ngualla, there may be the opportunity to extend the operation's life past the current 30 years indicated by the Study, or to increase production through the development of processes to treat some of the remaining mineralisation styles. Additional rare earth mineralisation has also been identified by wide spaced drilling in the Northern Zone and very recently by reconnaissance trench sampling (see fluorite section below) in February 2017 within the hills surrounding the carbonatite, that has yet to be evaluated further (Figure 17.1).

#### **17.2 THE BARITE OPPORTUNITY**

Barite presents a future potential additional opportunity for incremental revenue streams from the Ngualla project. Depending on the successful outcome of a sustainable barite business case including a technical route to produce the required customer specifications the Company may consider entering the business of selling a chemical or a drilling grade barite.



Figure 17.1: Significant grades and widths of niobium, fluorite and phosphate have been identified by drilling and trenching and is as yet only sparsely tested. Barite forms 38% of the host rock for the Weathered Bastnaesite Zone rare earth Mineral Resource and also may have potential as a by-product from rare earth processing.

## **17. KEY OPPORTUNITIES** (continued)

#### What is Barite?

Barite (barium sulphate, BaSO<sub>4</sub>) is an industrial mineral with a high density used predominantly (an estimated 80%) as a weighting agent in fluids used in the drilling of oil and natural gas wells. Barite is preferred as it is non-abrasive, insoluble and non-toxic.

#### What are the applications? Drilling Grade

Drilling fluid performs three primary functions: to pressurise the oil well; to cool the temperature of the drill bit; and to suspend the cuttings produced by the drill, which are then carried up to the surface. Barite also is used in the medical, construction, paints and plastics and automotive industries.

The American Petroleum Industry (API) sets the specifications for standard drilling grade barite in terms of specific gravity, barite purity, particle size and maximum allowable impurity levels. The US Environment Protection Agency also sets standards for drilling grade barite. Together these standards typically define required product specifications for drilling grade barite and include a minimum 90% barite content at 4.2mg/cm<sup>3</sup> with a maximum allowable residue greater than 75µm of 3%, a maximum of 30% of particles being below 6µm. Levels of mercury and cadmium must be low at 1ppm and 3ppm respectively and there are limits on the allowable levels of water soluble metals such as calcium.

#### **OTHER APPLICATIONS**

Non petroleum industry applications include as a filler, extender, or weighting agent in products such as paints, plastics, and rubber. Some specific applications include use in automobile brake and clutch pads, automobile paint primer for metal protection and gloss, use as a weighting agent in rubber, and in the cement jacket around underwater petroleum pipelines. In the metalcasting industry, barite is part of the mould-release compounds. Because barite significantly blocks x-ray and gamma-ray emissions, it is used as aggregate in highdensity concrete for radiation shielding around x-ray units in hospitals, nuclear power plants, and university nuclear research facilities. Ultrapure barite consumed as liquid is used as a contrast medium in medical x-ray examinations.

#### What about the market and pricing history?

Industrial Minerals (IM) quotes barite pricing on their website and this pricing is sometimes used as a guide within the industry. However, the pricing is not transparent and the sources for this 'bid and offer' pricing are not disclosed. Typical prices for 4.2 grade API barite drilling powder were around US \$115 to US \$135 per tonne in 2016, depending on the FOB port. Other applications of higher purity barite with specific whiteness grades used in the paint industry have a higher value at US \$ 200 to US \$250 per tonne. Prices are currently at a five year low as a results of reduced demand from the oil industry, demand levels being closely related to oil and gas drill rig activity. A more positive outlook is forecast for the next few years with a predicted upsurge in drilling activity driving demand back up to previous levels. (Source: US Geological Survey, British Geological Survey and industry sources).

#### 17.3 POTENTIAL FOR ADDITIONAL COMMODITIES FROM NGUALLA

In addition to rare earths, the Ngualla Carbonatite is host to several other additional mineral occurrences, which may have the potential to provide diversification to Ngualla's rare earth products with further work in the future. Carbonatite geological complexes are well known for their multi-commodity potential, the leading example being the large Palabora mine in South Africa, which produces or has produced a range of commodities including copper, sulphuric acid, magnetite, vermiculite, nickel sulphate, apatite, cobalt, zirconium as well as by-product gold, silver and platinum.

Barite (barium sulphate, BaSO<sub>4</sub>) may have future potential as a by-product of rare earth production at Ngualla. There is 8 million tonnes of contained barite within the Weathered Bastnaesite Zone at Ngualla at an average grade of 38% barite, which is upgraded to a 90% barite stream during the rare earth processing (see Mineral Resource section of this report).

#### Encouraging grades of near surface niobium, phosphate

and rare earth mineralisation were intersected over an area of more than 1km x 1km by wide spaced reconnaissance drilling to the north of the Bastnaesite Zone in 2012 (Figure 17.1) with no further follow-up completed as yet (ASX Announcement "Final drill results – Ngualla Rare Earth Project" dated 15 February 2012). The better intersections for each commodity returned from this Northern Zone include:

DRILL HOLE	INTERSECTION
NRC140	18m at 1.16% $Nb_2O_5$ from 18m and
	22m at 1.32% $Nb_2O_5$ from 50m and
	66m at 1.56% REO from 10m
NRC154	58m at 21.1% P₂O₅ from 4m

The recent discovery (ASX Announcement "Wide Zones of high grade fluorite identified at Ngualla" dated 20 February 2017) of wide high grade zones of fluorite mineralisation in the relatively unexplored hills surrounding the carbonatite is a high priority for further evaluation and may present the potential for production of fluorspar from Ngualla if additional work continues to be successful. The better fluorite and rare earth intervals from these trenches were:

TRENCH	INTERVAL
NCS011	78m at 37% fluorite from 0m to end of trench
NCS012	53m at 2.37% REO from 61m to end of trench

#### 17.4 INCREASED RECOVERY AND GRADE OF FLOTATION PROCESS

The flotation process in any rare earth process is a usual area for improvement and the Ngualla Project is no exception. Every deposit has its unique aspects and the best operators are diligent to unlock these aspects and optimize the process to drive for best overall economics. The opportunities include better understanding of the mix of mineralisation within the deposit and the ability to adapt the specific treatment opportunities, including pH, temperature and reagent dosage and types. A pilot sized unit will be installed to facilitate the testing of specific ore types and upcoming ore blends in front of the production unit. Close cooperation between geologists and metallurgists is critical to developing an understanding of the effects of the different mineralisation inherent in the Ngualla deposit.

Continuous on-line sampling and analysis of the flotation process will give continuous feedback on the performance of the process. This will be key to identifying short interval control options to optimise process performance. Other technology being reviewed includes bubble imaging, using high definition cameras to evaluate instantaneous flotation conditions in critical points in the flotation process.

Process optimisation starts on day one and the current list of opportunities includes; better flotation performance (Ore type, grade and recovery), optimised control on cerium recovery via calciner/leach operation (including lower energy and reagent consumption), improved waste management and water consumption.

Additionally, we continue to reach out to rare earth flotation experts around the globe in an effort to ensure we keep an open door to even further opportunities.

#### **About Appian**

Appian Natural Resources Fund is a private equity fund which has been established to invest specifically in the metals and mining sector. Appian has a uniquely collaborative investment approach that seeks to partner with local owners, managers and investors to leverage its world-class operational and corporate finance expertise.

Appian was established by ex-Anglo American, Rio Tinto, JPMorgan and Bain Capital individuals, collectively holding over 200 years of industry experience and a deep understanding of mine development and investment. This experienced team is complementary to Peak having built and managed 60+ operating mines (30 in Africa) and acted on ~US \$200 billion of mining corporate development transactions.

A collaborative cornerstone investor with a value-add approach and long-term investment horizon, Appian is focussed on achieving technical milestones and long term value creation for the investors and other stakeholders of both the Company and Appian.

For more information, visit: appiancapitaladvisory.com

#### **About IFC**

IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector. Working with private enterprises in about 100 countries, IFC use their capital, expertise and influence to help eliminate extreme poverty and boost shared prosperity. In FY14, IFC provided more than US \$22 billion in financing to improve lives in developing countries and tackle the most urgent challenges of development.

IFC has wide experience over 50+ years in international mining finance and demands best practice social and environmental standards. To date IFC have invested over US \$400 million in Tanzania.

For more information, visit: ifc.org



Figure 18.1: Investment Structure.



## **19. COMPETENT PERSONS' STATEMENTS**

The information in this report that relates to exploration results is based on information compiled and/ or reviewed by David Hammond, who is a Member of the Australasian Institute of Mining and Metallurgy. David Hammond is the Technical Director of the Company. He has sufficient experience which is relevant to the style of mineralisation and type of deposit under consideration and the activity which he is undertaking to qualify as a Competent Person in terms of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (the JORC Cade, 2012 edition). David Hammond consents to the inclusion in the report of the matters based on his information in the form and contest in which it appears.

The information in this report that relates to the Mineral Resource estimates is based on work conducted by Rod Brown of SRK Consulting (Australasia) Pty Ltd, and the work conducted by Peak Resources, which SRK has reviewed. Rod Brown takes responsibility for the Mineral Resource estimate. Rod Brown is a Member of the Australasian Institute of Mining and Metallurgy and has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration, and to the activities undertaken, to qualify as competent Person in terms of the Australasian Code for the Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code, 2012 edition). Rod Brown consents to the inclusion of such information in this report in the form and context in which it appears.

The information in this report that relates to Ore Reserve estimates was based on information compiled by Ryan Locke, a Principal Consultant with Orelogy Consulting Pty Ltd, Orelogy are an independent consultant to Peak Resources. Ryan Locke, who is a Member of the Australasian Institute of Mining and Metallurgy, has sufficient experience that is relevant to the style of mineralization and type of deposit under consideration and to the activity being undertaken to qualify as a competent Person as defined in the 2012 edition of the 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'. Ryan Locke consents to the inclusion in the report of the matters based on his information in the form and context in which it appears.

The information in this report that relates to metallurgical test work results is based on information compiled and / or reviewed by Gavin Beer who is a Member of the Australasian Institute of Mining and Metallurgy and a chartered Professional. Gavin Beer is a Metallurgical Consultant and has sufficient experience relevant to the activity which he is undertaking to be recognised as competent to compile and report such information. Gavin Beer consents to the inclusion in the report of the matters based on his information in the form and context in which it appears.

The information in this report that relates to infrastructure, project execution and cost estimating is based on information compiled and / or reviewed by Lucas Stanfield who is a Member of the Australasian Institute of Mining and Metallurgy. Lucas Stanfield is the General Manager - Development for Peak Resources Limited and is a Mining Engineer with sufficient experience relevant to the activity which he is undertaking to be recognised as competent to compile and report such information. Lucas Stanfield consents to the inclusion in the report of the matters based on his information in the form and context in which it appears.



## APPENDIX

Rare earth oxides		REO Grade (%)				% of Total REO			
		Measured	Indicated	Inferred	All	Measured	Indicated	Inferred	All
Lanthanum	$La_2O_3$	1.309	1.345	1.200	1.310	27.57	27.72	27.09	27.58
Cerium	CeO <sub>2</sub>	2.292	2.339	2.128	2.293	48.28	48.18	48.04	48.27
Praseodymium	$Pr_6O_{11}$	0.227	0.231	0.213	0.227	4.77	4.75	4.82	4.77
Neodymium	$Nd_2O_3$	0.783	0.799	0.763	0.784	16.48	16.45	17.23	16.50
Samarium	$Sm_2O_3$	0.076	0.078	0.071	0.076	1.60	1.61	1.60	1.60
Europium	Eu <sub>2</sub> O <sub>3</sub>	0.014	0.014	0.013	0.014	0.30	0.29	0.29	0.29
Gadolinium	$Gd_2O_3$	0.029	0.030	0.027	0.029	0.62	0.61	0.61	0.61
Terbium	Tb <sub>4</sub> O <sub>7</sub>	0.002	0.002	0.002	0.002	0.05	0.05	0.05	0.05
Dysprosium	$Dy_2O_3$	0.004	0.004	0.003	0.004	0.07	0.07	0.07	0.07
Holmium	$Ho_2O_3$	0.000	0.000	0.000	0.000	0.01	0.01	0.01	0.01
Erbium	$Er_2O_3$	0.002	0.002	0.002	0.002	0.03	0.04	0.04	0.03
Thulium	$Tm_2O_3$	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Ytterbium	Yb <sub>2</sub> O <sub>3</sub>	0.001	0.001	0.000	0.001	0.01	0.01	0.01	0.01
Lutetium	$Lu_2O_3$	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Yttrium	$Y_2O_3$	0.010	0.010	0.007	0.010	0.20	0.20	0.16	0.20
Total REO*	REO	4.75	4.85	4.43	4.75	100.00	100.00	100.00	100.00

Table 1: Weathered Bastnaesite Zone Resource +1% REO. Individual rare earth oxide grades and percentages of total REO.

Table 2: Ngualla 2016 total Mineral resource + 1% REO. Individual rare earth oxide grades and percentages of total REO.

Rare earth oxides		REO Grade (%)				% of Total REO			
		Measured	Indicated	Inferred	All	Measured	Indicated	Inferred	All
Lanthanum	$La_2O_3$	0.704	0.501	0.560	0.587	26.99	27.73	26.08	27.25
Cerium	CeO <sub>2</sub>	1.262	0.871	1.022	1.039	48.38	48.17	47.61	48.23
Praseodymium	$Pr_6O_{11}$	0.125	0.087	0.105	0.104	4.81	4.80	4.90	4.81
Neodymium	$Nd_2O_3$	0.429	0.285	0.360	0.348	16.44	15.75	16.75	16.16
Samarium	Sm₂O₃	0.043	0.030	0.040	0.036	1.66	1.64	1.88	1.66
Europium	$Eu_2O_3$	0.009	0.006	0.009	0.007	0.33	0.34	0.43	0.34
Gadolinium	$Gd_2O_3$	0.019	0.014	0.021	0.016	0.71	0.76	0.99	0.75
Terbium	Tb <sub>4</sub> O <sub>7</sub>	0.002	0.001	0.002	0.001	0.06	0.07	0.09	0.07
Dysprosium	Dy <sub>2</sub> O <sub>3</sub>	0.003	0.003	0.006	0.003	0.13	0.16	0.27	0.16
Holmium	$Ho_2O_3$	0.000	0.000	0.001	0.000	0.02	0.02	0.03	0.02
Erbium	$Er_2O_3$	0.001	0.001	0.002	0.001	0.05	0.06	0.09	0.06
Thulium	$Tm_2O_3$	0.000	0.000	0.000	0.000	0.00	0.00	0.01	0.00
Ytterbium	Yb <sub>2</sub> O <sub>3</sub>	0.001	0.000	0.001	0.001	0.02	0.02	0.04	0.04
Lutetium	$Lu_2O_3$	0.000	0.000	0.000	0.000	0.00	0.00	0.00	0.00
Yttrium	$Y_2O_3$	0.011	0.009	0.018	0.010	0.40	0.48	0.82	0.47
Total REO	REO	2.61	1.81	2.15	2.15	100.00	100.00	100.00	100.00



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