PITT STREET RESEARCH

Greenland Minerals Limited

A rare opportunity in Rare Earths

Share Price: A$0.082

ASX: GGG

Sector: Materials

20 September 2018

Sitting on the world's largest undeveloped deposit

Greenland Minerals (ASX:GGG) is a Perth-based resources company focused on the Kvanefjeld Rare Earths Project in Greenland. Demand for Rare Earths is strong given its use in various 21st Century products, most notably electric cars and wind turbines, and Greenland Minerals controls 100% of the world's largest undeveloped Rare Earths deposit. With the help of Shenghe Resources, a major Chinese Rare Earths player, we expect that Greenland Minerals can move towards an updated Feasibility Study for the project in the next year or so, with the mine potentially starting up in 2021.

Investment case

The Kvanefjeld Project has considerable advantages as a Rare Earths source, most notably its favorable metallurgy and wide spread of critical Rare Earths. A steady increase in Rare Earth and U3O8 prices, further progress on the Kvanefjeld flowsheet, and completion of permitting in Greenland can help drive favourable sentiment and re-rate the stock into our valuation range, and, potentially, beyond.

Valuation range of A$ 0.18 – 0.43 per share

We value Greenland Minerals at 18 cents per share base case and 43 cents per share optimistic case using a DCF approach with conservative assumptions on Rare Earths. Our valuation is highly sensitive to changes in the prices of critical Rare Earths such as Neodymium. Should prices return to the levels assumed in 2015, Kvanefjeld will be a very valuable Rare Earths mine indeed.

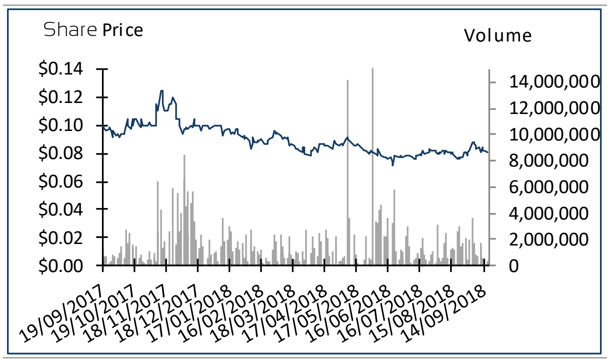
Year to June (AUD)	2017A	2018f	2019f	2020f	2021f
Sales (mn)	0.0	0.0	0.0	0.0	566.4
EBITDA (mn)	-1.3	-3.2	-2.2	-1.1	192.1
Net Profit (mn)	-1.3	-3.2	-2.2	-1.1	59.5
EBIT Margin (%)	NM	NM	NM	NM	26.4%
ROCE (%)	-10.6%	-15.1%	-2.0%	-0.1%	13.1%
Net Gearing (%)	-19.8%	-15.1%	-82.9%	446.2%	566.1%
EPS before extr. & amort.	(0.38)	(0.69)	(0.08)	(0.04)	2.20
EPS	(0.38)	(0.69)	(0.08)	(0.04)	2.20
DPS	NM	NM	NM	NM	NM
EV/Sales	NM	NM	NM	NM	NM
EV/EBITDA	(68.0)	(26.3)	(38.4)	(75.9)	0.4
P/E	(22.2)	(12.2)	(102.4)	(202.6)	3.8

Source: Company, Pitt Street Research

Market Cap. (A$ m)	91.1
# shares outstanding (m)	1,111.0
# share fully diluted	1,303
Market Cap Ful. Dil. (A$ m)	109
Free Float	100%
12 months high/low	$0.07 / $0.13
1 / 3 / 12-month performance	0% / 5.2% / -19%
Website	www.ggg.gl

Source: Company, Pitt Street Research

Share price (A$) and avg. daily volume (k, r.h.s.)



Source: FactSet, Pitt Street Research

Valuation metrics	
DCF fair valuation range (A$)	0.18 – 0.43
WACC	10%
Assumed terminal growth rate	None

Source: Pitt Street Research

Analyst: Stuart Roberts

Tel: +61 (0)447 247 909

Stuart.roberts@pittstreetresearch.com

Greenland Minerals Limited

Profit & Loss (A$m)	2017A	2018f	2019f	2020f	2021f	2022f	2023f	2024f	2025f
Sales Revenue	0.0	0.0	0.0	0.0	590.1	604.9	620.0	635.5	651.4
Other Income	0.1	0.1	0.1	2.9	18.1	6.6	3.6	1.0	(1.3)
Operating Costs	0.0	0.0	0.0	0.0	388.9	413.3	423.6	434.2	445.1
Exploration Exp.	0.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Corporate/Admin	1.3	1.3	1.3	3.0	3.0	3.0	3.0	3.0	3.0
EBITDA	**(1.3)**	**(3.2)**	**(2.2)**	**(1.1)**	**215.3**	**194.2**	**196.0**	**198.3**	**201.0**
Depn & Amort	0.0	0.0	0.0	0.0	42.4	42.4	42.4	42.4	42.4
EBIT	**(1.3)**	**(3.2)**	**(2.2)**	**(1.1)**	**172.9**	**151.8**	**153.6**	**155.9**	**158.7**
Net Interest	0.1	0.1	0.1	2.9	(72.1)	(70.7)	(60.8)	(50.5)	(39.9)
Operating Profit	**(1.3)**	**(3.2)**	**(2.2)**	**(1.1)**	**82.8**	**74.5**	**89.2**	**104.4**	**120.0**
Tax expense	0.0	0.0	0.0	0.0	0.0	22.4	26.8	31.3	36.0
Abnormals + Minorities	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NPAT	**(1.3)**	**(3.2)**	**(2.2)**	**(1.1)**	**82.8**	**52.2**	**62.5**	**73.1**	**84.0**

Cash Flow (A$m)	2017A	2018f	2019f	2020f	2021f	2022f	2023f	2024f	2025f
Total Revenue	0.1	0.1	0.1	2.9	608.2	611.5	623.6	636.5	650.1
Oper,Corp,Other Expenses	1.1	1.3	1.3	3.0	391.9	416.3	426.6	437.2	448.1
Feasibility & Exploration	5.8	10.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Tax Expense	(0.5)	0.0	0.0	0.0	0.0	22.4	26.8	31.3	36.0
Interest Expense	(0.1)	0.0	0.0	0.0	90.1	77.3	64.4	51.5	38.6
Operating Cashflow	**(6.3)**	**(11.2)**	**(3.2)**	**(2.1)**	**124.2**	**93.6**	**103.9**	**114.5**	**125.4**
Capex (-asset sales)	(0.5)	0.0	0.0	566.7	566.7	25.0	25.0	25.0	50.0
Investements, Loans	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Investing Cashflow	**0.4**	**0.0**	**0.0**	**(566.7)**	**(566.7)**	**(25.0)**	**(25.0)**	**(25.0)**	**(50.0)**
- Dividends (ords & pref)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
+ Equity raised	7.6	12.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0
+ Debt drawdown (repaid)	0.0	0.0	0.0	1043.3	83.5	(161.0)	(161.0)	(161.0)	(161.0)
Net Change in Cash	**1.7**	**0.8**	**86.8**	**474.5**	**(359.0)**	**(92.4)**	**(82.1)**	**(71.5)**	**(85.6)**
Cash at End Period	**2.4**	**3.1**	**89.9**	**564.4**	**205.4**	**113.0**	**30.9**	**(40.7)**	**(126.2)**
Net Cash/(Debt)	**2.4**	**3.1**	**89.9**	**(478.9)**	**(921.4)**	**(852.9)**	**(774.0)**	**(684.5)**	**(609.1)**

Balance Sheet (A$m)	2017A	2018f	2019f	2020f	2021f	2022f	2023f	2024f	2025f
Cash	2.4	3.1	89.9	564.4	205.4	113.0	30.9	-40.7	-126.2
Total Assets	13.3	21.7	109.5	1152.3	1439.6	1331.5	1235.4	1150.1	1075.9
Total Debt	0.0	0.0	0.0	1043.3	1126.8	965.8	804.9	643.9	482.9
Total Liabilities	1.4	1.1	1.1	1045.0	1249.5	1089.2	930.6	772.2	614.0
Shareholders Funds	11.9	20.7	108.4	107.3	190.1	242.3	304.8	377.8	461.9

Ratios									
Net Debt/Equity (%)	-19.8%	-15.1%	-82.9%	446.2%	484.7%	352.0%	254.0%	181.2%	131.9%
Interest Cover (x)	-18.8	-43.1	-22.3	-0.4	3.0	2.7	3.2	3.9	5.0
Return on Equity (%)	-11.1%	-15.7%	-2.0%	-1.0%	43.5%	21.5%	20.5%	19.3%	18.2%

Table of Contents

Introducing Greenland Minerals

Greenland Minerals is a Perth-based resources company focused on the Kvanefjeld Rare Earths Project. This project, located in southern Greenland, has been worked on by Greenland Minerals since 2007 and has been 100%-owned by the company since 2012. Over the last 11 years Kvanefjeld has emerged as one of the largest undeveloped Rare Earth Oxide resources in the world, with a current JORC 2012 resource of 1.01 billion tonnes grading 1.1% REO. The project also has substantial uranium (593 million pounds) and zinc resources.

What are Rare Earths and why are they important to the global economy in the 21st Century?

Rare Earths critical for high-end electronics, turbines and defence equipment

The Rare Earth Elements are 17 members of the periodic table[1] that are often found in the same ores and deposits. They are sometimes nicknamed the 'vitamins of industry' because of their use in smart electronic products, wind turbines and sophisticated defense equipment. The rise of the electric car as a 21st Century transport option will depend in part on the availability of Rare Earths. A significant factor in the market for Rare Earths today is China, which accounts for around 85% of the world's mine production and has substantial and sophisticated downstream production capability. China's dominance of Rare Earths gives the country potential leverage over price in the event that few new deposits are developed outside of China in the years ahead.

What is Kvanefjeld's current state of development?

Involvement of Shenghe was a major step forward

Kvanefjeld has gone through an initial Feasibility Study that was published in May 2015 and updated in April 2016. These studies envisage a mine life of 37 years with a primary product of 'critical' Rare Earth Oxide, 'critical' meaning that these particular Rare Earths are expected to be in short supply in the future. An improved cost profile for Kvanefjeld in 2016 suggested average free cash flow of US$376m p.a, up 14% on the 2015 estimates. In this update, expected capital costs came down markedly, from US$1.36bn to US$832m. Greenland Minerals is continuing to work hard on costs. A key step forward, from late 2016, has been the involvement of a major Chinese Rare Earths company called Shenghe Resources, which now owns 11% of Greenland Minerals. Shenghe Resources has brought considerable technical expertise into the project as a collaborator as well as a shareholder.

What comes next for Greenland Minerals?

The company expects to work on a Feasibility update once the flowsheet has been optimized and the relevant permits have been granted by the Greenland government. After this, Greenland Minerals and its collaborators will move to Bankable Feasibility Study. In this note we envisage a start-up of production at Kvanefjeld around 2021.

If Greenland Minerals is so good, why is it currently capitalized at only A$91m?

We think that the main reason for the apparent undervaluation of Greenland Minerals is concerns that environmental and related permitting issues have some years to progress. We look for a re-rating once permitting has completed and the company can work on an update to its Feasibility Study.

[1] Lanthanum, Cerium, Praseodymium, Neodymium, Promethium, Samarium, Europium, Gadolinium, Terbium, Dysprosium, Holmium, Erbium, Thulium, Ytterbium, Lutetium, Scandium and Yttrium.

Ten reasons to look at Greenland Minerals

1. The Kvanefjeld Rare Earths Project is massive, with a JORC resource of 1.01 billion tonnes containing 11.1 million tonnes of Rare Earths Oxides, 593 million pounds of uranium and 2.25 million tonnes of zinc. Various drilling campaigns since 2007 have contributed to progressive resource increases and there is strong potential for further extensions.

2. The prospect for Rare Earth demand is strong, with their use in permanent magnets and rechargeable batteries, among other ‘21st Century’ products, likely to increase into the foreseeable future as the world increasingly turns to clean, green technologies.

3. The long-term pricing environment for Rare Earths is favorable, due to constrained supply out of China, the world’s major producer, which has moved to shut down mines that have environmental issues and is now capping production and lowering exports.

4. Kvanefjeld has potential to be a low-cost, long life producer, with Greenland Minerals having shown this in a 2012 Pre-Feasibility Study and a 2015 Feasibility Study as well as in the 2016 operation of a pilot plant. Greenland Minerals currently anticipates a mine life for Kvanefjeld of 37 years, based on a 108 Mt ore reserve.

5. Kvanefjeld may become a particularly attractive source for a ‘critical’ number of Rare Earth elements, notably Neodymium, Praseodymium, Terbium and Dysprosium, since it appears to be the only major orebody in the world that is non-refractory and therefore amenable to yielding a wide spread of Rare Earths.

6. The Kvanefjeld Project has had a long development timeline with Greenland Minerals having been involved since 2007. This history has allowed a deep foundation of technical understanding to be established, along with strong in-country relationships. Greenland Minerals has also developed strong knowledge as to how the rare earth sector operates.

7. Shenghe Resources is driving growth in shareholder value, with this Chinese Rare Earths company having contributed to proposed changes in the Kvanefjeld flowsheet in 2018 that are expected to markedly lower capital costs from those suggested in 2015 and 2016.

8. The regulatory environment in Greenland is broadly favorable, with the Greenland government having shown a generally ‘pro-mining’ attitude in recent years and having permitted uranium exploration to proceed. We believe this bodes well for the granting of a Mining License related to Kvanefjeld.

9. Greenland Minerals has solid management. Dr. John Mair has been involved with Kvanefjeld since 2008. Since his 2014 appointment as Managing Director he has overseen the corporate evolution of Greenland Minerals as a Rare Earths play aligned closely with Shenghe. Backing Mair is a well-qualified board chaired by the experienced company director Tony Ho.

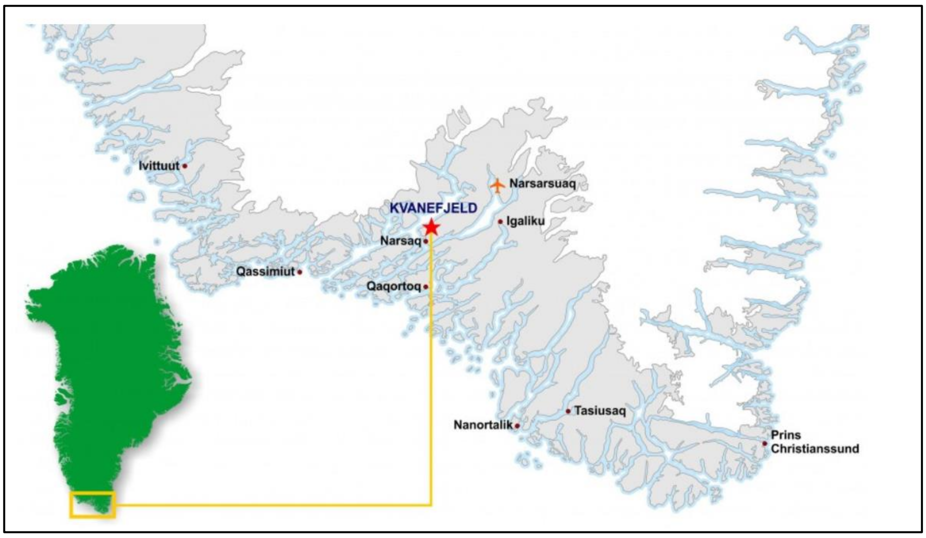
10. Greenland Minerals is undervalued on our numbers. We value the company at 18 cents per share base case and 43 cents per share optimistic case using a DCF-based approach with conservative estimates on long-run Rare Earths pricing and capital costs.

Kvanefjeld has all the qualities of a great Rare Earths project

Greenland Minerals has been working on Kvanefjeld for the last 11 years, and in that time has built up a large knowledge base on the project. We see a number of major advantages for Greenland Minerals with Kvanefjeld:

A favorable location. Kvanefjeld is in Greenland's southernmost municipality, Kujalleq, around 8 km from the coastal town of Narsaq (Figure 1). The capital of Greenland, Nuuk, is 460 km north of Narsaq. The climate in the Narsaq district is mild by Greenlandic standards, ranging between minus two degrees and 10 degrees Celsius over the year.

Figure 1: Kvanefjeld's location in Greenland



Source: Company

Transport to the project area is straightforward. Narsarsuaq Airport, one of two airports in Greenland capable of serving large airliners, is only 35 km away[2]. More importantly, the deep-water fjords in the Narsaq area provide direct year-round shipping access, vital for the development of a project like Kvanefjeld.

Favorable geology. Kvanefjeld, which has been explored since the late 1950s, is hosted in the northern part of an intrusive alkaline complex known as 'Ilimaussaq', famous in geological circles for a syenite called 'lujavrite'. This rock type has long been known to be favorable for uranium and Rare Earths, with much of these value elements sitting within an unusual phosphor-silicate mineral called steenstrupine. The steenstrupine at Kvanefjeld, in the upper sections of the lujavrite, is around 25% Rare Earth Oxide and is enriched across all the key Rare Earths. Importantly, steenstrupine is non-refractory, unlike most REO-bearing minerals, and readily liberates Rare Earths without complex mineral cracking processes. The deposits that Greenland Minerals controls at Kvanefjeld feature thick sub-horizontal mineralized lenses where the highest grades are in the upper part of the lens, making for a low waste-to-ore ratio.

The steenstrupine at Kvanefjeld is non-refractory, unlike most REO-bearing minerals

A favorable jurisdiction. Greenland, population 56,000, is a possession of Denmark that has had substantial self-government since 2009[3]. In recent years the country has elected 'pro-mining' governments, including that of the current Prime Minister, Kim Kielsen, who took office in late 2014. One of the

[2] Air Greenland has regular flights between Kangerlussuaq, Greenland's main transport hub, and Copenhagen, with a flight time of between 4 and 5 hours. Kangerlussuaq is around two hours flight north from Narsarsuaq.
[3] After a 2008 referendum Greenland became an 'autonomous administrative division' of Denmark.

factors that had previously inhibited development of Kvanefjeld is a 1988 ban by the Danish government on uranium mining. The ban as it pertained to Greenland was repealed by the Greenland Parliament in October 2013, with the country becoming an IAEA signatory in September 2016.

A large resource base. As at February 2015 the Kvanefjeld Project had a JORC 2012 resource inventory of 1.01 billion tonnes containing 593 million pounds of uranium, 11.14 million tonnes total Rare Earth Oxides and 2.25 million tonnes of zinc. This makes Kvanefjeld one of the largest undeveloped Rare Earths projects in the world.

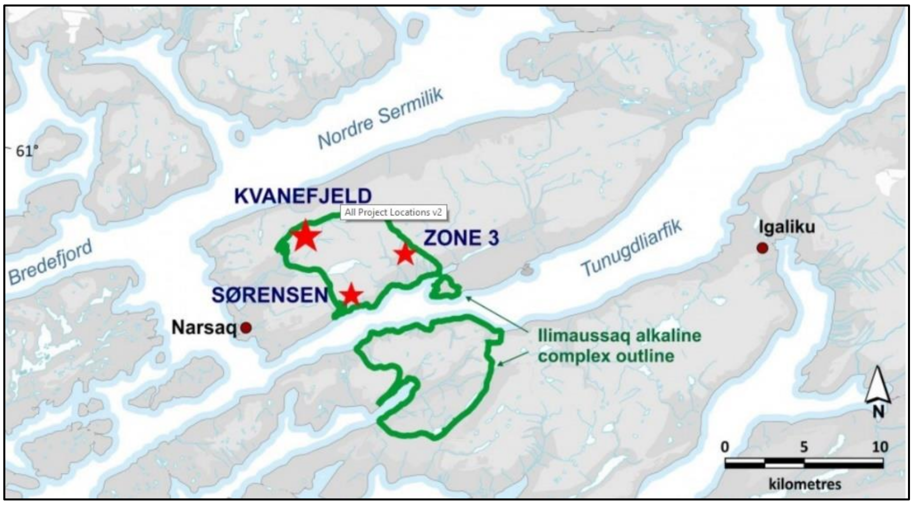
A favorable spread of Rare Earths. Not every Rare Earths deposit around the world is the same in terms of the distribution of minerals. Some have only a few of the 17 elements in meaningful amounts. For example, the Nolans Project of Arafura Resources in Australia's Northern Territory is mostly just Neodymium and Praseodymium. Kvanefjeld has these two elements as well as Europium, Terbium and Dysprosium in meaningful quantities. This has allowed Greenland Minerals in its Feasibility work to focus on 'critical' Rare Earths expected to be in short supply in the years ahead

Favorable project economics. The proposed stripping ratio for Kvanefjeld is only one to one in the early years, at 1.4% REO and 400 ppm uranium, while the non-refractory metallurgy allows for simple and inexpensive processing. Both factors suggest a low cost of production for the project. In addition, there are numerous by-products to be enjoyed, beginning with U3O8 but also including zinc and fluorspar. This has led in the past to the suggestion that it may have the world's lowest production costs. Obviously, time will tell as to the long-run veracity of this latter claim, particularly given the recently depressed price of U3O8.

Kvanefjeld has a large resource base

The latest resource and reserve estimate for Kvanefjeld was made in 2015. The Kvanefjeld Project consists of three deposits within the 80 sq. km exploration lease area – the main Kvanefjeld deposit, and the more recently explored Sørensen and Zone 3 deposits (Figure 2).

Figure 2: Kvanefjeld, Sørensen and Zone 3



Source: Company

There is room for further significant increases in resources and reserves.

Following fresh assays on historic core samples from the Kvanefjeld deposit that allowed an increase in the density of geochemical data, Greenland Minerals announced a JORC 2012 resource of 1.01 billion tonnes at 1.1% REO. An initial reserve estimate was established in June 2015. Significantly, this

108-million-tonne reserve comes solely from the upper part of the Kvanefjeld deposit alone (Figure 3).

Figure 3: Kvanefjeld JORC 2012 resource

RESOURCE	MT ore	REO ppm	U3O8 ppm	ZN ppm
Measured	143	12,100	303	2,370
Indicated	308	11,100	253	2,290
Inferred	559	10,700	264	2,463
Total	1,010	11,000	266	2,397
RESERVES	**MT ore**	**REO ppm**	**U3O8 ppm**	**ZN ppm**
Proven	43	14,700	352	2,700
Probable	64	14,000	368	2,500
Total	108	14,300	362	2,600

Source: Company

There is room for further significant increases in resources and reserves. Various drilling campaigns since 2007 have contributed to progressive resource increases, however Greenland Minerals has only evaluated about 20% of the total project area over the last 11 years[4]. At the time of the 1.01-billion-tonne ore resource estimate, Greenland Minerals noted that there were numerous drill intercepts outside the three resource 'shells', highlighting the potential for future resource upgrades. The fact that all three deposits are mineralogically very similar suggests massive upside as future drill campaigns step outside the shells and begin to connect them up.

China dominates Rare Earths production

China is the 'Saudi Arabia' of Rare Earths. In 1992 China's leader, Deng Xiaoping, famously commented that 'Rare Earths will do for China what oil did for Saudi Arabia'. China's decision in the 1980s to develop its Rare Earth mining and processing capacity means that today it controls around 85%-95% of the global supply of Rare Earths, with 70% of the world's light Rare Earths coming from a single mining operation – the Bayan Obo deposit in Inner Mongolia. Currently, the only major Rare Earth producer outside of China is the Australian company Lynas Corp, which since 2011 has operated the Mt. Weld mine, 35 km south of Laverton in the far Northern Goldfields of Western Australia. It is worth noting that, as a result of extensive R&D into Rare Earths processing over many years, China is generally regarded as years ahead of any other country in the know-how associated with Rare Earths refining and separation. This is, arguably, more of a competitive advantage than control of the largest Rare Earth orebodies.

Chinese policy to result in tightening Rare Earths prices over time

China is strengthening its control over domestically produced Rare Earths. In October 2016 China's Ministry of Industry and Information Technology released its five-year plan for the Rare Earths industry. Under this plan the country will effectively cap production at 140,000 tonnes p.a. and, to accommodate expected double-digit domestic demand growth, will decrease the percentage permitted for export from close to 60% in 2015 down to just 30% in 2020. With the plan also affirming the country's intention to prevent illegal mining activity, as well as to strictly enforce environmental regulations, the likely impact of the plan, if followed through, will be a tightening of prices over time.

[4] See the company's March 2015 presentation to the PDAC (the Prospectors & Developers Association of Canada) meeting, slide 3.

Shenghe knows a lot about Rare Earths

Shenghe Resources is the world's second largest Rare Earths company. An integrated producer that sits within the orbit of Chinalco[5], Shenghe has its main operations located at Leshan in Sichuan Province and at Ganzhou in Jiangxi Province. Shenghe is a large company, publicly traded in Shanghai[6] with a current market capitalization of US$2.3bn[7]. It is also a global player, having led, in mid-2017, the consortium which acquired the Mountain Pass Rare Earths Mine in California[8] for US$20.5m after its previous owner, Molycorp, went bankrupt in 2015. Shenghe's relationship with the Institute of Multipurpose Utilization of Mineral Resources of the Chinese Academic of Geological Sciences (IMUMR) ensures that its technical expertise in Rare Earths is top notch. And as a key instrument in China's Rare Earths ambitions, Shenghe has a strong incentive to work with other companies around the world to source new mines that can integrate into China's downstream processing sector. For all these reasons we think the Shenghe/Greenland Minerals strategic relationship is a positive development for the Australian company.

The Shenghe relationship brings very substantial expertise to the project

Shenghe's relationship with Greenland Minerals is a relatively recent development. Shenghe and Greenland Minerals announced a strategic relationship in late 2016 where the two companies would work together to develop the potential of Kvanefjeld. To cement the relationship, the Chinese company took a 12.5% equity stake in Greenland Minerals worth A$4.625m (at 3.7 cents per share). This stake, which required Foreign Investment Review Board approval in Australia[9], came with a board seat currently held by Xiaolei Guo. The stake has since diluted slightly but remains 11%.

Shenghe searched the earth for new Rare Earths deposits and picked Greenland Minerals' Kvanefjeld. As a basis for developing an international growth strategy, Shenghe has investigated a substantial number of known Rare Earth projects outside China, including projects located in Australia, Canada and Africa[10]. It is notable that, aside from their involvement in the consortium that is restarting Mountain Pass, Greenland Minerals is the only company Shenghe has invested in and commenced a strategic working relationship. This is certainly a strong validation of the quality of the Kvanefjeld project.

Since 2016, Shenghe has been involved in Kvanefjeld in two main ways. Firstly, it has helped optimize Kvanefjeld's flowsheet, with a lot of work done by its own staff as well as collaborators at IMUMR on both the concentrator and the refinery of the Project. Secondly, it has also done work on commercial terms for future Kvanefjeld product. Greenland Minerals announced in August 2018 that it had signed a non-binding Memorandum of Understanding with Shenghe on offtake from Kvanefjeld in the order of 32,000-34,000 tonnes p.a., the former in chemical concentrate, the latter in mineral concentrate. The two parties envisage an agreement to become binding once the Kvanefjeld flowsheet is optimized.

Shenghe connects Greenland Minerals with downstream processing capacity. One of the most critical aspects of Shenghe's involvement is it provides a path to market through access to Rare Earths separation technology and capacity. No other emerging project really has a comparable

[5] Chinalco, the Aluminum Corporation of China, is a state-owned enterprise which the government used to restructure the Rare Earths industry in the years leading up to 2016.
[6] Shanghai Stock Exchange code 600392.
[7] 18 September 2018 close in Shanghai at 9.06 yuan per share.
[8] This mine is located in San Bernardino county near the California-Nevada border. Mountain Pass is one of the biggest rare earth mines outside of China.
[9] Granted in November 2016.
[10] We understand Shenghe looked at over 50 projects outside China as a basis for international growth before selecting Kvanefjeld.

relationship with a large- scale refiner. Since end-products such as magnets cannot be made from mixed rare earth concentrate, having such a partner is vital for would-be producers such as Greenland Minerals. Through Shenghe's involvement, the company can now look to create complete value chains through to high-purity metals and oxides. Importantly, Shenghe and Greenland have outlined a strategy to develop refining capacity outside China. This could be important from a political perspective given the current uncertain relationship between the US and China where Rare Earths could become yet another source of tension between the two countries.

Feasibility work at Kvanefjeld has been promising

The initial Feasibility Study painted a healthy future for Greenland Minerals. This Study, announced in May 2015, suggested an NPV for the Kvanefjeld of US$1.4bn, using a discount rate of 8%. The IRR in this analysis was 21.8%. However, by April 2016 Greenland Minerals was able to recalibrate that study with lower selling prices for some metals and a higher discount rate of 10% but with a significantly higher NPV of A$1.59bn and an IRR >40%. We describe the 2015 Feasibility Study in Appendix I of this note.

Kvanefjeld has a big advantage in being a 'complete' Rare Earths project. Unlike many of the products being worked on by development-stage companies such as Alkane Resources, Arafura Resources and Hastings Technology Metals, Kvanefjeld has a fuller range of Rare Earths beyond Neodymium and Praseodymium.

By April 2016, Kvanefjeld's estimated NPV was up 13%. There were various cost savings across the Project between 2015 and 2016, but two key changes to the model are noteworthy (Figure 4):

- **Capital costs were reduced.** The original capital cost of the project as per 2015 was a high US$1.36bn. In 2016 the capital budget was reduced to US$832m. Part of this involved a reduction in civil works, with Greenland Minerals having found that the concentrator and refinery for Kvanefjeld could be consolidated in one place, saving US$115m. However, a substantial part of the reduction had to do with items which the company decided to outsource to third-party providers.

Figure 4: 2015 vs 2016 costs and revenues from Feasibility Study

	2015	2016	Change
REVENUE (USDm)			
Uranium	73.2	51.0	-30.3%
cREO	584.7	611.8	4.6%
Lanthanum/Cerium	82.7	33.6	-59.4%
Other	14.5	14.5	0.0%
Total	755.1	710.9	-5.9%
	2015	**2016**	**Change**
COSTS (USDm)			
Project	237.4	252.1	6.2%
Separation	190.4	82.8	-56.5%
Total	427.8	334.9	-21.7%
MARGIN (USDm)	329.6	376.0	14.1%

Source: Company

- **Extraction rates were improved.** In September 2015 Greenland Minerals had announced that the first refinery pilot plant operation had achieved 95% Rare Earth extractions out of concentrate sourced from the beneficiation pilot plant operation several months earlier. The Feasibility

Study work had been done on only 77%. This work suggested that atmospheric leaching with sulphuric acid was a viable refining method. Greenland Minerals now used a 90% extraction rate.

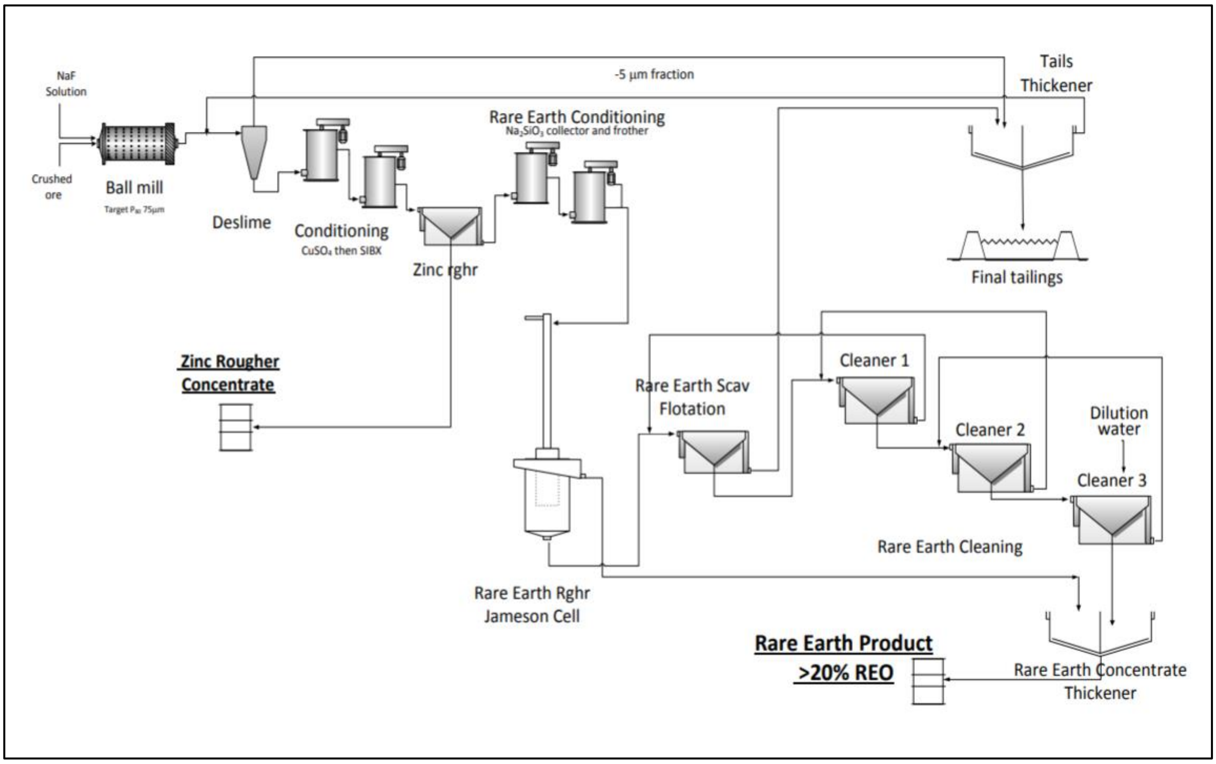
- **Revenue numbers came down, but costs came down more.** As we note in the Figure above, the average revenue of the Project was 6% lower, but, thanks to higher extraction rates, costs came down 22%.

Shenghe has driven further value increases since late 2016

The Shenghe relationship has been driving further prospective increases in value at Kvanefjeld since late 2016. We noted above that Shenghe and IMUMR have done a lot of work on both the concentrator and the refinery of the Project. This has resulted in two major steps forward in the last eight months, notably;

- **The concentrator.** In December 2017 Greenland Minerals announced that Shenghe's work had markedly increased the estimated grade of the Rare Earth Phosphate mineral concentrate. Specifically, work by Shenghe and its IMUMR collaborators had established that, with different flotation reagents, the grade of the Rare Earths Phosphates rose to 23%, from the original 14% in Kvanefjeld's May 2015 Feasibility Study. This was particularly important from a capital cost perspective important because it opened up the possibility, now being investigated, that concentrate could be directly shipped to downstream customers, saving the capital cost on the refinery. In the 2015 Feasibility Study this refinery was budgeted at US$371m.

Figure 5: Enhanced flotation process flowsheet



Source: Company

Greenland Minerals announced in April 2018 that a second collaboration, this time with a private firm called Baotou Meng Rong, had achieved similar concentrate grade results with a different method to that used by IMUMR. The best method out of these two will be selected by Greenland Minerals and Shenghe for further pilot plant work.

- **The refinery.** In January 2018 Greenland Minerals announced that the Shenghe collaborators had developed a new acid leach circuit for the refinery that used hydrochloric acid for direct concentrate leaching rather than sulphuric acid for direct leaching and hydrochloric acid for secondary leaching as per the 2015 Feasibility Study. This suggested lower capital costs would be required for any refinery that would be built at Kvanefjeld.

Now working towards a Feasibility update

We see four things happening over the next twelve months that can drive Kvanefjeld forward:

- **Continued technical optimization**, as Shenghe and its collaborators work towards the flowsheet (Figure 5) that will optimally harness the unique metallurgical advantages of Kvanefjeld.
- **Completion of permitting.** Greenland Minerals first submitted its Mining License Application for Kvanefjeld at the end of 2015, but over two years later this has not been granted. As far as we can tell this does not reflect any deficiencies in the Kvanefjeld project so much as the paperwork required. As part of the MLA the company has been obliged to conduct Environmental and Social Impact Assessments for Kvanefjeld, as well as a Maritime Safety Study (to ensure that ship voyages to and from Narsaq are safe and do not impact the environment). The Maritime Safety Study was lodged with the Greenland government in October 2017 while the Environmental and Social Impact Assessments were lodged in mid-2018. The next step is a public consultation, with responses to queries collated in a White Paper, prior to granting of permits.
- **Completion of a Feasibility update**, based on all that has been learned by Shenghe and Greenland Minerals since late 2016 as well as onsite engineering studies to optimize construction and civil design.
- **Initial project financing discussions**, based on the improved project economics from a more optimal flowsheet, as well as, potentially, better product pricing than was the case two or three years ago.

The prices of Rare Earths have been in recovery since late 2016

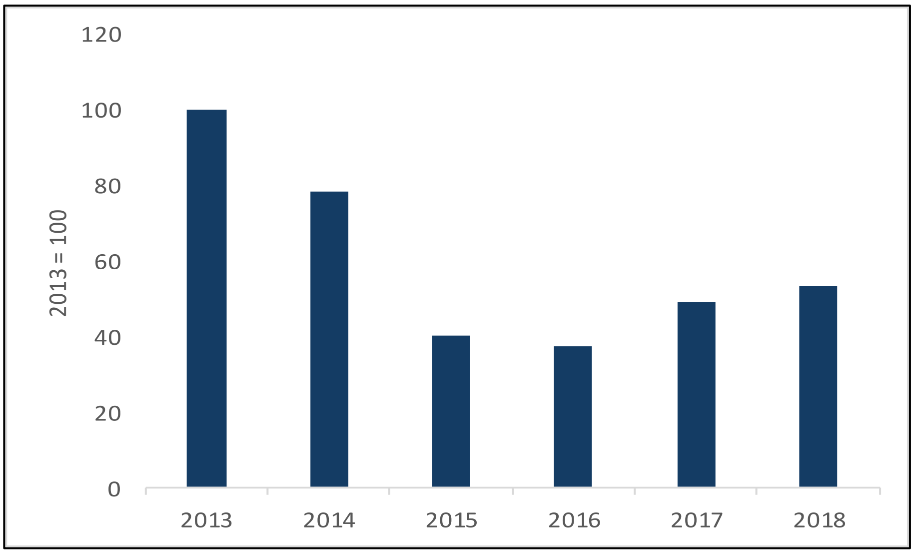
Rare Earths have been known to spike in price

The Rare Earths market was badly impacted by the price spikes of May 2011, when high demand from a variety of users coincided with China's move to choke back supply via an unofficial trade embargo with Japan[11], lowered export quotas and higher export taxes[12].

After 2011 Rare Earths prices steadily declined for the next few years (Figure 6). Basically, the strategy of major Rare Earths users in the face of longtime Chinese supply dominance has been twofold[13] – firstly, stockpile materials as a contingency against sudden shortages, and secondly, look for alternative materials[14]. It's fair to say that this strategy has been the right one, since it quickly erased the 2011 spike. Not only did demand moderate but some new supply came on the market from outside China – Mt. Weld in Western Australia was commissioned about this time, and Dong Pao in northern Vietnam two years later. The resulting correction took five years to play out.

[11] This was because of an incident near the disputed Senkaku Islands, in which a Chinese fishing vessel captain was detained by the Japan Coast Guard – see *Japan-China relations strained over Rare Earths find* by Sriparna Pathak, Asia Times, 18 April 2018.
[12] See *Supplies squeezed, Rare Earth prices surge* by Keith Bradsher, the New York Times, 2 May 2011.
[13] See *What happened to the Rare-Earths crisis?* by Kristin Majcher, MIT Technology Review, 25 February 2015.
[14] See, for example, Pavel et. al., *Substitution strategies for reducing the use of rare earths in wind turbines*, Resources Policy, Volume 52, June 2017, Pages 349-357.

Figure 6: Our estimate of average Rare Earths prices since 2013



Source: Pitt Street Research, mineralprices.com, kitco.com, minerals.usgs.gov

Rare Earths are now recovering, thanks largely to the recent Chinese five-year plan. Most prices bottomed in late 2016 and a general price recovery across the Rare Earths spectrum had become apparent by mid-2017[15]. We argue that Rare Earths prices will generally move north from here, with or without 2011-style spikes:

We expect Rare Earths prices to increase from here

- On the supply side, despite Lynas' success in starting up Mt. Weld, one can make the case that China has more control over the Rare Earths industry than it did in 2011, when it was only beginning to clean up environmentally-unfriendly operations – consider the Shenghe investment in Mountain Pass[16], and the fact that Lynas' output only constitutes around 18,000 tonnes in a global supply pool of around 134,000 tonnes[17]. Outside China, there is the potential for the new Malaysian government, elected in May 2018, to temporarily disrupt the market by regulatory action against Lynas' refinery at Kuantan, where the government may have concerns about environmental issues[18].
- On the demand side, the outlook for Rare Earths in many products, most notably electric cars, is much stronger than it was at that time of the 2011 spike[19].

Greenland Minerals to benefit from turnaround in uranium price

Increase in the number of nuclear reactors globally to drive the price of U308 upwards

Uranium has been a poor performer in recent years. When Greenland Minerals announced its Feasibility Study results in May 2015, U308 averaged ~US$35 a pound. That was well down from the US$136/lb of June 2007 and the US$65/lb of February 2011 but at the time Greenland Minerals expected stronger long-term prices. So far it has been disappointed - U308 was below US$20/lb by mid-2017.

The spot U3O8 price has gradually recovered in 2018, thanks largely to supply curtailments. As at 3 September it had reached US$26.50/lb, up from $23.75 on 25 December 2017. Driving the recovery has been cutbacks from

[15] See Greenland Minerals' market release dated 4 July 2017 and headlined '*Rare Earth market prices rise, sector outlook improves, Kvanefjeld Project well positioned'*.
[16] Admittedly only 9.9%, but the Chinese company does have technical service agreements, as well as marketing agreements.
[17] Source: Statista, *Forecasted demand rare earth demand globally in 2018, by application (in metric tons)*.
[18] See *Pakatan to review Lynas rare earth operations* by Ong Han Sean, The Star, 13 May 2018
[19] Especially with Tesla now in the market with its Model 3 as of mid-2017.

major producers such as Cameco, which announced the shuttering of its MacArthur River mine in Canada, the largest uranium mine in the world, in late 2017. Similar moves were made by the French company Orano and the Kazakh state-owned company KazAtomprom, as well as Australia's Paladin Energy, which placed the Langer Heinrich mine in Namibia on care and maintenance in May 2018.

The long run outlook for U3O8 is strong. Around 11% of the world's electricity is generated by about 450 nuclear power reactors but around 60 more reactors are under construction and 150-160 are planned. This increase in reactor numbers, against a background of rising electricity demand, and the need to replace old fossil fuel units, especially coal-fired ones, is likely to drive sustained demand for U3O8 in the medium to long term.

The project economics of Kvanefjeld will be enhanced by a sustained upturn in uranium. In the 2016 Feasibility update Greenland Minerals reduced its revenue assumptions for uranium to US$51, from US$73m, however part of that reduction involved refinery recoveries coming down from 90% to 86%[20]. From the perspective of 2018, this suggests long-run optimism on the part of Greenland Minerals' consultants as far as uranium is concerned.

[20] The May 2015 Feasibility Study suggested that the incremental cost of recovering U3O8 from the high-grade concentrate could be less than US$6/lb, making Kvanefjeld a very low-cost uranium producer able to operate in but the most depressed market environments.

Key addressable markets for Greenland Minerals

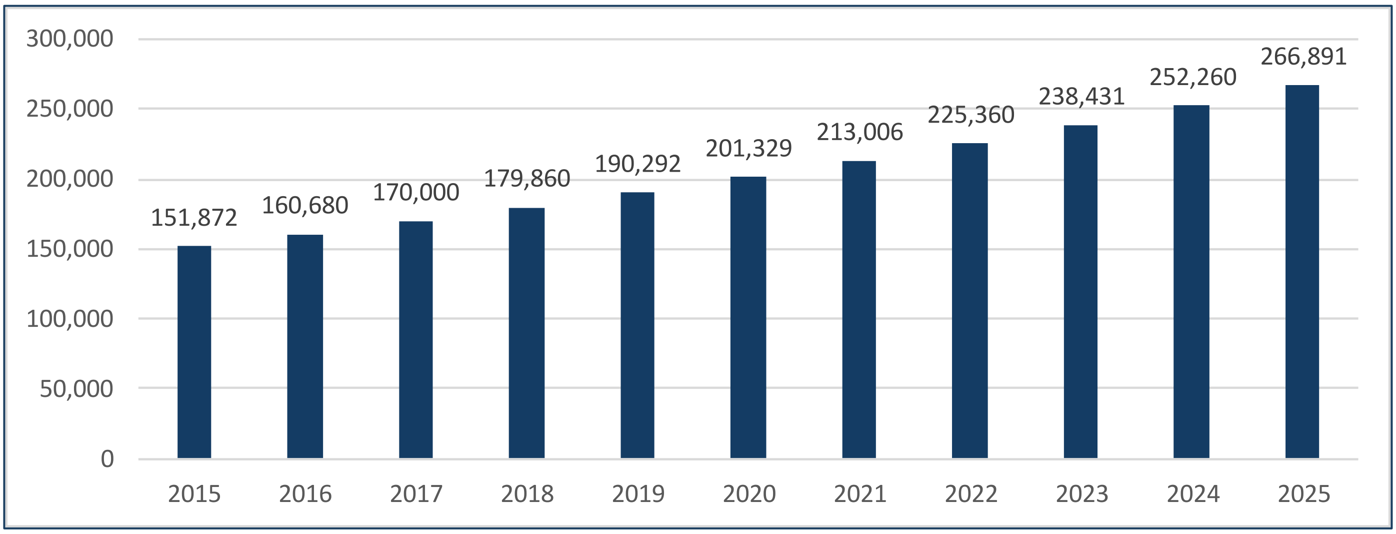
Rare Earths are a group of 17 elements, comprising the 15 lanthanides and the elements Scandium (Sc) and Yttrium (Y). The 15 lanthanides are further classified into light (atomic number 57 to 64) and heavy (atomic number 65 to 71) Rare Earth Elements. Cerium, Praseodymium, Neodymium, and Europium are the majorly known light Rare Earth elements while Dysprosium and Terbium are more popular in the heavy Rare Earths category.

Rare Earths consumption growing by nearly 6% p.a. to nearly 267k tpa in 2025

Industrial Mineral Company of Australia (IMCOA) estimates that the Rare Earths market was worth US$3-4BN in 2017 with a global consumption of approximately 170,000 tonnes per annum (tpa). The consumption of Rare Earths is poised to grow at a CAGR of 5.8% during 2017-2025 to reach approximately 266,891 tpa by 2025 (Figure 7). The growth is anticipated to be primarily driven by rising demand of Rare Earths in emerging clean technologies such as wind turbines, Electric Vehicles (EVs), energy-effective lighting, and rechargeable batteries.

Adamas Intelligence, an independent metal and mineral research company, estimates that China accounts for 75% of the global demand for Rare Earths, followed by Japan (14%), Europe (4%), US (3%), and Rest of World (4%).

Figure 7: Global Rare Earths demand (in tonnes)



Source: IMCOA

Magnets and catalysts drive Rare Earths demand

In 2017, the amount of Rare Earths consumed for magnets manufacturing was estimated to account for about 27% and 73% of the global Rare Earths consumption in volume and value terms, respectively (Figure 8). The most important Rare Earths for permanent magnets (used in wind turbine generators and EV motors) are Neodymium (Nd), Praseodymium (Pr) and Dysprosium (Dy).

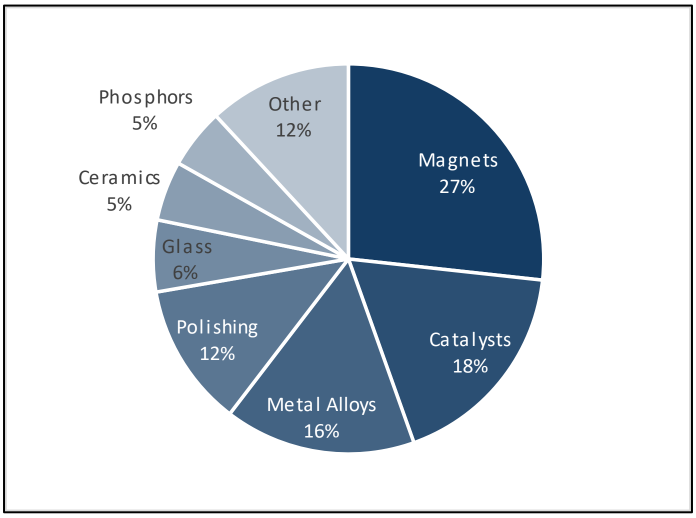
Tesla to boost demand for NdPr permanent magnets

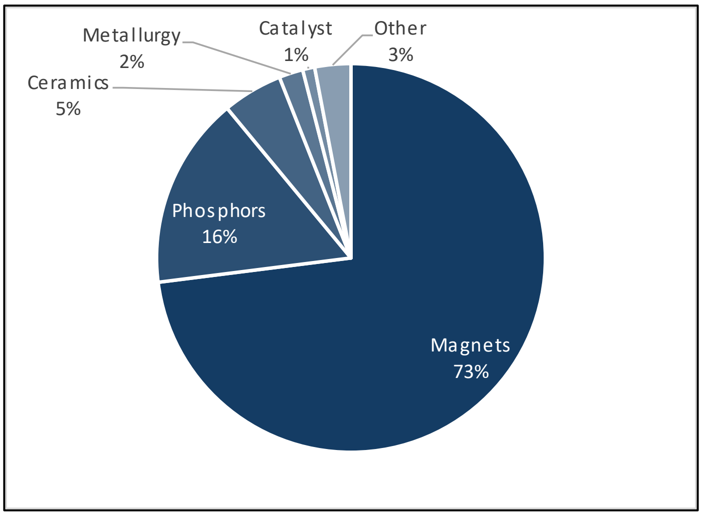
Roskill, a metal and mineral consultancy firm, estimates that between 2016 and 2021, the global Neodymium-Iron-Boron (NdFeB) magnet production will rise 4-5% per annum. In addition, Tesla's decision to move from their patented AC induction motors used in all previous models to a 3-phase NdPr permanent magnet motor in the Model 3 RWD Long Range model will further boost the demand for NdPr permanent magnets.

Catalysts, which primarily find application in petroleum processing and automobiles, accounted for 18% of the total Rare Earths demand in 2017.

Cerium and Lanthanum are the primary Rare Earths used for catalysts manufacturing. Roskill estimates that the demand for Cerium and Lanthanum will grow by 4% per annum through to 2027.

Figure 8: Demand breakdown of Rare Earths by end application by volume and value (right)





Source: IMCOA

The demand for Rare Earths currently exceeds supply, which stood at 133,500 tonnes in 2017, as per the data released by the US Geological Survey in January 2018. However, the production is expected to rise to keep pace with the rising demand and by 2020 may exceed demand, except for Neodymium and Praseodymium elements for which the supply-demand gap will continue to increase due to their extensive use in manufacturing of permanent magnets for EVs and wind turbines (Figure 9).

Roskill predicts that by 2021, the high price of Neodymium and concerns over supply availability will make projected growth rates of NdFeB permanent magnets unsustainable, and demand for these magnets is forecast to fall rapidly from 2022, before stabilizing at a lower growth rate.

Figure 9: Global Rare Earth supply and demand scenario in 2020

Rare Earth	Demand		Supply/Production	
	Tonnes	Share in Total Demand	Tonnes	Share in Total Production
Cerium (Ce)	72,175	36%	76,950	34.20%
Lanthanum (La)	49,425	25%	60,750	27%
Neodymium (Nd)	46,100	23%	42,975	19.10%
Praseodymium (Pr)	15,175	8%	13,725	6.10%
Yttrium (Y)	9,675	5%	13,275	5.90%
Gadolinium (Gd)	3,675	2%	5,400	2.40%
Dysprosium (Dy)	1,850	1%	3,150	1.40%
Samarium (Sm)	1,600	1%	4,725	2.10%
Erbium (Er)	900	0%	900	0.40%
Terbium (Tb)	400	0%	675	0.30%
Europium (Eu)	250	0%	675	0.30%
Ho-Tm-Yb-Lu	275	0%	1,800	0.80%
Total	**201,500**	**99.80%**	**225,000**	**100%**

Source: IMCOA

Dysprosium is currently in short supply

Production outside of China to come online in medium term

Demand for Dysprosium is anticipated to grow driven by the increasing use of magnets in high temperature applications including new energy vehicles (NEVs). However, almost 100% of Dysprosium production currently takes place in China and it is already in short supply, due to which manufacturers are actively trying to reduce Dysprosium-containing magnet consumption wherever possible and to develop new ways to reduce intensity of Dysprosium use. In the next 2-3 years, the large hard-rock sources of Dysprosium outside China are expected to come on-line, which, to a great extent, will reduce the supply-demand deficit in the medium term.

Demand for Yttrium is anticipated to witness subdued growth due to increasing popularity of light-emitting-diode lighting over traditional fluorescent lighting, which has reduced the consumption of Yttrium-based phosphors. In 2017, the global consumption of Yttrium Oxide was estimated to be 5,000 to 7,000 tonnes. China produces almost 100% of Yttrium and is able to meet global demand for the element. Globally, Yttrium is mainly consumed for ceramics and phosphors, and to lesser extent in electronic devices, lasers, optical glass, and metallurgical applications.

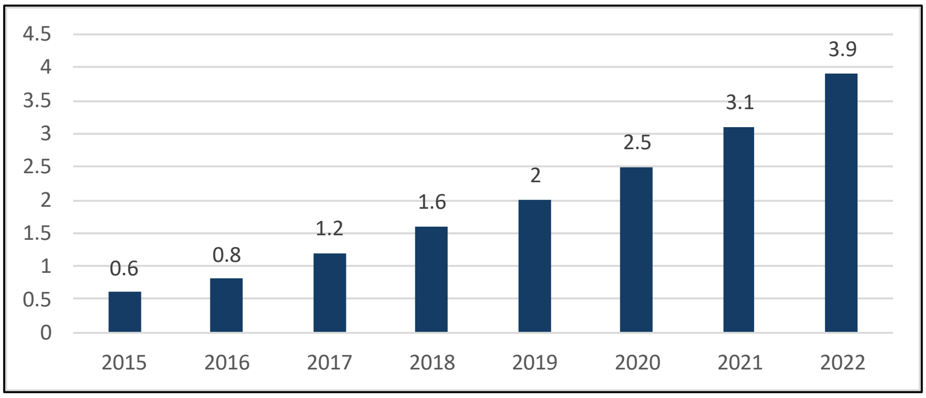
Rising Electric Vehicle Sales Boosting Rare Earths Demand

EV sales to grow by 25% per annum through 2022

According to Frost & Sullivan, global EV sales are estimated to be around 1.6M units in 2018 and would further increase to 3.9M units by 2022, growing at a 25% CAGR during 2018-2022 (Figure 10). This growth would primarily be driven by an ongoing support and commitments for increased deployment of EV's from policy makers and the automotive industry.

Battery Electric Vehicles (BEVs) make up 66% of the global EV market and are growing faster than those of plug-in hybrid vehicles (PHEV), which accounted for the remaining 34% of the market in 2017. The share of BEVs has increased from 60% in 2015 to 66% in 2017.

Figure 10: Global Electric Vehicle sales (in M)



Source: Pitt Street Research, Frost & Sullivan

Demand for Neodymium and Praseodymium boosted by EV sales

According to Argonaut Research EV's, on average, use 1 kg more Rare Earth Oxides than conventional internal combustion engines. Hence, the projected rise in EV sales will significantly boost the demand for Rare Earths, particularly Neodymium and Praseodymium.

China extends its leadership position in the global EV Market

China expected to remain the largest market for EV's

There has been growth in EV sales across many markets. However, China has outperformed all major markets by huge margin. In 2017, China accounted for ~48% of all global EV sales followed by Europe with 26% and the US with 17%. China has the largest fleet of EV's on the road, overtaking the US for the first time in 2017. In the next 5-7 years, China is expected to retain its position as the biggest market for EV's, dominated by domestic OEMs who account for about 94% of sales in the country (~45% of global sales). The growth in sales is driven by Chinese government providing subsidies to the sector to reduce fuel imports, improve air quality, and foster local manufacturers. This shows that China would continue to be the major consumer of Rare Earths driven by the rising production of EV's in the country to cater to the local demand.

EV30@30 to propel Chinese Electric Vehicle production

In June 2017, the so-called 'EV30@30' campaign was launched in the Eighth Clean Energy Ministerial meeting in which all Electric Vehicles Initiative (EVI) members set an aspirational goal of 30% market share for EV's in the total vehicles market (except two-wheelers) by 2030 (Figure 11).

In the EV30@30 scenario, EV stock is forecast to reach 228M units by 2030. This scenario would require about 18M EV's to be produced per year through 2030, creating potential demand for 27,000 tonnes of Rare Earths per year (though we estimate that the demand would ramp up from a current annual demand of about 2,000 tonnes to upwards of 90,000 tonnes per annum by 2030 at about 40% CAGR, that is if these ambitious targets are to be achieved.

Figure 11: Announced country targets and objectives for EV deployment

Country	2017	Target 2020	Target 2025-30
China	1.22M	5M	40-50% of total vehicle sales
EU (for countries part of EVI)	~0.65M	15% of total car sales	30% of total car sales
EU (for countries not part of EVI)		0.45-0.76M	5.42-6.27M
India	6.8K	NA	- 30% of total car sales - 100% BEV sales for buses
Japan	0.21M	NA	20-30% of total car sales
New Zealand	5.88K	64K[1] electric cars	NA
Korea	25.92K	0.2M EVs in PLDVs[2]	NA
UK	0.13M	0.40-0.43M electric cars	NA
US	0.76M	NA	- 3.3M EVs in eight states combined - California: 1.5M ZEVs[3] (15% of effective sales) by 2025 - 5M ZEVs by 2030

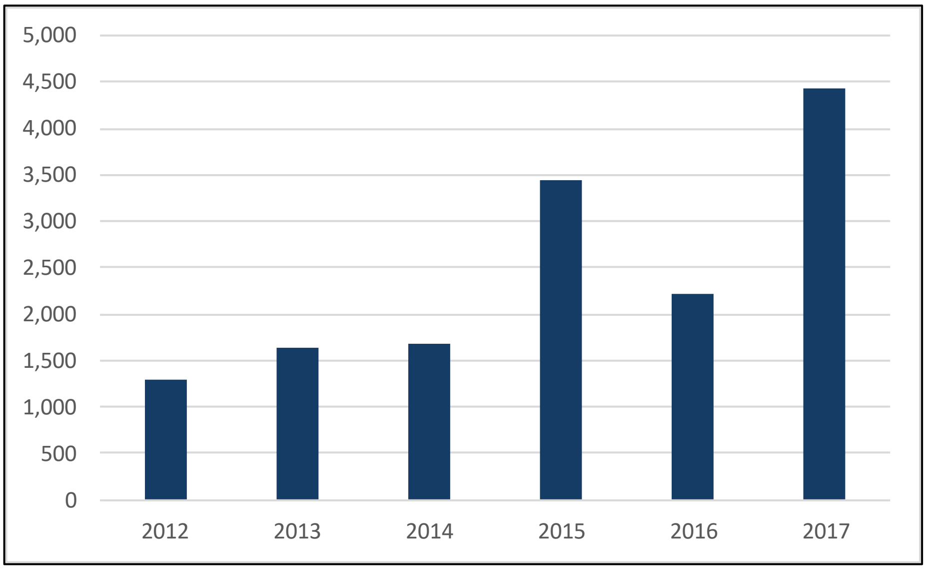
Source: IEA *[1]Target by 2021, [2]Passenger Light Duty Vehicles, [3]Zero Emission Vehicles*

Increasing utilization of Rare Earth permanent magnets in wind power installation

According to the European Union Rare Earth Element (EU REE) market survey report, published in January 2017, Rare Earth permanent magnets (utilizing Praseodymium, Neodymium, Terbium, and Dysprosium) are primarily used in offshore wind power installations.

The Global Wind Energy Council (GWEC) estimates that global new offshore wind power installations grew 95% from 2,217 MW in 2016 to reach 4,430 MW in 2017 (Figure 12). About 84% of all offshore installations are located in 11 European countries (UK and Germany accounting for majority of the installations). The remaining 16% are located largely in China, followed by Vietnam, Japan, South Korea, the US, and Taiwan.

Figure 12: Global annual installed offshore wind power capacity (MW)



Source: GWEC

Ambitious plans by China, Japan, the US, Taiwan and South Korea to set up offshore wind power generation capacity is anticipated to drive the market in the next few years. China is expected to achieve its national 2020 target of 5 GW of offshore wind power capacity while Japan targets 10GW of offshore wind power by 2030. Similarly, Taiwan, South Korea, and the US, each has a target to add 5-10 GW of offshore wind power by 2030.

An additional 120 GW in wind power to be installed by 2030 provides significant boost to Rare Earths demand

Globally, GWEC forecasts that the total installed offshore wind capacity would reach 120 GW by 2030, with an achievement of an installation rate of about 10 GW per year. This anticipated rise in offshore wind power generation would significantly boost the Rare Earth market. As per the EU REE survey (January 2017), approximately 2,500 tonnes of Rare Earths (Nd - 2,375 tonnes; Pr - 100 tonnes; Tb - 25 tonnes and Dy - 0.25 tonnes) per year would be required to support an annual offshore wind power capacity of 10 GW.

Greenland Minerals has significant Neodymium and Praseodymium production capacity, which puts the company in a favourable position given the rising demand for NdPr permanent magnets, fuelled by the phenomenal growth in EV's and offshore wind power markets.

China holds a near-monopoly in global RE supply

Global Rare Earths production only rose 4% in 2017

The US Geological Survey (USGS) estimates that global Rare Earths production increased marginally by 3.8% in 2017 to reach 133,500 tonnes as compared to 128,620 tonnes in 2016. As we have previously noted, China holds a near monopoly in the market. Australia, thanks to Lynas' Mt. Weld operation, is the second largest producer of Rare Earths with ~15% of the global production. The rest of the world is accounted for by India, Malaysia, Brazil, Russia, Thailand, and Vietnam (Figure 13).

Figure 13: Global Rare Earths supply (in tonnes)

	2016	2017
Australia	15,000	20,000
Brazil	2,200	2,000
China	105,000	105,000
India	1,500	1,500
Malaysia	300	300
Russia	2,800	3,000
Thailand	1,600	1,600
Vietnam	220	100
Total	**128,620**	**133,500**

Source: USGS

Through September 2017, China exported 39,800 tonnes of Rare Earth materials, a 10% increase compared to exports in the same period in 2016. Global exports of Rare Earth compounds from Malaysia, a leading supplier of material sourced outside of China, increased to 15,100 tonnes through August 2017, a 57% increase compared with year-to-date exports in 2016. The Rare Earth concentrates from Mt. Weld in Australia are used to produce compounds at Kuantan in Malaysia.

China may become a net importer of Rare Earths

Roskill forecasts that China may become a net importer due to tightening supply in the country owing to environmental inspections, government stockpiling, increased trading activity and demand growth for many Rare Earth products such as permanent magnets for wind turbines and EV's.

Tighter supply in China and increasing prices have led to the acceleration of non-Chinese Rare Earth projects, with projects in Australia, Russia, Brazil, Burundi, Canada, and Tanzania, amongst others, scheduled to enter production by 2027. The increase in non-Chinese production over the next decade is anticipated to significantly reduce China's dominance in Rare Earths supply. However, China is expected to remain the major supplier of REE products to the global market.

> *The changing trade scenario wherein China is anticipated to turn net importer of rare earths, offers a window of opportunities for companies like Greenland Minerals to plug the widening demand / supply gap for rare earths – Neodymium and Praseodymium.*

Competitive Landscape

Due to high entry costs, the Rare Earths market has limited number of players. According to EU REE Survey (January 2017), in H2 2016, there were about 23 active Rare Earths mining companies worldwide (Figure 14). In addition, there is a considerable illegal production carried out mainly in China, though China is making efforts to legalize all operations.

Figure 14: Key companies operating in the Rare Earths market

Company Name	Company Headquarters	Mine/Region	Capacity (tonnes per annum)	LREE/HREE[2] Enrichment
Baotou Steel Rare Earth	China	Bayan Obo	59,500	LREO
Jiangzi Copper Rare Earth	China	Maoniuping	25,000	LREO
Lynas Corporation[1]	Australia	Mount Weld	22,000	LREE
Minmetals Ganzhou Rare Earth	China	Jiangxi	9,000	HREO
Rainbow Rare Earths	UK	Gakara/Burundi	6,000	LREE
Indian Rare Earth	India	Tamil Nadu	2,800	LREO
China Iron and Steel Research Institute Group	China	Weishan	2,600	HREO
Chinalco Rare Earth	China	Guangzi	2,500	HREO
Lovozerskiy GOK	Russia	Lovozero	2,400	HREO
Xiamen Tungsten	China	Fujian	2,000	HREO
Gaundong Rare Earth Industry	China	Guandong	2,000	HREO
China Minmetals Rare Earth	China	Hunan	2,000	HREO
Nuclear Industries of Brazil	Brazil	Buena Norte	1,500	LREE
Kerala Metals and Minerals	India	Kerala	240	LREO
Lavreco/Sojitz/Toyota	Vietnam	Dong Pao	220	LREO
China Minmetals Rare Earth	China	Yunnan	200	HREO
Pegang Mining	Malaysia	Kinta Valley	100	LREO

Source: Technologies Metal Research (TMR)

[1]Lynas Corporation is also the owner of Kangankunde Rare Earth project in Malawi

[2]LREE – Light Rare Earth Elements; HREE – Heavy Rare Earth Elements; LREO- Light Rare Earth Oxide; HREO – Heavy Rare Earth Oxide

Greenland Minerals will face competition in the Rare Earth market from a number of upcoming Rare Earth projects. There are around 50 deposits around the world worth considering: Top projects in terms of high-grade TREO are given in Figure 15 below:

Figure 15: Competitors with advanced stage global REE projects

Deposit	Country	Developer	REO resource (MT)	MT ore	TREO%
Kvanefjeld	Greenland	Greenland Minerals	11.14	1,010	1.10%
Ngaulla	Tanzania	Peak Resources	4.62	214	2.15%
Nechalacho	Canada	Avalon Advanced Materials	3.95	269	1.47%
Mountain Pass	USA	Shenghe-led consortium	2.07	32	6.57%
Mrima Hill	Kenya	Pacific Wildcat Resources	1.89	27	7.04%
Mt Weld	Australia	Lynas Corporation	1.74	23	7.50%
Nolans Bore	Australia	Arafura Resources	1.46	56	2.60%
Dubbo Zirconia	Australia	Alkane Resources	0.56	75	0.74%
Bear Lodge	USA	Rare Element Resources	0.50	16	3.05%
Yangibana	Australia	Hastings Technology Metals	0.25	21	1.17%

Source: Company data

Benefit from by-products such as Uranium, Zinc and Fluorspar

Demand for uranium driven by increasing nuclear power capacity installations

Focus Economics estimates that global Uranium consumption was 83,200 tonnes in 2017 and is poised to grow 6.25% to reach 88,400 tonnes in 2018, driven by increasing demand for Uranium to generate electricity (Figure 16). Ux Consulting estimates that the global nuclear power capacity would grow to over 483 GW by 2030, a 27.3% absolute increase over the capacity of 379.4 GW in 2015. This would result in an annual uranium demand of 136,000 tonnes in 2030, about 54% higher than estimated annual consumption in 2018.

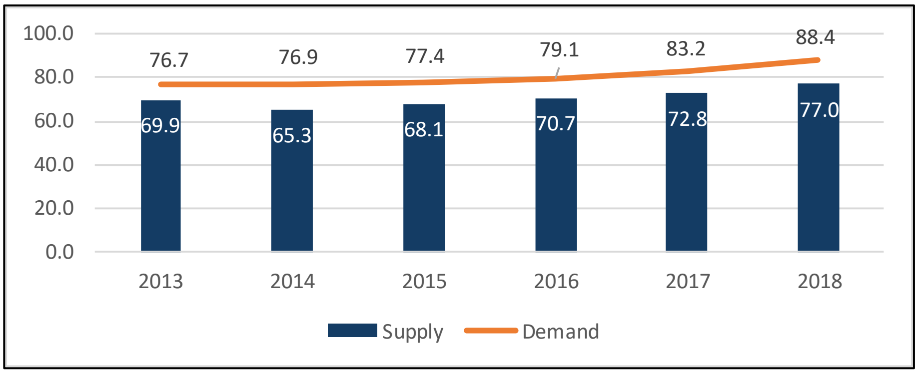
Most Uranium demand coming from India and China

India and China are anticipated to be the major drivers of uranium demand. China plans to have 58 GW nuclear power generation capacity by 2020, ~68% increase from 34.6 GW in 2018, while India plans to more than double its current nuclear power generation capacity to 6.2 GW by 2024.

Output curbs expected in an attempt to drive prices higher

Global Uranium production is estimated to grow about 5.7% to reach 77,000 tonnes in 2018 from 72,800 tonnes in 2017 (Figure 16). However, not much growth is expected in production in the next few years due to low Uranium prices which is making high cost production unsustainable. According to Focus Economics, the market is expected to witness substantial output curbs as producers try to drive Uranium prices higher.

Figure 16: Uranium demand and supply (k tonnes)

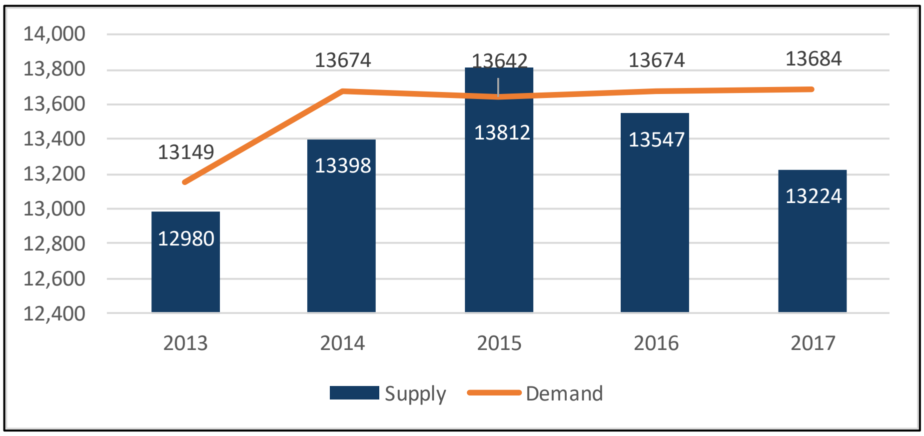


Source: Focus Economics

Supply deficit in Zinc to exist till 2022

According to the International Lead and Zinc Study Group (ILZSG), Zinc demand remained stable during 2014-2017 and is expected to rise nearly 2% in 2018 driven by a rebound in steel demand in China. However, the production has declined by about 4.2% during 2015-17 (Figure 17), primarily due to sharp tightening in mining supply in Australia and India. Wood Mackenzie, a metal and mining research and consultancy company, forecasts that the global Zinc production would rise during 2018-2020 boosted by increased mine production in China and Australia.

Figure 17: Zinc demand and supply (k tonnes)



Source: ILZSG

Rising consumption and production cut in China to boost Fluorspar prices

Steady growth in Fluorspar demand expected through 2022

There are two principal commercial grades of Fluorspar produced – Metallurgical spar and acid-spar. Metallurgical spar is primarily used in steel and cement production and accounts for 39% of the total world demand for Fluorspar. Acid-spar's principal application is in the manufacturing of hydrofluoric acid (HF), which is primarily used in the production of fluorocarbons. According to Roskill, the demand for Fluorspar for manufacturing HF reached more than 2 Mt in 2017, driven by increased use of fluorochemicals (an application of HF) in pharmaceuticals, polymers and agrochemicals. The consumption during 2018-2022 is anticipated to grow at a CAGR of 4%-5%, owing to high growth forecast in key Fluorspar consuming markets including steel, aluminum, fluorinated refrigerants, consumer products and Lithium batteries.

According to the USGS, the global Fluorspar production grew marginally to 6 Mt in 2017 from 5.9 Mt in 2016. China accounted for more than 60% of the global production in 2017. However, Chinese Fluorspar production is expected to decline due to mine closures prompted by environmental inspections.

Long term rising prices due to sustained supply / demand imbalance

In the medium to long term, Fluorspar prices are projected to increase on account of a rising supply deficit resulting from increases in production of downstream value-added fluorspar products amid continued production cuts in China.

In the Uranium market, production cost would be key in production decisions due to the prevailing low price of the commodity. However, the Uranium market does not look attractive in the near term due to the existing supply glut. Consequently, with mines closing down in China due to tightening environmental inspections, the supply of Zinc and Fluorspar is going to be affected significantly.

However, the demand for by-products Zinc and Fluorspar is not expected to cool down in the medium term. Therefore, the current supply deficit could be highly attractive for Greenland Minerals.

Valuation

We value Greenland Minerals at 18 cents per share base case, 43 cents per share optimistic case. Our basic valuation approach is as follows:

- We created Discounted Cash Flow (DCF) models of Kvanefjeld broadly based on the assumptions of the 2015 Feasibility Study and Greenland Minerals' 2016 update to that study. Our DCFs used a 10% WACC and a long run AUD/USD exchange rate of 0.75.
- We assumed mine startup in 2021.
- We assumed initial selling prices and mining/processing costs and escalated these at a 2.5% p.a. inflation rate.
- We assumed a 37-year mine life based on the current 108 million-ton JORC reserve.
- We assumed a 30% corporate tax rate.
- We assumed that the government of Greenland would collect a 2% royalty on product sales.
- We assumed an equity capital raising by Greenland Minerals of A$90m in order to provide the standard equity buffer in the project's capital budget. It must be emphasized that we do not expect Greenland to make such a raising at the current price, however for valuation purposes we use a discount to the current share price.

Clear scope for savings on capital costs

Capital costs. As we note above, Greenland Minerals has twice estimated the capital costs of Kvanefjeld in recent years - in 2015 at US$1.36bn and in 2016 at US$832m. Given the progress the company has reported in flowsheet optimization since 2017, there is strong potential for further reductions in capital costs. However, for conservatism's sake we assume US$850m for a base case assumption and US$700m for an optimistic case. We note that the 2016 Feasibility Update envisaged the possibility of direct shipping of concentrate, saving several hundred million dollars on the cost of a refinery. Consequently, we believe the risk is to the downside on our numbers.

Funding of the project. We assumed that after the A$90m equity buffer, Kvanefjeld is debt-funded at an interest rate of 8%. We assume debt is amortized over a seven-year period after start-up.

Rare Earths pricing. For both our base and optimistic cases we assumed US$42,000/t REO for the critical Rare Earths basket which will be the mainstay of the mine. We believe this was conservative (Figure 18), with our estimate way below the levels used in the 2015 Feasibility Study. We also note that in the 2016 update Greenland Minerals maintained its pricing forecasts for Neodymium, Praseodymium, Terbium and Dysprosium on the reasonable expectation that these metals would be in structural deficit by 2020. As we show below, Kvanefjeld is valuable even on the current U308 price, and highly sensitive to any changes in Rare Earths pricing

Figure 18: Initial selling prices

	Base	Optimistic
LaCe REO Price (US$/t)	2,000	3,000
Other REO Price (US$/t)	42,000	42,000
Uranium Price (US$/t)	45,000	55,000
Fluorspar Price (US$/t)	270	350
Zinc Price (US$/t)	1,800	2,400

Source: Pitt Street Research

Initial operating costs. We assumed mining costs of US$3/t for both base and optimistic cases, while for processing costs we assumed US$65/t base case coming down to US$55/t for an optimistic case

Initial fixed costs. We assumed in each case that fixed costs would be 8% of the projected capital costs.

The resulting DCF valuations have been summarized in Figure 19 below with our base case and optimistic scenario yielding a value per share of A$ 0.18 and A$ 0.43 per share. The mid-point of this range is A$ 0.31 per share.

Figure 19: Discounted Cashflow valuation for Greenland Minerals

	Base	Optimistic
Value of Kvanefjeld	394.9	1,072.9
Corporate overhead	-13.1	-13.1
Cash now (A$m)	7.7	7.7
Cash to be raised (A$m)	90.0	90.0
Option exercises (A$m)	15.1	15.1
Total value (A$m)	**494.7**	**1,172.6**
Total diluted shares (million)	2,708.8	2,708.8
Value per share (A$)	**0.18**	**0.43**
Valuation midpoint	$0.308	
Share price now (A$ per share)	$0.082	
Upside to midpoint	275.6%	

Source: Pitt Street Research

High sensitivities to Rare Earths prices

We ran a sensitivity analysis on our model to the Rare Earths basket. What this showed was that a re-rating of Rare Earths to the kind of pricing envisaged in the 2015 Feasibility study would yield valuations on our numbers well in excess of our optimistic case (Figure 20).

Figure 20: Sensitivities of our model to Rare Earths pricing

Critical REO/t	Base case NPV (A$m)	Optimistic case NPV (A$m)	Base case per share	Optimistic case per share
17,000	-1,752	-806	-$0.61	-$0.26
22,000	-1,254	-354	-$0.43	-$0.09
27,000	-759	25	-$0.24	$0.05
32,000	-331	375	-$0.09	$0.18
37,000	46	724	$0.05	$0.30
42,000	395	1,073	$0.18	$0.43
47,000	744	1,422	$0.31	$0.56
52,000	1,093	1,771	$0.44	$0.69
57,000	1,442	2,120	$0.57	$0.82
62,000	1,792	2,470	$0.70	$0.95
67,000	2,141	2,819	$0.83	$1.08
72,000	2,490	3,168	$0.96	$1.21
77,000	2,839	3,517	$1.08	$1.34

Source: Pitt Street Research

Re-rating Greenland Minerals

Greenland Minerals' stock is currently trading below our base case valuation. We see four factors helping to re-rate Greenland Minerals into our valuation range:

- Success in further test work both at the concentrator and the refinery stage of the flowsheet;
- Granting of a Mining License for Kvanefjeld;
- Completion of an updated, or second, Feasibility Study;
- A binding commercial agreement with Shenghe on future product offtake from Kvanefjeld.

Furthermore, Greenland Minerals has a management team capable of taking Kvanefjeld to the next stage. Managing Director Dr. John Mair has been involved with Kvanefjeld since 2008. Since his 2014 appointment as Managing Director he has overseen the corporate evolution of Greenland Minerals as a Rare Earths play aligned closely with Shenghe. CFO Miles Guy brings an accounting and corporate governance background.

The Greenland Minerals board has the kind of skillset required to build an emerging Rare Earths play, in our view. The Sydney-based Non-Executive Chairman Tony Ho brings as a commercial background gained mainly in the retail sector. Simon Cato brings a capital markets expertise gained over three decades in the financial services industry. And Xiaolei Guo, a Shenghe executive, brings deep knowledge of the Chinese Rare Earths sector.

We see five main risks related to Greenland Minerals stock

1) Pricing risk - Rare Earths pricing may become unfavorable, as per the post-2011 period;
2) Geo-strategic risk. The US-China Trade War and related geo-strategic issues may impact the Rare Earths market in a way that makes project financing of Kvanefjeld difficult;
3) Regulatory risk. Permitting of Kvanefjeld may take longer than expected;
4) Political risk. Greenland's government may adopt a less 'pro-mining' stance. The next Greenlandic general election is due in 2022.
5) Funding risk. As at June 2018, Greenland Minerals held A$7.7m in cash. The company is likely to have to raise cash in the future in order to continue the development of Kvanefjeld.

Figure 21: Greenland Minerals' capital structure

		% of fully diluted	Note
Ordinary shares, ASX Code GGG (million)	1,111.0	86.0%	
Listed options (million)	181.6	14.0%	Exercise price 8 cents, expiry date 30 September 2018
Unlisted options (million)	4.0	0.3%	Exercise price 15 cents, expiry date 31 March 2021
Options and performance rights (million)	6.0	0.5%	
Fully diluted shares	1,292.5		

Source: Pitt Street Research

Major shareholders

Currently Greenland Minerals has only one major shareholder, Shenghe Resources, with 11% of the register.

Companies to watch in the Rare Earths space

We note five companies that are comparable to Greenland Minerals (Figure 22):

Hastings Technology Metals (ASX:HAS). HAS owns 91% of the Yangibana Rare Earths Project in the Gascoyne region of Western Australia. This project, which will mainly produce Neodymium and Praseodymium, completed its Definitive Feasibility Study in November 2017. Yangibana will produce 15,000 tpa of mixed Rare Earth carbonate at around US$13/kg REO over an 8-year mine life. The project has offtake MOU agreements with three Chinese Rare Earth producers.

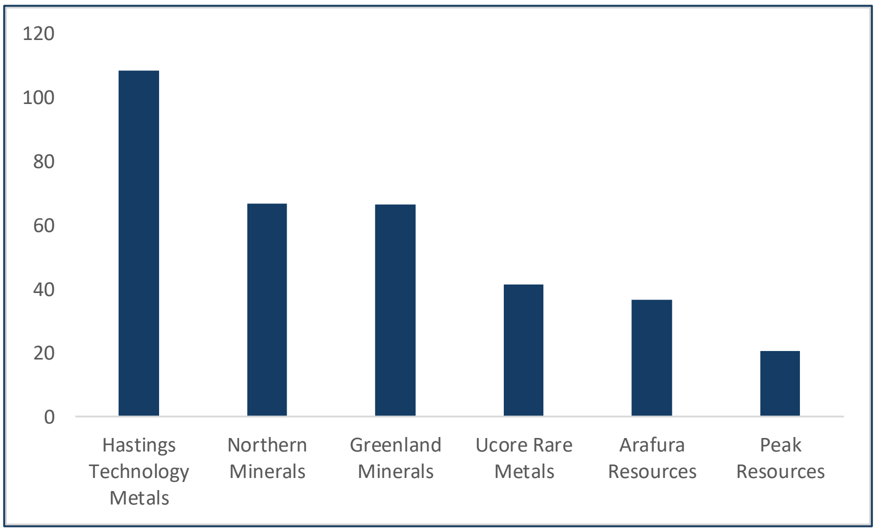
Northern Minerals (ASX:NTU). This company is developing the Browns Range deposit in the northern Tanami region of Western Australia near the Northern Territory border. Browns Range is primarily valued for Dysprosium and may produce 300,000 kg of this Rare Earth annually over an 11-year mine life. Northern Minerals already has a Chinese buyer for pilot plant offtake, which commenced operation in August 2018.

Ucore Rare Metals (TSX-V:UCU). This company's Bokan Mountain project is located on Prince of Wales Island in southeast Alaska. Bokan is relatively small – 4.79 million tonnes of indicated resource at 0.6% REO – but the fact that it is a US deposit is likely to attract attention given the strategic importance now placed on Rare Earths by the US government[21].

Arafura Resources (ASX:ARU). This company's Nolans Bore Project in the Northern Territory will mainly focus on Neodymium and Praseodymium. A Definitive Feasibility Study is underway, with a 30+-year mine life envisaged at production costs under US$7/kg REO. With the orebody rich in P2O5, this mine will produce phosphoric acid as a by-product.

Peak Resources (ASX:PEK). This company owns 75% of the Ngualla Rare Earths Project in southern Tanzania. This is a potentially large project, with a resource of 214 million tonnes grading 2.15% REO. The current mine plan involves local beneficiation of ore which is then shipped to a company-owned refinery in the UK. As with Arafura, the main output will be Neodymium and Praseodymium.

Figure 22: Peer group market capitalization (USD M)



Source: Pitt Street Research

[21] American's 2019 National Defense Authorization Act prohibits the U. Department of Defense from acquiring rare earth magnets from China (as well as three more roguish nations - Russia, Iran, and North Korea).

Conclusion: Progress expected with Shenghe's help

Greenland Minerals has made strong progress over the last two years in moving Kvanefjeld forward. Sustained increases in Rare Earths prices, completion of permitting in Greenland and reductions in expected capital and operating costs as Greenland Minerals and Shenghe optimize the flowsheet will help move this high-quality asset forward and contribute to a re-rating of the stock. We have set a valuation range for GGG of A$ 0.18 to A$ 0.43 per share.

SWOT Analysis

Strengths:

- World's largest undeveloped Rare Earths deposit
- Forward outlook for Rare Earths strong
- Shenghe relationship
- Potentially very low operating costs

Weaknesses:

- Potential delays in permitting
- Recent weaknesses in uranium prices
- High capital costs

Opportunities:

- High demand for Rare Earths in a 'clean, green' economic environment
- Potential for lowered capital costs through flowsheet optimization, driven by Shenghe

Threats:

- US-China trade war featuring Rare Earths
- Potential substitutionary activity reducing demand for critical Rare Earths

Appendix I - The 2015 Feasibility Study at Kvanefjeld

The initial Feasibility Study at Kvanefjeld painted a healthy future for Greenland Minerals. This Study, announced in May 2015, suggested an NPV for the Kvanefjeld of US$1.4bn, using a discount rate of 8%. However, as we note above, the 2016 numbers were much better.

A low-cost, long life mine. The 2015 Feasibility Study envisaged a 3 million tonnes p.a. open pit mining operation over 37 years, solely based on the 108-million-tonne ore reserve estimated in June 2015. The project flowsheet at that time, established after several years of metallurgical test work involving pilot flotation plants and refineries, was straightforward:

- A concentrator working via froth flotation[22] that floats off 6,000 tpa sphalerite zinc concentrate and produces 16,000 tonnes of fluorspar p.a. via water treatment, while generating a Rare Earth Phosphate mineral concentrate for refining;
- A refinery in which 1 million pounds of uranium and a Rare Earth intermediate concentrate is produced by atmospheric sulphuric acid leaching, followed by
- Two separation plants, one producing relatively low-value CeO2 (Cerium Oxide) and La2O3 (Lanthanum Oxide), the other producing ~7,800 tonnes of critical REOs[23].

High Margins. The 2015 Feasibility Study calculated the production cost at US$8.56/kg critical REOs, suggesting a gross margin close to 90%[24].

A high capital cost. The 2015 Feasibility Study estimated total capital cost for Kvanefjeld at US$1.36bn. This included US$161m in contingencies (16% of the project value), a US$111m port facility and another US$111m in various regional infrastructure items. This expensive budget has driven the search since 2015 for a lower cost flowsheet that is easier to scale-up from early cash flows.

[22] By June 2015 Greenland Minerals was able to announce its operation of a pilot beneficiation circuit that uses froth flotation. This operation was conducted and funded as part of the European Union's EuRare programme, which is encouraging the development of new Rare Earths mines in the EU. Greenland Minerals' circuit, which included a Jameson cell, processed 26 tonnes of ore to produce 2 tonnes of REO concentrate, the targeted amount.

[23] The key rare earths in this output are Neodymium 3,860 tonnes, Praseodymium 1,224 tonnes, Europium 30 tonnes, Terbium 40 tonnes and Dysprosium 237 tonnes.

[24] It must be noted that his was after including U308, La2O3, CeO2, Zinc and CaF2 (Calcium Fluoride). The price of zinc, at US$2,400/tonne is currently above the US$1,000 envisaged in the Feasibility Study, but U3O8 at US$26.50/lb (source: Ux Consulting) is a far cry from the US$70/lb selling price Greenland Minerals modelled in 2015.

General advice warning, Disclaimer & Disclosures

Terms & Conditions

The information contained herein ("Content") has been prepared and issued by Pitt Street Research Pty Ltd ACN 626365615 ("Pitt Street Research"), an Authorised Representative (no: 1265112) of BR Securities Australia Pty Ltd. ABN 92 168 734 530, AFSL 456663. All intellectual property relating to the Content vests with Pitt Street Research unless otherwise noted.

Disclaimer

The Content is provided on an as is basis, without warranty (express or implied). Whilst the Content has been prepared with all reasonable care from sources we believe to be reliable, no responsibility or liability shall be accepted by Pitt Street Research for any errors or omissions or misstatements howsoever caused. Any opinions, forecasts or recommendations reflect our judgement and assumptions at the date of publication and may change without notice. Pitt Street Research will not accept any responsibility for updating any advice, views, opinions or recommendations contained in this document.

No guarantees or warranties regarding accuracy, completeness or fitness for purpose are provided by Pitt Street Research, and under no circumstances will any of Pitt Street Research officers, representatives, associates or agents be liable for any loss or damage, whether direct, incidental or consequential, caused by reliance on or use of the Content.

General Advice Warning

The Content has been prepared for general information purposes only and is not (and cannot be construed or relied upon as) personal advice nor as an offer to buy/sell/subscribe to any of the financial products mentioned herein. No investment objectives, financial circumstances or needs of any individual have been taken into consideration in the preparation of the Content.

Financial products are complex, entail risk of loss, may rise and fall, and are impacted by a range of market and economic factors, and you should always obtain professional advice to ensure trading or investing in such products is suitable for your circumstances, and ensure you obtain, read and understand any applicable offer document.

Disclosures

Pitt Street Research has been commissioned to prepare the Content. From time to time, Pitt Street Research representatives or associates may hold interests, transact or hold directorships in, or perform paid services for, companies mentioned herein. Pitt Street Research and its associates, officers, directors and employees, may, from time to time hold securities in the companies referred to herein and may trade in those securities as principal, and in a manner which may be contrary to recommendations mentioned in this document.

Pitt Street Research receives fees from the company referred to in this document, for research services and other financial services or advice we may provide to that company. The analyst has received assistance from the company in preparing this document. The company has provided the analyst with communication with senior management and information on the company and industry. As part of due diligence, the analyst has independently and critically reviewed the assistance and information provided by the company to form the opinions expressed in the report. Diligent care has been taken by the analyst to maintain an honest and fair objectivity in writing this report and making the recommendation. Where Pitt Street Research has been commissioned to prepare Content and receives fees for its preparation, please note that NO part of the fee, compensation or employee remuneration paid will either directly or indirectly impact the Content provided.