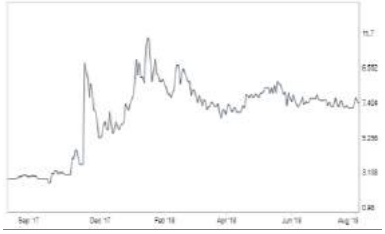
Alternative Resource Capital

MKA LN/CN **Mining & Metals**



Source: LSE

Market data

Price (p)	8.0
12m High (p)	12.8
12m Low (p)	2.8
Shares (m)	108.7
Mkt Cap (£m)	8.6

Company summary

AIM and TSX-V quoted Mkango Resources is developing the Songwe Hill REE project in Malawi, funding for which is being provided on an earn-in basis by a subsidiary of global commodities trader Noble Group. A resource update for the project is expected by the end of 2018, with completion of a bankable feasibility study targeted by the end of 2019.

Management

CEO	Will Dawes
Exec President	Alex Lemon
Non-Exec Chairman	Derek Linfield
NED	Adrian Reynolds
NED	David Berg
NED	Eugene Chan

Major shareholders

Talaxis (Noble Group)	13.2%
RESOC	10.3%
Leominex	7.9%

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Mkango Resources*

Advanced REE play funded to construction decision

'Magnet' rare earths appear set for an upwards step-change in pricing over the coming years, driven by growing demand for NdPr based permanent magnets for use in EVs and wind turbines coupled with a tightening of the REE export market in China, the world's dominant producer. We believe Mkango offers lower risk exposure to this developing story relative to other junior REE plays, its Songwe Hill project in Malawi potentially funded right through to production via a strategic alliance with Talaxis, a subsidiary of global commodities trading group Noble. Talaxis has committed £12m to fund a bankable feasibility study by the end of next year for a 49% stake in Songwe Hill and has an option to then move to 75% ownership (and offtake rights) in return for financing construction (estimated at US$216m in a 2015 prefeasibility study). If exercised, this would see Mkango with a 25% free-carried interest in an a globally significant REE operation which could be cash flowing as early as H2 2021. We estimate Mkango's share of steady-state EBITDA could be US$20-25m pa, multiples of its current market capitalisation of US$11m. The second instalment of Talaxis' BFS funding (£7m on publication of an updated resource by the end of this year) should, in our view, be the next catalyst for an upwards re-rating of Mkango's shares, which are trading at a substantial discount to the valuation of its share of Songwe Hill ascribed by the Talaxis deal.

- **REE market at inflexion point:** We believe REE are set to be the next commodity beneficiary of the emerging electric vehicle revolution, NdPr being key ingredients in the manufacture of high-strength permanent magnets used in the motor drivetrains of EVs. Against the well-documented growth outlook for EVs which we believe will be a significant driver of demand for the 'magnet' REE over coming years, REE supply looks set to tighten as the world's dominant producer China continues to rationalise its domestic industry.
- **Songwe Hill – a globally significant REE project:** In our opinion, Songwe Hill is one of the very few REE projects outside of China that we see having the potential to be brought into production over the next few years, its favourable orebody geometry and mineralogy amenable to simple, low-strip open-pit mining and relatively straightforward, low-temperature mineral processing. This underpins a predicted low-cost structure, with a capex requirement significantly below most of the peer group. We believe cash margins of c60% could be sustained once in production, for average operational EBITDA of >US$90m pa.
- **Talaxis agreement unlocks path to production:** Mkango could be exposed to 25% of this future cash generation without any further funding calls should Talaxis exercise its earn-in option in full. Talaxis has firmly committed £12m for a 49% stake to fund the BFS (of which £5m has been deployed to date, for 20%), and has an option to move to 75% (and 100% offtake rights) in return for financing the project build (estimated at US$216m in the 2015 PFS).
- **Valuation:** Mkango is trading at c40% discount to the 13p valuation of its share of Songwe Hill and the downstream Maginito venture ascribed by the initial Talaxis deal (in our view a minimum valuation benchmark), and considerably below our NPV-based valuation (20p on a risk-adjusted attributable basis today, rising to 100p at production). Moreover, the group's Thambani niobium-uranium-tantalum project offers a 'free play' on further value-unlocking potential. We consider this an attractive entry point given the scope for material re-rating as future milestones are met, starting with an updated resource for Songwe by end 2018 and the next tranche of investment by Talaxis thereafter.

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Investment summary

REE set to be another commodity beneficiary of the EV revolution

With third-party funding already committed to advance its Songwe Hill project in Malawi right through bankable feasibility study (BFS) to point of construction decision, we believe Mkango Resources represents a low-risk exploration and development play on a highly compelling commodity class that looks set to be another beneficiary of the emerging electric vehicle and 'cleantech' revolution.

Clean energy technologies sparking renewed interest in the REE sector

NdPr are vital ingredients in high-strength permanent magnets used in EV motor drivetrains

The REE neodymium and praseodymium (NdPr) are key ingredients in the manufacture of high-strength permanent magnets, demand for which is leveraged to the fast-growing clean energy sector – the highest growth end-use market for NdFeB permanent magnets are electric and hybrid-electric vehicles (EVs use an additional c1kg of NdPr per electric drive motor vs a standard vehicle) and wind turbines. EV take-up levels have exceeded expectations to date, and appear set for further growth over the next decade given government policy in the world's major car markets coupled with shifting consumer attitudes.

The Chinese REE export market is tightening amidst a restructuring of its domestic industry

Against this backdrop of rising demand, China, the world's dominant supplier of REE over the past two decades, is rationalising supply through the closure of illegal and environmentally unsustainable operations and consolidation of its official production base with a focus on sustaining an orderly market for its own downstream requirements. This is tightening the Chinese export market, with some industry analysts going so far as to predict that China may emerge as a net importer of certain REE over the longer term.

Songwe Hill poised to capitalise

This structural change in the REE market is increasing the strategic significance of high-quality projects outside of China, particularly those with potential to be integrated with downstream processing capabilities to create viable new and secure supply networks.

Mkango's Songwe Hill project benefits from a high proportion of 'magnet' REE in its assemblage

NdPr accounts for 35% of forecast future REO (rare earth oxide) production of over 2,800t pa (as estimated by a 2015 prefeasibility study) from Mkango's Songwe Hill project in Malawi, with more than 80% of the project's revenue geared to NdPr and the other 'magnet' REE dysprosium and terbium. The PFS projected production scale for Songwe Hill equates to over 2% of the global REE market today, and over 3% of the market for the economically key NdPr oxides.

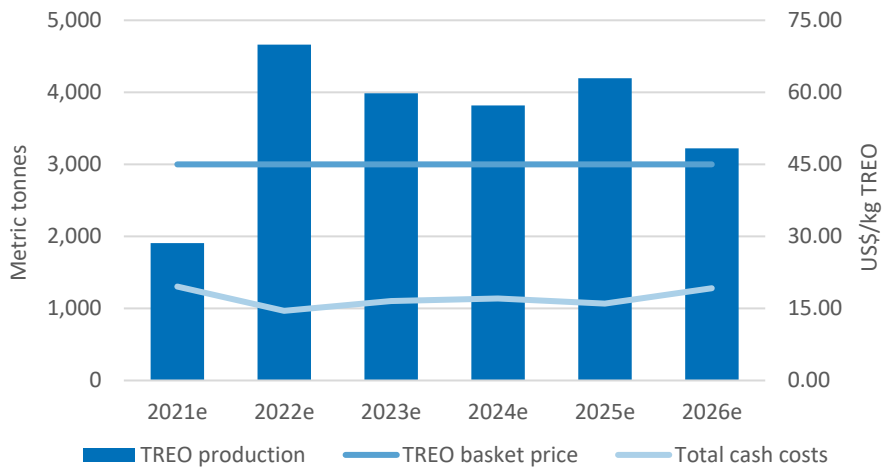
Our analysis points to operational EBITDA potential of >US$90m pa

We see considerable upside to the PFS economics, most notably through an upsizing of the mineable reserves (through in-fill drilling of currently inferred-category resources and step-out drilling of mineralisation which remains open), further optimisation of the proposed process flowsheet and, potentially, the inclusion of a REE separation facility (not considered in the PFS). The latter would enable more downstream value-add to be captured, further increasing the strategic value of the asset. On our estimates, once built this could see an operation capable of sustaining EBITDA of over US$90m pa for a margin of 60% (and this despite our cash flow model assuming a 'basket' REE price some 25% lower than that used in the PFS).

Economics will be proved up by a BFS scheduled for completion by the end of next year

These areas of potential upside are being investigated as part of the BFS programme now underway, with the first phase of work focused on at least 5,000m of drilling which is expected to result in an updated resource statement by the end of 2018. The BFS should be completed by the end of 2019, and we fully expect it to build on the compelling economics laid out in the PFS.

Figure 1: Songwe Hill potential production, revenue and cost profile (first six years)



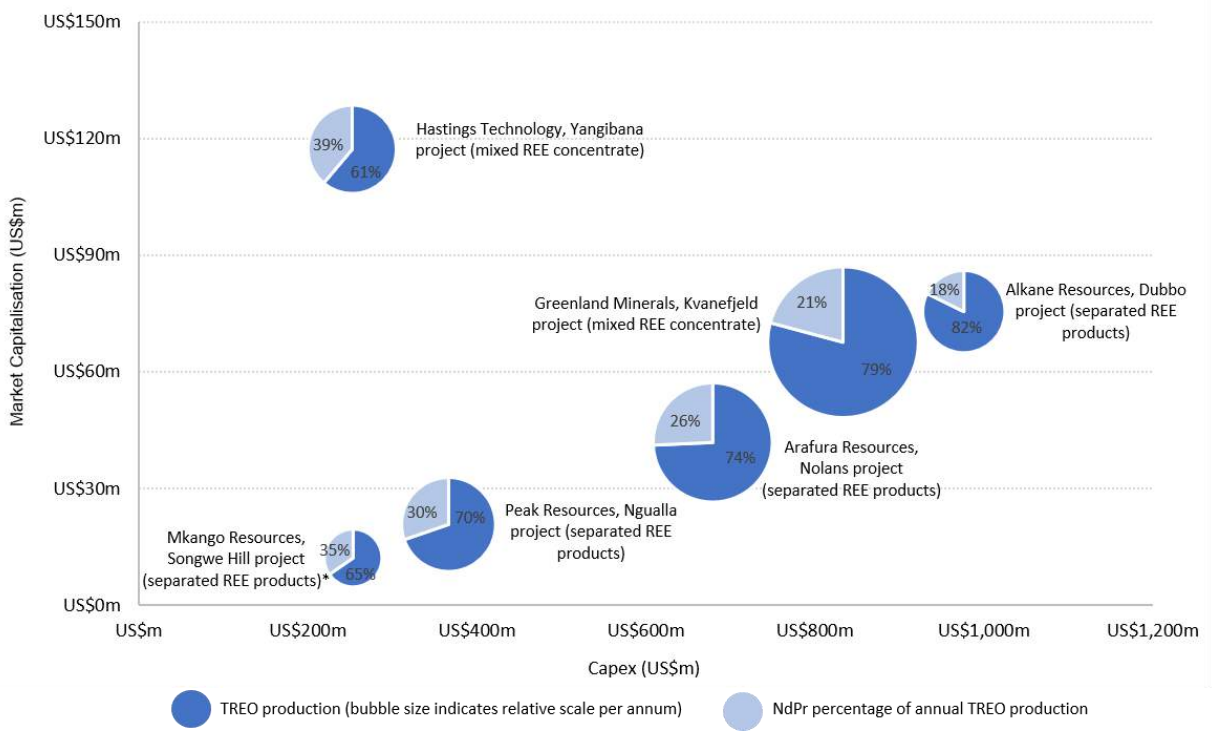
Source: ARC estimates

Favourable metallurgy underpins competitive cost structure

Well positioned relative to peer projects

Would-be junior REE project developers typically face two major hurdles to unlocking value – demonstrating a technically and economically viable process recovery route and delivering a funding solution to what can be substantial capital build costs. In this regard we believe Mkango has gone a long way towards de-risking the project. Aided by Songwe Hill's favourable mineralogical assemblage, a thorough programme of metallurgical test work undertaken during the PFS programme concluded that low-temperature conventional process technology should be capable of recovering the key magnet REO at competitive costs with an upfront capital bill significantly lower than most of the peer group of advanced projects (Figure 2).

Figure 2: Songwe compares favourably against other REE projects on NdPr percentage and development cost



**ARC estimates for Songwe Hill potential BFS scenario*

Source: Bloomberg, company websites

Talaxis agreement maps out path to cash flow

Mkango could be free-carried to 25% of future cash flows

The company has over the past year put together an innovative potential funding solution by way of a strategic tie-up with Talaxis, a subsidiary of Noble, the global commodity trading and supply-chain management group. Talaxis has committed to directly invest £12m in the project, sufficient to fund the entire BFS programme, in return for a 49% stake. Moreover, it has an option to move to 75% ownership in Songwe (and 100% offtake rights) in return for then sourcing full financing for the project build (estimated at US$216m in the 2015 PFS). This could potentially carry Mkango through the entire BFS programme and subsequent project construction with no further cash call, yet still retaining 25% exposure to what we estimate could be over US$90m pa in operational cash flow from Songwe Hill.

Undemanding valuation offers attractive entry point

Mkango's current market capitalisation is less than 50% of our estimate of what would be its 25% attributable share of future steady-state annual earnings from Songwe Hill – once in production, single-asset junior miners in Africa typically trade at around 4x EBIDTA. This suggests Mkango could re-rate towards 100p per share over the longer-term once production has been achieved, a level backed up by our risked estimate of its attributable share of NPV at that point.

The Talaxis agreement places a value of 13p per share on Mkango's share of Songwe Hill and Maginito, and we see significant upside potential beyond that on an NPV basis

Clearly markets justifiably apply hefty discounts to pre-production plays given the substantial risks to achieving projected future cash flows, but we believe Mkango's shares should currently at the very least trade in line with the 13.4p per share valuation of its attributable share of Songwe Hill (11.5p) and the downstream Maginito JV (1.9p) ascribed by the Talaxis transaction, and potentially towards our 20p risk-adjusted estimate of its attributable share of our estimate of Songwe's NPV. The low end of this near-term valuation range represents c70% upside to Mkango's current share price, in our view a very attractive entry point given the company is ostensibly now funded through to completion of the BFS at the end of next year.

We see significant potential re-rating catalysts over the near to medium term, most notably publication of an updated resource statement (by end 2018) and accompanying technical report (by early 2019), which will trigger the next £7m of committed investment from Talaxis and de-risk the path to construction decision.

Figure 3: Potential valuation evolution with time

Valuation method	Today	Post construction financing	At production
Talaxis transaction read-through value	13p (51% stake)	55p (25% stake)	na
Attrib. share of risked Songwe Hill $NPV_{10\%}$	20p (80% risked)	66p (30% risked)	100p (10% risked)
Attributable EBITDA multiple (4x)	na	na	94p

Source: ARC estimates

Upcoming catalysts

- In-fill and step-out drilling results (H2 2018)
- Revised resource statement (by end 2018) and second Talaxis investment on subsequent publication of resource technical report (by early 2019)
- Project updates (throughout 2019)
- Completion of BFS (by end 2019)
- Talaxis construction investment decision (end 2019/early 2020)

Valuation

Talaxis transaction read-through valuation

We believe Mkango's share price should be underpinned by the read-through valuation for its attributable share of Songwe Hill from the binding earn-in agreement with Talaxis. The latter has agreed to invest £12m at the project level for an eventual 49% interest on completion of a BFS by the end of 2019. £5m of this has been invested to date (giving Talaxis a 20% interest in Songwe Hill), with the £7m balance (for an additional 29%) committed for deployment on publication of an updated resource statement and accompanying technical report.

The Talaxis agreement values Mkango's share of its REE businesses at 13p per Mkango share...

This puts a transaction value of £24.5m on the project, of which Mkango's 51% attributable share would be £12.5m (11.5p per Mkango share). Moreover, Talaxis has also committed to invest £2m for an eventual 49% stake in the downstream Maginito JV (of which £1m for 24.5% has been invested to date), valuing Maginito at £4m (of which Mkango's residual 51% interest would be £2.1m, or 1.9p per share). Combined, this implies some **13.4p of value for Mkango's interest in its REE businesses as ascribed by the initial transaction with Talaxis**. This represents around 70% upside to the Mkango's current share price, before apportioning any value for its other assets such as the Thambani uranium-niobium-tantalum project.

...rising to at least 55p per Mkango share if Talaxis exercises its option to fund construction capex

The agreement with Talaxis provides for the latter to increase its interest in Songwe Hill to 75% on sourcing project finance post completion of the BFS. The PFS estimated project capex at US$216m (£160m) – were Talaxis to fund this entirely through equity, it would take its total investment to £172m for a 75% stake, valuing Songwe Hill at £229m on a 100% basis. Mkango's 25% attributable share of this would be £57m (52.8p per share), taking its total transaction implied value to **54.7p per share** after also accounting for Maginito. This points to nearly six-times valuation upside potential on successful project financing in late 2019/early 2020.

DCF analysis

We have built a cash flow model of Songwe Hill using the key operational and cost assumptions from Mkango's November 2015 PFS (p26), but have adjusted to incorporate some of our own assumptions on how work currently underway as part of the BFS programme may further optimise the economics (chiefly resource/reserve upside on further drilling and process flow sheet optimisation, including the incorporation of an in-house REE separation facility – see pp27-30 for discussion).

Using an REE basket price assumption of US$45/kg (some 25% lower than the US$60/kg used in the PFS – see pp17-19 for further discussion) and a 10% *real* discount rate, we estimate a post-tax NPV for the project (discounted from today, and excluding feasibility study expenditure) of **US$283m** (assuming construction begins in 2020, with first production in H2 2021). The positive impact of our assumed reserve upside, reduced mining strip ratio and optimised process flow sheet (including downstream REE separation) more than offsets our more conservative pricing assumptions versus the PFS economics (we would derive an $NPV_{10\%}$ of US$249m if using the operational, cost and pricing assumptions used in the PFS).

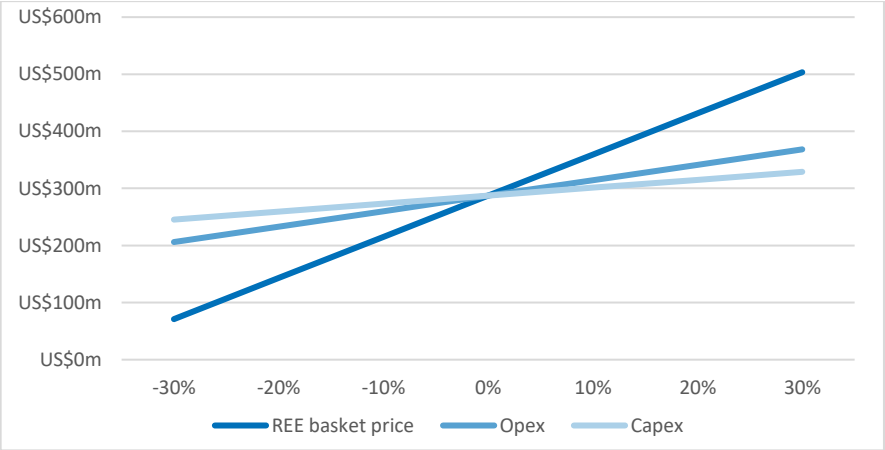
Though introducing assumptions beyond the scope of the published PFS, we nevertheless consider our NPV estimate to be conservative. Most pertinently, we believe an increased reserve could support an expanded operation above the level

Our model points to substantial upside potential with expansion

considered in both the PFS and our own base-case cash flow model. For illustrative purposes we have run a scenario that envisages a doubling of capacity (for an assumed two-thirds increase in capex), which we believe our assumed 50% increase in reserves (still well within the current resource base) could more than adequately support. Under this scenario, our NPV estimate would rise to **over US$400m**.

Figure 4 below illustrates the sensitivity of our base-case NPV estimate to variable REE basket price, opex and capex. The greatest sensitivity is REE prices – in this regard we note that current market prices for Songwe Hill's key REE are below both the assumptions used in the PFS (albeit those assumptions were forecasts for 2020, two years from now) and our own more conservative pricing assumptions. However, prices for the two key magnet elements Nd and Pr are recovering, and we believe the longer-term supply-demand outlook is supportive of further strengthening.

Figure 4: Songwe Hill $NPV_{10\%}$ (base-case ARC assumptions) sensitivity analysis



Source: ARC estimates

On completion of the BFS, Mkango's stake in the unfunded project will be diluted to 51% in return for Talaxis having directly invested £12m in the project. Given we have not included the BFS costs in our NPV calculation (as they will not be borne by Mkango), we attribute 51% of our NPV estimate to Mkango today.

Figure 5 illustrates how our NPV estimate evolves over time with completion of funding (at which point Mkango's equity-attributable interest would drop to 25% in return for Talaxis meeting 100% of the construction costs) and construction.

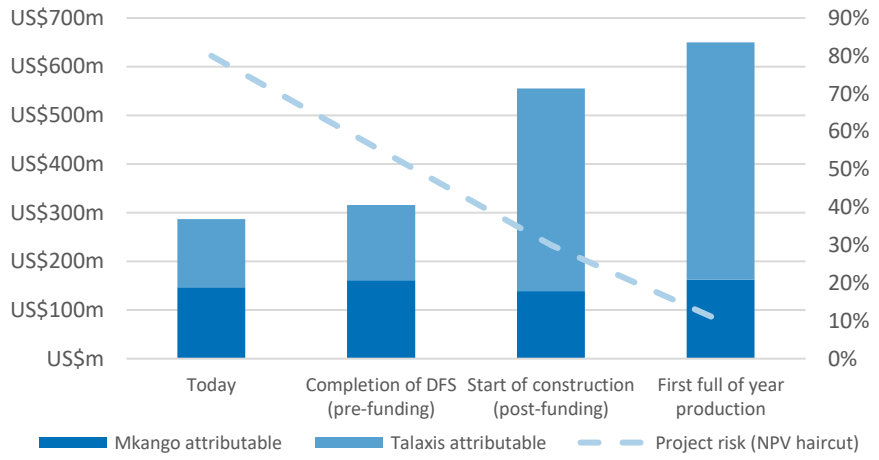
Markets understandably apply substantial risk discounts to feasibility-study stage projects, reflecting the significant hurdles that must be overcome to realise the value implied by DCF analysis (most notably funding and construction risks). This discount to NPV typically narrows as a project advances through funding, construction and into steady-state production. While Mkango's equity attributable share of Songwe Hill will reduce should Talaxis exercise its option to finance the project construction on completion of the BFS, we would argue that this is more than offset by an associated reduction in the risks attached to Mkango realising its share of the project's inherent value at that point.

NPV analysis points to 20p valuation potential in the near term, rising to 100p longer term

On this basis, we would suggest a fair NPV-based valuation of **20p per share today** (being a substantial 80% risk discount to our estimate of Mkango's 51% share of Songwe Hill's NPV today), rising to around **100p per share once Songwe Hill reaches steady production** (being be a 10% risk discount to our estimate of what would be Mkango's 25% share of NPV at that time). The former is more than double Mkango's

current share price, and the latter over 12x. This is a risked NPV growth path that could potentially play out over the next four years without significant share dilution given the funding agreement with Talaxis. Moreover, this analysis takes no account for potential 'blue-sky' valuation upside potential from the Maginito downstream JV with Talaxis nor the Thambani uranium-niobium-tantalum project in Malawi.

Figure 5: NPV and illustrative risk profile evolution



Source: ARC estimates

Market comparable valuation metrics

Direct peer analysis is problematic given the general scarcity of publicly-quoted REE companies with advanced projects, but also because each REE project has a unique product suite and therefore revenue drivers. Nonetheless, to provide context we have plotted Songwe Hill against five of the more advanced REE projects with significant NdPr components (the key 'magnet' elements driving REE demand).

Figure 6: REE project developers market comparable metrics

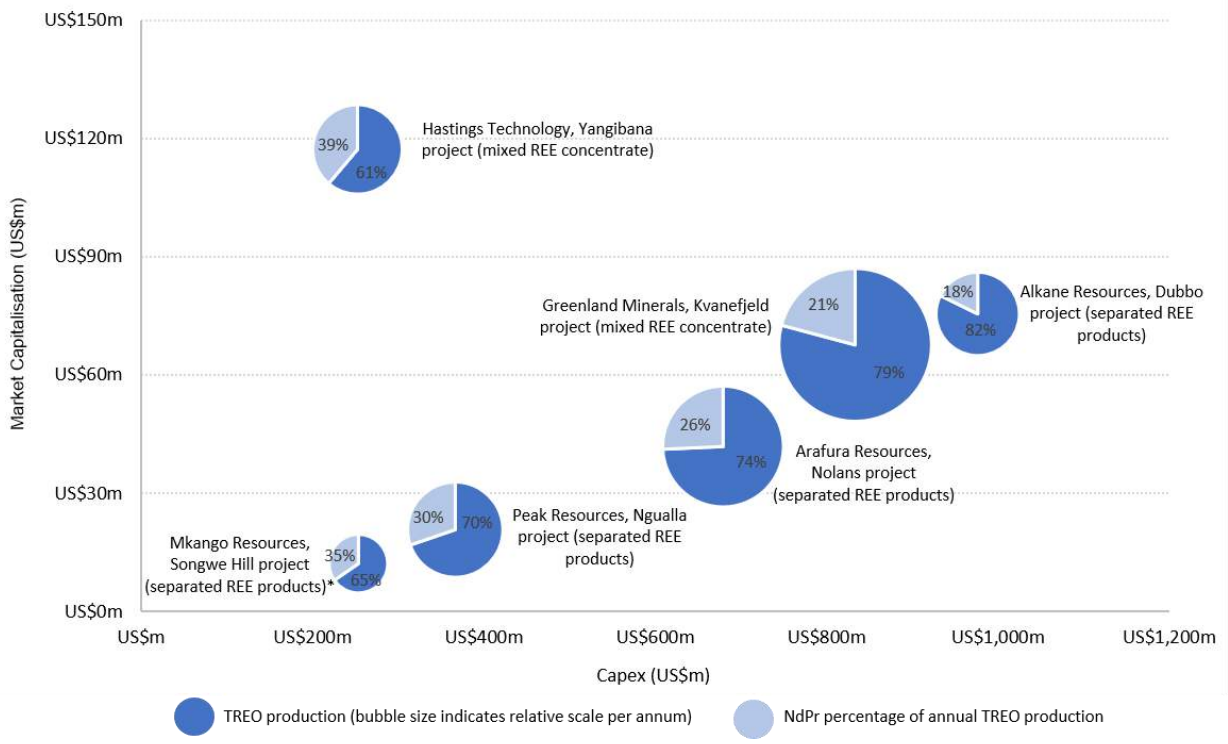
Company (ticker)	Share Price	Mkt Cap US$m	Project	Resources (100% basis) Mt	% REO	Kt REO
Alkane Resources (ALK AU)	A$0.20	76	Dubbo (100%)	75	0.9	662
Arafura Resources (ARU AU)	A$0.10	43	Nolans (100%)	56	2.6	1,456
Greenland Minerals (GGG AU)	A$0.08	68	Kvanefjeld (100%)	1,010	1.1	11,140
Hastings Technology (HAS AU)	A$0.22	117	Yangibana (100%)	21	1.2	246
Peak Resources (PEK AU)	A$0.03	20	Ngualla (75%)	214	2.2	4,620
Average		**65**		**275**	**1.6**	**3,625**
Mkango Resources (MKA LN)	£0.08	12	Songwe Hill (80%)	32	1.5	469

Company	Target production (100% basis) tpa REO	% NdPr	Capex US$m	US$/tonne (attributable) Resource	Prod TREO	Prod NdPr
Alkane Resources (ALK AU)	6,522	18	979	115	11,640	65,557
Arafura Resources (ARU AU)	14,000	26	680	30	3,084	11,995
Greenland Minerals (GGG AU)	24,391	21	832	6	2,787	13,373
Hastings Technology (HAS AU)	7,820	39	251	477	15,013	38,669
Peak Resources (PEK AU)	9,290	30	365	6	2,925	9,669
Average	**12,405**	**27**	**621**	**127**	**7,090**	**27,853**
Mkango Resources (MKA LN)	3,400*	35	255*	31	4,269	12,337

**ARC estimate of potential Songwe Hill BFS development scenario (incorporating downstream REE separation)* *Source: Bloomberg, company websites*

Songwe Hill compares very favourably in terms of its high proportion of NdPr in the forecast product mix (and crucially has a significantly lower capex requirement than most its peers – capex being a key barrier to production), yet it is significantly trailing the peer group average market valuation metrics.

Figure 7: Songwe compares favourably against other REE projects on NdPr percentage and development cost



**ARC estimates for Songwe Hill potential BFS scenario* *Source: Bloomberg, company websites*

Once production and positive cash flow has been established at Songwe Hill, we would expect Mkango to be valued on an earnings multiple basis. AIM-quoted, single-asset junior mining companies operating in Africa are trading at EV/EBITDA multiples of 2-7x (Figure 8). Applying the average of 4x to our estimate of Mkango's 25% attributable share of EBITDA from Songwe Hill in 2022 (our modelled first full year of stable production post ramp-up in H2 2021) suggests Mkango could command a market valuation of US$137m or 94p once Songwe Hill is in established production (a level similar level to that derived by our NPV evolution analysis).

Figure 8: AIM-quoted African single-asset junior mining companies

Company	Ticker	Commodity	Country	Price GBp	Mkt Cap US$m	EV US$m	2018e EBITDA US$m	EV/EBITDA X
Avesoro Resources	ASO LN	Gold	Liberia	239	256	374	132	2.8
Base Resources	BSE LN	Mineral Sands	Kenya	16	235	353	108	3.3
Bushveld Minerals	BMN LN	Vanadium	South Africa	27	375	354	50*	7.1
Caledonia Mining	CMCL LN	Gold	Zimbabwe	685	95	84	30	2.8
Gem Diamonds	GEMD LN	Diamonds	Lesotho	114	207	206	102	2.0
Hummingbird Resources	HUM LN	Gold	Mali	27	122	146	43	3.4
Kenmare Resources	KMR LN	Mineral Sands	Mozambique	218	313	347	97	3.6
Pan African Resources	PAF LN	Gold	South Africa	7	220	214	32	6.7
Average								**4.0**

**ARC estimate (Bushveld's equity-attributable share of consolidated EBITDA)* *Source: Bloomberg consensus estimates, company websites*

Forecasts

Our five-year summary operational and financial forecasts in Figures 9-12 below assume Songwe Hill investment (funded by Talaxis) is fully consolidated in Mkango's accounts until the end of 2019. From that point on we switch to an equity-attributable accounting method, assuming Talaxis exercises its option to fund the project build in its entirety, thereby diluting Mkango's equity interest to 25%.

Figure 9: Summary Songwe Hill operational data

		LOM avg	2018e	2019e	2020e	2021e	2022e
REO volumes (contained in concentrate)	t	3,400	-	-	-	1,908	4,664
REO basket sales price	US$/kg	45.00	-	-	-	45.00	45.00
Total cash costs (including royalties)	US$/kg	18.00	-	-	-	19.56	14.50
Margin	%	60	-	-	-	57	68
Mkango equity interest (year-end)	%		51	25	25	25	25

Source: ARC estimates

Figure 10: Summary profit & loss

		2017	2018e	2019e	2020e	2021e	2022e
Revenue	US$m	-	-	-	-	21.5	52.5
Operating costs	US$m	-	-	-	-	(9.3)	(16.9)
Corporate G&A	US$m	(0.7)	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)
Other	US$m	(1.7)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)
EBITDA	**US$m**	**(2.4)**	**(1.3)**	**(1.3)**	**(1.3)**	**10.9**	**34.3**
D&A	US$m	(0.0)	-	-	-	(1.1)	(2.7)
EBIT	**US$m**	**(2.4)**	**(1.3)**	**(1.3)**	**(1.3)**	**9.8**	**31.6**
Net finance and FX costs	US$m	(0.1)	-	-	-	-	-
Pre-tax profit/(loss), before exceptional items	**US$m**	**(2.5)**	**(1.3)**	**(1.3)**	**(1.3)**	**9.8**	**31.6**
Tax	US$m	-	-	-	-	(3.1)	(9.2)
Net profit/(loss), adjusted	**US$m**	**(2.5)**	**(1.3)**	**(1.3)**	**(1.3)**	**6.7**	**22.4**

Source: ARC estimates

Figure 11: Summary cash flow

		2017	2018e	2019e	2020e	2021e	2022e
Cash flow from operations	US$m	(0.6)	(0.8)	(0.8)	(0.8)	8.2	25.5
Cash flow from investing activities	US$m	-	(6.8)	(9.5)	(0.7)	(0.7)	(0.7)
Cash flow from financing activities	US$m	1.0	19.4	-	-	-	-
Increase/(decrease) in cash	**US$m**	**0.3**	**11.8**	**(10.3)**	**(1.5)**	**7.5**	**24.8**

Source: ARC estimates

Figure 12: Summary balance sheet

		2017	2018e	2019e	2020e	2021e	2022e
Cash	US$m	0.7	12.5	2.2	0.6	8.1	33.0
P,P&E	US$m	0.0	0.0	0.0	44.6	62.7	60.4
Intangible and other assets	US$m	0.3	7.1	16.5	17.2	17.9	18.6
Total Assets	**US$m**	**1.0**	**19.6**	**18.7**	**62.5**	**88.8**	**112.0**
Total Liabilities	US$m	2.3	2.3	2.3	2.3	2.3	2.3
Equity	US$m	(1.3)	17.3	16.5	60.3	86.5	109.7
Liabilities & equity	**US$m**	**1.0**	**19.6**	**18.7**	**62.5**	**88.8**	**112.0**

Source: ARC estimates

Risks

- **Commodity pricing:** Though some 25% below the basket price used in the PFS economic analysis, our REE price assumptions are materially higher than current market levels. Though we feel the compelling supply-demand outlook is supportive of future higher prices, there can be no guarantee this will materialise. Lower than forecast future REE prices would have an adverse impact on our valuation and financial estimates.
- **Funding:** We consider Mkango carries significantly lower funding risk relative to many of its REE project developer peers given its strategic agreement with Talaxis. Nevertheless, there is risk attached to Talaxis meeting its funding obligations and options, particularly given potential financial constraints at its parent group, Noble. However, we note that £5m of the £12m initial investment has already been deployed, with the £7m balance only subject to an updated resource and accompanying technical report being published.
- **Technical:** As with all pre-production projects, there is risk that the operational and cost performance of a future mining operation at Songwe Hill may differ materially from the estimates laid out in project technical and economic studies undertaken to date. Moreover, our own cash flow modelling introduces assumptions beyond the scope of the 2015 PFS – the reasonableness of these assumptions will only become apparent on completion of the BFS next year.

Rare earths market overview

Though a small market compared with many more mainstream globally traded commodities, REE are integral to the workings of many industrial applications and clean energy technologies. And after several muted years, significant interest has returned to the sector over the past twelve months, with prices for select REE rising on the back of excitement surrounding the demand outlook for permanent magnets and growing concerns surrounding security of supply, for so long dominated by China.

NdPr permanent magnets are widely used in EV motors and wind turbines

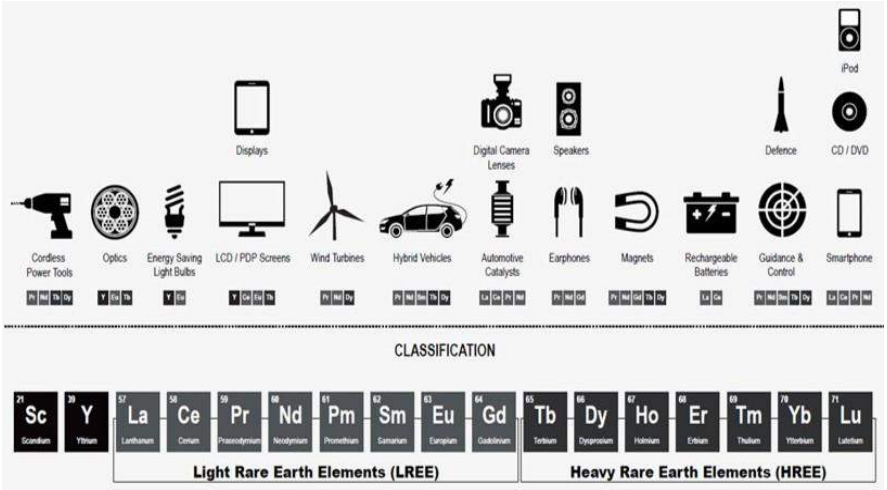
Magnets containing the light rare earth elements (LREE) neodymium and praseodymium are amongst the strongest available commercially, and are particularly attractive to the fast-growing electric vehicles market as they allow motors to be reduced in size and weight versus induction motors without compromising power. Such characteristics also make NdPr permanent magnets well suited for use in wind turbines, another growing source of demand. Some heavy rare earth elements (HREE) such as dysprosium and terbium are also used in magnet manufacturing, albeit in less quantities compared with neodymium and praseodymium.

On the supply side of the equation, concerns are mounting over future security of supply as China – the dominant supplier accounting for >80% of global REE output – continues to pursue policies that seek to curtail illegal domestic production and consolidate its industry around downstream, value-added products.

Rare earth elements 101

REE are generally considered to comprise the 15 lanthanide elements plus yttrium and scandium (yttrium being included as it has a similar ionic radius to the lanthanides and similar chemical properties, and scandium owing to its tendency to be concentrated into many of the same minerals as the lanthanides). REE are further sub-classified as either light or heavy based on electron configurations – LREE have an increasing number of unpaired electrons in their 4f shells (starting at lanthanum, which has zero unpaired electrons, through to gadolinium, which has seven), while HREE have paired electrons (a clockwise and counter-clockwise spinning electron).

Figure 13: REE classification and uses



Source: China Water Risk

Despite the name, REE are not particularly rare – lanthanum, cerium, neodymium, yttrium, and scandium are actually more abundant in nature than lead, while praseodymium, dysprosium, samarium, gadolinium, erbium, and ytterbium are more abundant than tin. However, the physical and chemical characteristics of REE tend to see them occur in dissipated form in most rock types, and so it is rare to find REE highly concentrated in nature, and even more so in a mineralogical assemblage that lends itself to economically viable processing. Geologically, most economic REE deposits occur in alkaline igneous rocks, and specifically carbonatite intrusions. Less commonly, economic mineralisation can occur in pegmatites, and also as placer deposits from deep weathering of the igneous pre-cursor rocks.

REE specific chemical and physical properties lend them for use in a wide array of applications. In simple terms these end-use applications can be grouped into two broad categories: 'process enablers' (in which instance the REE are used in production processes but are not contained in the end product) and 'product enablers' (in which instance REE are necessary to provide the physical and/or chemical properties that are integral to the performance of the end product).

Permanent magnets have emerged as the most important end-use application for REE

Examples of *process* enabling applications include using LREE in polishing powders in the glass, electronics and optic industries, and as fluid-cracking catalysts in refining and other chemical processes. The most important *product* enabling application is use in the manufacturing of permanent magnets (for use in electric vehicles, wind turbines and other industrial motors), where the addition of certain REE (most notably neodymium and praseodymium) significantly boosts the strength of the magnets whilst maintaining mass below an acceptable level for the end-use application. Other product enabling end-use applications include REE phosphors for lighting and displays (e.g. in fluorescent lamps and LCD screens), use in batteries, in autocatalysts, and as additives in high-tech alloys, glass and ceramics.

Figure 14: REE classification and uses

Source: Adamas Intelligence

Supply: China still dominates, but exports tightening

China accounted for over 80% of global production of REE in 2017 according to speciality commodity consultant Roskill, a position of dominance it has held since the 1990s when its technological strides in processing domestic ores and its undercutting of global REE prices coincided with the decline of the Mountain Pass operation in the US, hitherto the world's single largest producer.

However, China's share of global supply has fallen from over 90% earlier this decade, a result of Chinese government policy to crack down on environmentally unfriendly illegal domestic production (which had surged toward the end of last decade amid elevated global REE prices following the imposition of export duties in China) and to further consolidate and vertically integrate its legitimate domestic production via output quotas and export licences.

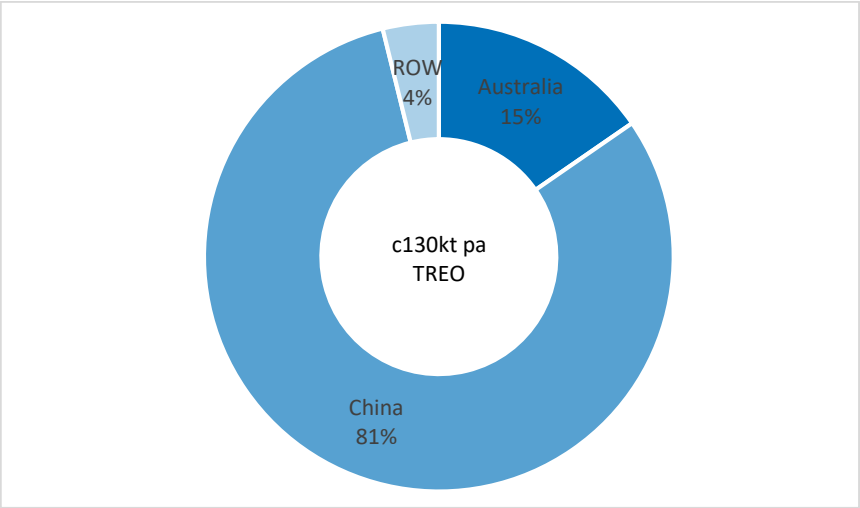
China, the world's dominant REE producer, is restructuring its domestic industry

Nevertheless, China remains by far the dominant producer of REE globally, a situation perhaps of concern to the West given the strategic importance of REE to many industrial processes and technological applications. Perhaps understandably given its status as by far the world's largest consumer of REE, China appears to be attempting to restructure its REE supply with a view to concentrating domestic output towards downstream value-added products to support other strategic domestic industries. The knock-on effect of this is a tightening of exports of semi-finished and finished REE products from China for industrial use elsewhere in the world, increasing the strategic importance of REE supply chains being developed outside of China.

Near term production sources outside of China are limited

Currently the only significant non-Chinese REE supplier is ASX-quoted Lynas Corp (LYC AU), which accounts for around 12% of global production from its integrated Mount Weld operation in Australia. Africa has only one production source at present (accounting for <1% of global REE supply), with UK-quoted Rainbow Rare Earth last year commencing production of high-grade mineral concentrates from its Gakara veins deposit in Burundi. However, there are several advanced exploration projects elsewhere on the continent which, if developed, could see Africa gain an increasing share of global REE production over coming years. In addition to Mkango's Songwe Hill project, notable projects include Ngualla in Tanzania (owned by Peak Resources, PEK AU) and Longonjo in Angola (Rift Valley Resources, RVY AU).

Figure 15: Global REE production by geography in 2017



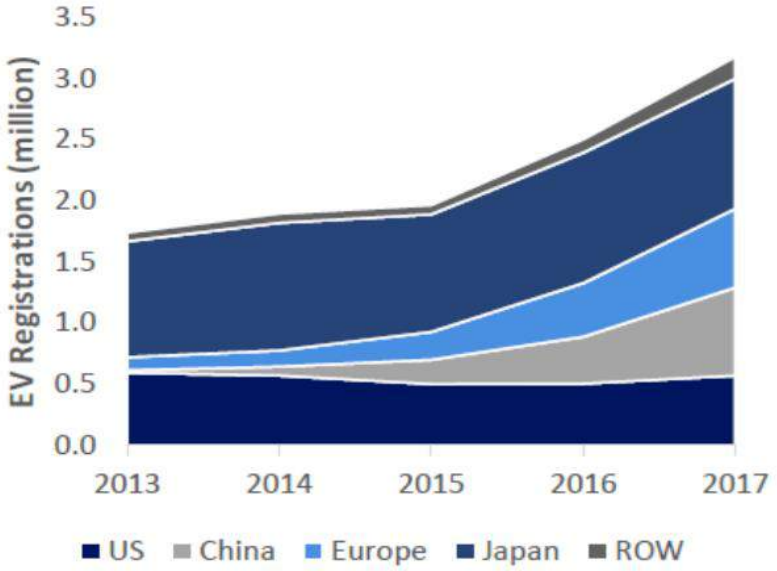
Source: USGS

Demand: Nd-Pr use in motor magnets driving growth

The EV market is growing at a CAGR of over 50%...

While there are multiple end use applications for the REE suite, it is permanent magnets, already the single largest end-use market, that are expected to be the dominant driver of demand growth over the near to medium term given their use in the electric vehicle (EV) sector (which is expanding at a CAGR of >50% - Figure 16) and in wind turbine technology. Given their status as the dominant REE used in permanent magnet alloys, it follows that neodymium and praseodymium (and to a lesser extent dysprosium) have the most compelling forward-looking demand fundamentals across the REE suite.

Figure 16: EV take-up rates have soared over the past five years



Source: Adamas Intelligence (April 2018)

...driving demand for NdPr based permanent magnets

High-strength, high-performance NdPr based permanent magnets have been commercially available since the 1980s, but recent developments in the EV market and wind turbine technology have driven a marked increase in demand – Roskill estimates a CAGR of over 9% over the past five years (Figure 17). The consultant expects demand growth from this sector to be maintained at well over 5% pa over the next five years, from a larger starting base, based on projected future take-up levels in the EV market and further growth in the wind turbine market.

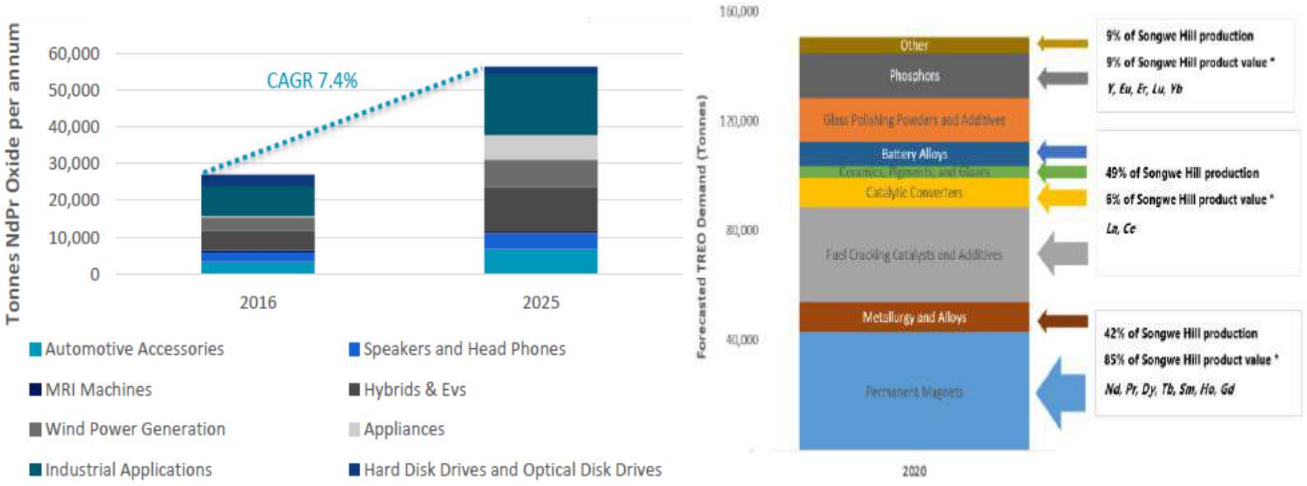
Figure 17: REE demand forecast by end-use application

Application	Main REE	Demand (kt pa REO)				CAGR (% pa)		
		2012	2017e	2022f	2027f	2012-17	2017-22	2022-27
Magnets	Nd, Pr, Dy	24.3	37.5	50.1	57.9	9.1	5.9	2.9
Catalysts	La, Ce	23.8	30.3	37.4	42.5	5.0	4.3	2.6
Polishing	Ce	14.3	15.1	17.0	19.7	1.2	2.3	3.0
Batteries	La, Ce	8.4	10.8	14.4	11.7	5.2	5.9	-4.0
Metallurgy	Ce, La	9.1	9.8	10.6	11.8	1.4	1.6	2.2
Glass	Ce, La, Er	8.1	9.5	11.8	14.7	3.3	4.5	4.4
Ceramics	Y, Ce, Nd	5.5	7.8	9.8	12.4	7.3	4.6	4.8
Phosphors	Y, Pr, Ce, La	6.0	2.7	2.7	2.8	-14.9	0.1	0.8
Other	Ce, La, Y	7.2	13.1	18.6	25.6	12.8	7.2	6.6
Total		**106.5**	**136.3**	**172.3**	**199.2**	**5.0**	**4.8**	**2.9**

Source: Roskill Consulting (reproduced in third-party report)

Consultant Adamas Intelligence forecasts that, when combined with more modest growth in other end-use market segments, this strengthening demand from permanent magnet motor applications in the automotive and wind-power generation markets could see gross demand for Nd and Pr grow by a CAGR of over 7% to 2025. This could see REE demand (on an oxide concentrate basis) from permanent magnets alone exceed 40,000t pa by the end of this decade (Figure 18), and potentially breach 50,000t pa during the first half of next decade.

Figure 18: REE demand growth forecast by end-use (LHS) and anticipated Songwe Hill 2020 product demand (RHS)



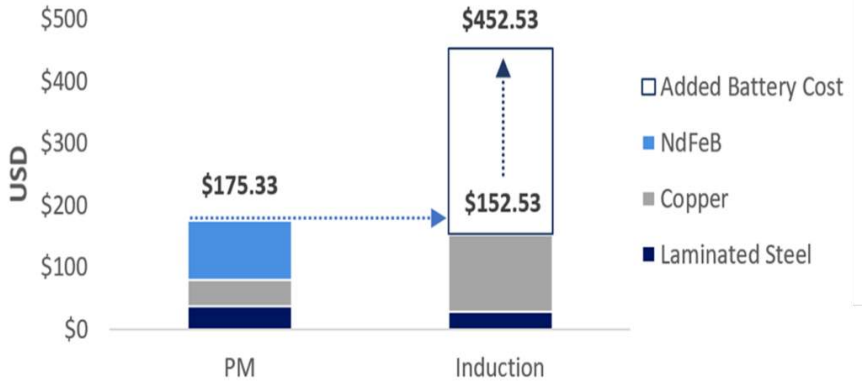
Source: Adamas Intelligence (reproduced in third-party presentations)

REE-bearing permanent magnet motors are currently used in over 90% of EVs, and, in our opinion, are likely to remain the optimal motor technology of choice for the sector (as evidenced by Tesla's recently announced switch from induction motors to permanent magnet motors in its manufacturing of its new EV models).

Permanent magnet EV motors have greater capacity than similar sized induction motors

Adamas Intelligence estimates that batteries used to power an induction motor require at least a 5% greater capacity versus those used to power a similar sized permanent magnet motor to compensate for the former's lower efficiency, and that, in addition to adding weight, this this could increase the powertrain costs by upwards of US$300 (assuming a conservative US$100/kWh battery cost). We thus are of the view that REE permanent magnet motors are likely to remain significantly more economic for EV use, even in the event of future REE price increases.

Figure 19: Material costs for comparable permanent magnet and induction motors



Source: Adamas Intelligence (April 2018)

While Nd and Pr are critical ingredients to the magnets in EV powertrain motors, growth in hybrid-electric vehicles should also benefit demand for other REE, most notably cerium and lanthanum, which have use as fuel additive and in catalytic converters (Figure 20). Fuel-cracking catalysts and additives are currently the second largest end-use market for REE behind permanent magnets. According to Roskill, this market currently stands at around 30,000t pa, and is forecast to grow at a CAGR of over 4% over the next five years.

Figure 20: REE are critical components in fully electric and hybrid electric vehicles

Source: Mkango Resources

Pricing trends

REE are not exchange-traded commodities, pricing instead established on a trade by trade spot or contract basis between producers/traders and end-use customers. However, indicative market pricing data is published by certain commodities market intelligence agencies, usually on an FOB China basis. Until 2015 there was effectively a two-tier market structure, with lower prices in China for domestic use and higher prices for export product (the latter in theory equating to the domestic price plus the applicable export tariff, though in practice FOB prices often exceeded domestic prices by an even larger premium).

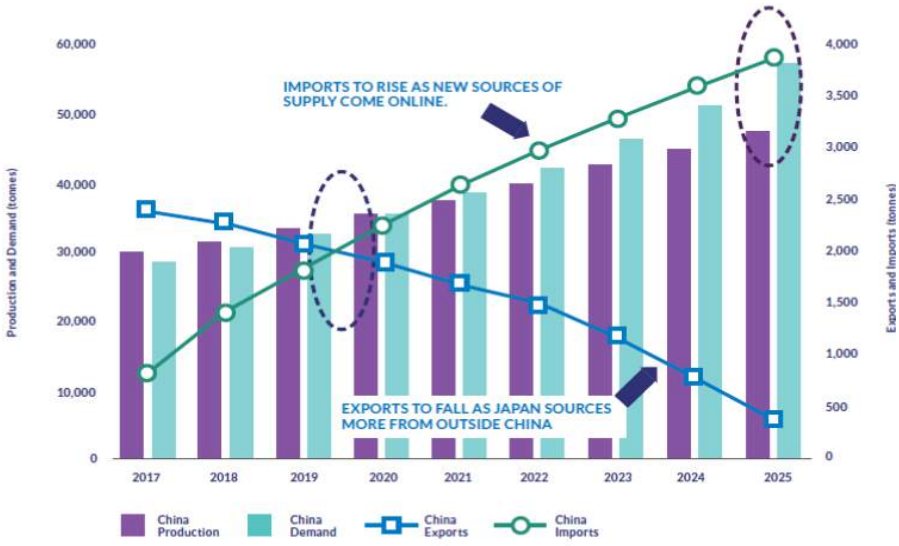
From 2008 through to 2011 both Chinese domestic and FOB prices of all REE increased sharply, driven by a significant pull back in Chinese exports that prompted subsequent panic buying by foreign customers on supply concerns. However, the 2011 price spike only served to fuel a surge of illegal/unregulated REE production in China that increased global supply and consequently saw prices soften materially. A World Trade Organisation ruling in 2014 lead to China abolishing its export quotas in 2015, marking a pricing nadir and a convergence of the hitherto tiered domestic and export pricing structure.

REE prices drifted across the board through 2016, but the 'magnet' REE began a marked recovery in the second half of 2017 on rising demand for permanent magnets from the EV markets in particular. Prices cooled somewhat in H1 2018 following an increase in China's quota for mined ore, but given the compelling supply-demand drivers discussed previously we believe pricing risk now lies to the upside over the medium to longer term.

Rising domestic production costs and tightening Chinese exports could drive REE prices higher

China's continued crackdown on illegal mining and simultaneous stricter enforcement of environmental controls on legitimate operations could lead to an increase in domestic production costs. Together with a greater emphasis on production of more downstream products, this could reduce material available for export and, in time, perhaps even see China becoming a net importer of certain REE (Figure 21). There is therefore a strong strategic rationale for alternative REE supply sources being developed outside China.

Figure 21: China Nd-Pr import-export forecast



Source: Adamas Intelligence (reproduced in third-party presentation)

Mkango's Songwe Hill deposit carries a high proportion of the key 'magnet' REE

Mkango's Songwe Hill deposit is blessed with a high proportion of the four REE most critical to the two largest end use markets – Nd and Pr for permanent magnets (Nd and Pr are forecast to account for 27% and 8% respectively of Songwe Hill's future REO concentrate production) and La and Ce for fuel-cracking catalysts and additives (38% and 12%). Based on its supply-demand outlook to 2020, specialist industry consultant Adamas Intelligence estimated an average 'basket price' for the suite of REE in Songwe Hill's future production mix at just under US$60/kg for use in the 2015 prefeasibility study (Figure 22).

*Figure 22: PFS base case Songwe REO price contribution forecasts**

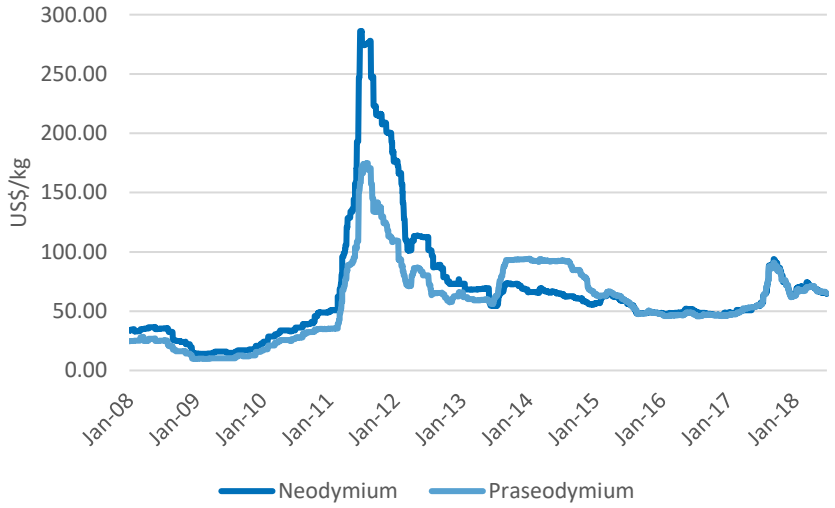
Element	Symbol	REO in concentrate	Revenue contribution
Lanthanum	La	37.8%	5%
Cerium	Ce	12.0%	1%
Praseodymium	Pr	8.0%	14%
Neodymium	Nd	26.6%	53%
Samarium	Sm	4.0%	1%
Europium	Eu	0.9%	7%
Gadolinium	Gd	2.2%	2%
Terbium	Tb	0.3%	3%
Dysprosium	Dy	1.2%	12%
Yttrium	Y	5.8%	2%
Songwe basket			**US$60/kg**

**Forecast prices in 2020, as estimated by Adamas Intelligence* *Source: Mkango Resources*

We note that the underlying price assumptions for the individual REE are some way ahead of current market pricing (particularly in the case of the HREE), albeit we are

still two years from the reference date for those assumptions. Prices for the key magnet elements are now trending upwards however, and we consider a long-term price assumption of cUS$100/kg for NdPr reasonable given the compelling supply-demand dynamics outlined above. On this basis we apply a US$45/kg 'basket' REE price assumption for Songwe Hill in our cash flow modelling (a 25% discount to the PFS pricing assumption, largely reflecting our more conservative outlook for the less core HREE).

Figure 23: Nd and Pr ten-year price history (Shanghai market)



Source: Bloomberg

Company overview

Mkango Resources Ltd is a TSX Venture Exchange (TSX-V) and AIM-quoted exploration and development company focused on advancing REE and associated minerals projects in Malawi. Its core asset is the Songwe Hill REE project, which is currently being advanced through bankable feasibility in conjunction with Talaxis Ltd, a wholly-owned subsidiary of the global commodities trader and supply-chain management company Noble Group.

Corporate history

Mkango was formed in January 2011 with the reversal into an erstwhile TSX Venture Exchange quoted shell of Lancaster Exploration Ltd, a private company controlled by Mkango's current executive management team whose principal asset was the Songwe Hill REE exploration project in Malawi.

The group raised C$7.8m in conjunction with the transaction through a private placing of shares and warrants at C$0.50/unit. A further three funding rounds were undertaken in the Canadian market over the period 2013-15 as Songwe Hill was progressed through resource drilling and prefeasibility study. In June 2016 Mkango undertook a 3-for-1 share consolidation and took a secondary listing on London's AIM market, raising £1m through a placing of new shares and warrants at 3.3p/unit in conjunction with the new listing.

Capital structure and funding position

Noble subsidiary Talaxis is Mkango's largest shareholder

In December 2016 Mkango issued two-year share purchase warrants to a wholly-owned subsidiary of Noble (which now trades as Talaxis) as part of an agreement between the two parties to collaborate on marketing strategies for future REE production at Songwe Hill (an agreement which subsequently evolved into a formal earn-in to the project by Talaxis – see pp21-22). At the same time, a placing of shares to new and existing shareholders (at3.5p/share) added two specialist Swiss institutional funds to Mkango's register, the Rare Earth Elements Fund and the Metals Exploration Fund. Talaxis became the company's single largest shareholder in September 2017 after subscribing to a £0.5m private placing, also priced at 3.5p/share.

Figure 24: Major shareholders

Talaxis (Noble Group)	13.2%
RESOC	10.3%
Leominex*	7.9%
M McNulty	4.9%
Rare Earth Elements Fund	2.8%
Metals Exploration Fund	2.8%

**Mkango directors W. Dawes and A. Lemon each hold 17.3% of Leominex Source: Mkango Resources*

As at 31 March 2018, Mkango had cash on the balance sheet of US$8.6m, most of which had been injected in the first quarter of the year by Talaxis following the commencement of its earn-in agreement. This cash is therefore largely ring-fenced for direct investment in the Songwe Hill project, though some can be utilised to fund corporate-level activities (while Talaxis is funding the project feasibility study, Mkango is managing it).

Mkango has a significant number of warrants and options outstanding, issued as part of previous equity placings. Of the 55m (for US$7.3m of cash on exercise) of total

warrants and options outstanding, some 45m (for US$2.7m) are in the money at Mkango's current share price.

Figure 25: Capital structure

Shares outstanding (as at 07/08/18)	108.7m	
Options	7.0m	C$0.06
	2.8m	C$0.07
Warrants	22.3m	£0.066
	12.0m*	£0.066
	7.6m	C$0.60
	2.5m	C$0.15
	0.7m	£0.035
Fully diluted shares	164.1m	
Current cash position (as at 31/03/18)		US$8.6m**
Potential future cash inflow from option/warrant exercise		US$7.3m

**Warrants held by Talaxis **Includes £6m of Talaxis investment to projects Source: Mkango Resources*

Talaxis alliance

In November 2016 Mkango entered into an agreement with Talaxis that provides for the latter to earn up to an ultimate 75% interest in Songwe Hill in return for funding the project right through to production.

Talaxis is earning a 49% interest in Songwe Hill through the staged investment of £12m to fund the project BFS...

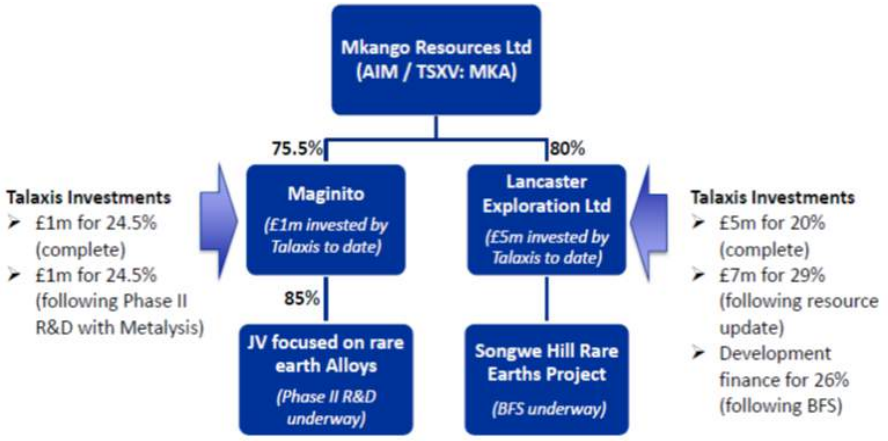
The first part of the agreement will see Talaxis earn a 49% interest in the project through the staged investment of £12m to fund a bankable feasibility study (BFS) of the project. The first £5m of this investment has been received by the project company (Lancaster Exploration), earning Talaxis a 20% stake. The proceeds are being used to fund the first phase of the BFS, including in-fill, geotechnical and exploration drilling, bulk sampling, metallurgical optimisation work and environmental and social studies. Talaxis will commit the £7m balance of BFS funding (earning an additional 29% interest in the project) on Mkango publishing a technical report on an updated NI 43-101 compliant resource (the latter targeted by the end of 2018).

...and has an option to move to 75% ownership and offtake rights by funding the project build

On completion of the BFS, Talaxis will have the option to acquire a further 26% interest in Songwe Hill (taking its total ownership to 75%) and to secure off-take rights for 100% of future production by arranging funding for project development. Mkango's November 2016 prefeasibility study of Songwe Hill estimated the project development capital expenditure requirement at US$216m (p26). Should Talaxis choose to exercise, Mkango would then hold a 25% interest in the project, free carried through to the commencement of production.

The alliance with Talaxis also extends to Mkango's downstream research and development initiatives. Under the terms of the November 2017 agreement, Talaxis can invest £2m to earn up to a 49% interest in Mkango's Maginito subsidiary, a newly-established venture focused on neodymium alloy powders, magnet and other technologies (including Mkango's collaboration with the private UK metal alloys research group Metalysis). The first £1m has been committed (earning Talaxis a 24.5% interest in Maginito), and is being deployed to fund expenditure under the Metalysis joint venture (a work programme focused on advanced alloys using neodymium or praseodymium with other elements for magnet development and potential 3D printing applications). The £1m balance will be invested on successful completion of this phase of the research and development programme with Metalysis, earning Talaxis a further 24.5% interest in Maginito.

Figure 26: Talaxis agreement structure



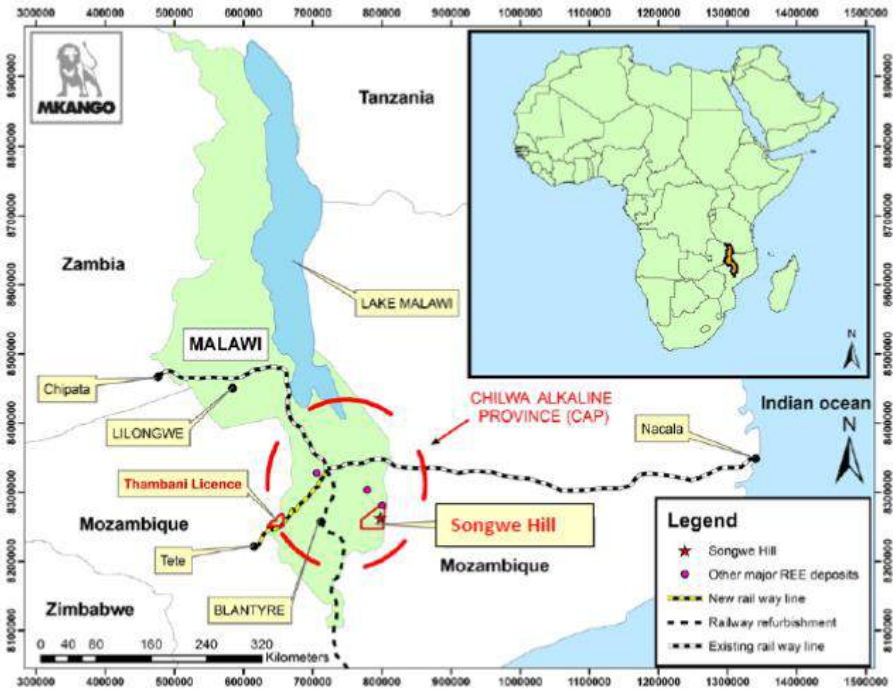
Source: Mkango Resources

Songwe Hill REE project

Songwe Hill is the principal project within Mkango's Phalombe licence in southeastern Malawi, which lies approximately 70km from the country's former capital, Zomba, and 90km from the commercial centre of Blantyre (which has an international airport and a railhead). A paved highway passes within 15km of the project, linked by secondary gravel and dirt roads which allow year-round access.

The Songwe Hill deposit forms a steep-sided conical hill with a diameter of approximately 800m that rises to a summit elevation of 990m. Its slopes are densely vegetated with elephant grass following the rainy season (December to March), but vegetation does not hinder access at other times of the year. Climatic conditions are not expected to impact on the future operation of the planned mine, which it is expected will operate all year round.

Figure 27: Songwe Hill project location



Source: Mkango Resources

Geology and resources

Songwe Hill is a carbonatite hosted REE deposit

Songwe Hill has been interpreted as a volcanic vent associated with multiple phases of alkalic intrusions into the pervading Precambrian granulite/gneiss basement rocks. The principal lithologies of the vent complex are carbonatite, fenite and breccia, with REE mineralisation occurring in all three. The mineralised body is thought to be a carbonatite plug with essentially sub-vertical margins, striking northeast-southwest in plan view.

The carbonatites, fenites and breccias are exposed intermittently over a surface area of approximately 350m by 100m, though the main zone of mineralisation outcrops along the northeastern slope of the hill. Mineralisation is untested to the northeast and southwest beyond the limits of the present drilling and below the deepest vertical intersection (approximately 350m below surface), but is considered open.

Management believes there is further exploration potential both at Songwe Hill and at other carbonatites identified in the wider region.

The dominant REE-bearing minerals are synchysite and apatite, the latter anomalously enriched in the HREOs relative to that typically encountered in carbonatite deposits. Mineralisation is closely associated with strontianite and baryte and is interpreted to have formed through sub-solidus hydrothermal alteration following the carbonatite intrusion.

Resources currently stand at 31.8Mt grading 1.5% TREO, including reserves of 8.5Mt at 1.6%

The first significant investigation of the REE potential of Songwe Hill was undertaken in the late 1980s by a Japanese consortium in conjunction with Malawi's Geological Survey. After being granted the licence in 2010, Mkango undertook a two-phase diamond drilling programme totalling some 6,850m. The results from this culminated in the estimation of a maiden NI 43-101 compliant mineral resource totalling 31.8Mt grading 1.48% total rare earth oxides (TREO) in late 2012. A prefeasibility study (PFS) of the development potential of the project in 2014-15 resulted in a maiden mineral reserve of 8.5Mt at 1.60% TREO being calculated from the indicated portion of the resource inventory. Management anticipates that the BFS drilling now underway could upgrade a material amount of currently in pit-shell inferred resources to measured and indicated status (enabling them to be included in a future updated reserve calculation).

Figure 28: 2012 resource statement and 2015 reserve calculation

Category	Tonnage	TREO	TREO content
	Mt	%	t
Indicated	13.16	1.62	213,098
Inferred	18.59	1.38	256,149
Total Resources	**31.75**	**1.48**	**469,247**
Proven	8.48	1.60	136,139
Probable	-	-	-
Total Reserves	**8.48**	**1.60**	**136,139**

Source: Mkango Resources

2015 prefeasibility study demonstrates viability

A 2015 PFS demonstrated the potential for a 2,840t pa REE-in-concentrate open-pit operation

In November 2015 Mkango completed an updated PFS of the potential for developing Songwe Hill as an open-pit mining operation with an on-site ore beneficiation and hydrometallurgical recovery facility to produce around 2,840t per annum of REO enriched mixed chemical concentrate (of which over one-third is accounted for by the economically important 'magnet' rare earths, including neodymium and praseodymium).

Mining

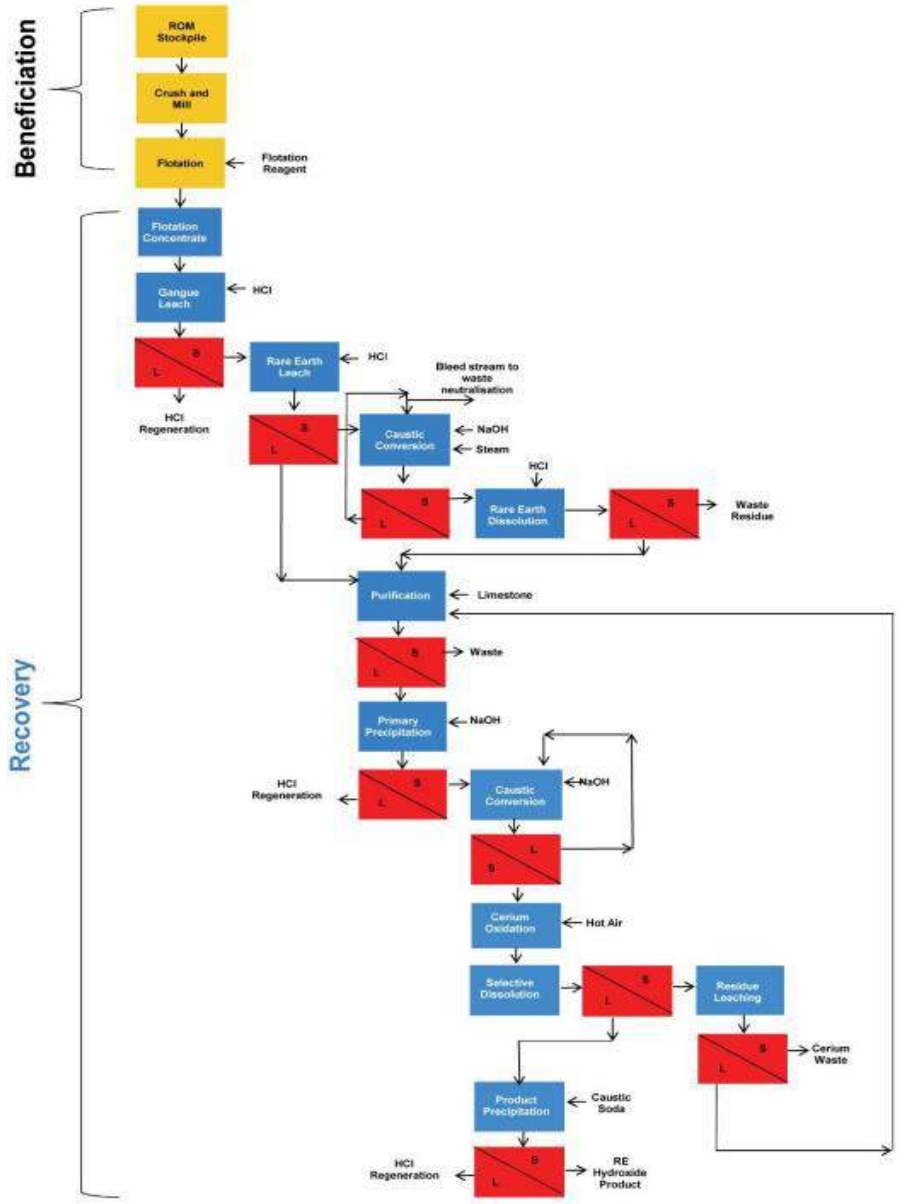
The mineral reserve was optimised based on a conventional open-pit mining operation, which the PFS assumes is undertaken on a contract basis (a contract mining company visited the project during the PFS work programme and was integrally involved in the mine planning exercise). The PFS envisages an 18-year life of mine (LoM), but with annual rates and grades varying and ore stockpiling undertaken in order to manage the grade feed to the plant to optimise returns (the PFS mill-feed grade averages c2.0% TREO over the first five years before declining thereafter, for a LoM average of 1.6% TREO).

Flow sheet comprises conventional low-temperature processing

Processing

Delivering a technically and economically viable process route is undoubtedly the critical challenge of any rare earths project. In this regard Mkango is well advanced, having undertaken a comprehensive three-year programme of mineralogical studies leading up to the PFS metallurgical test work programme. This identified that the economically key 'magnet' LREE are associated with the fluorocarbonate mineral synchysite, and confirmed that Songwe Hill's phosphate mineral apatite contains significantly higher concentrations of HREE and yttrium relative to typical carbonotite-hosted deposits. These mineralogical characteristics should allow Songwe Hill ore to be treated using hydrometallurgical processes to recover its REE content, rather than having to employ more energy and capital intensive high-temperature process recovery routes (as required by projects dominated by monazite, xenotime or other refractory REE minerals).

Figure 29: Songwe Hill PFS process flowsheet



Source: Mkango Resources

A two-stage leaching process will be adapted to recycle acid

There are two main components to the flowsheet proposed in the PFS – a beneficiation plant and a REO concentrate recovery plant. The beneficiation plant will comprise comminution and flotation circuits, the former utilising crushing and milling to reduce the size of ore particles, and the latter using various reagents to separate the REO minerals from gangue material. The beneficiated flotation concentrate then feeds to the recovery plant, which involves a two-stage selective hydrochloric acid (HCl) leach process with capability for HCl to be recycled via calcium sulphate precipitation with sulphuric acid.

In the first (gangue leach) stage, it was proposed that HCl be used to remove calcite, with minimal rare earth losses. HCl would then be recycled from the resulting solution using sulphuric acid (sulphuric acid being considerably cheaper to produce versus the cost of importing HCl if the latter were not recycled). Solid sulphur could be transported to site and used to produce concentrated sulphuric acid along with co-generation of power from a combined sulphur burner and steam turbine plant. HCl lost during the process would be replaced by importing solid calcium chloride.

Residue from the gangue leach would then undergo a second, more intensive HCl leach during which most of the rare earths are dissolved. Caustic conversion followed by HCl dissolution on the leach residue would next be undertaken to maximise overall recovery. The resultant pregnant liquor solution would then report to the purification stage, during which impurities are removed and cerium selectively precipitated and stockpiled for potential future sale (as management considers that cerium faces challenging market fundamentals, and that it is thus optimal to remove as much of it as possible from the final mixed REO concentrate product).

PFS indicated project economics

PFS demonstrated potential for US$16/kg on-site cash costs

At US$97m (US$132m if including the sulphuric acid plant), the processing facility is the single largest item in the overall PFS capex estimate of US$197m (US$216m after application of 10% contingency factor). The PFS capex estimate was considered accurate to +/- 25%. On-site cash operating costs (which include contract mining costs, on-site processing costs and G&A costs) were estimated at US$16.4/kg REO produced, and total cash operating costs (after also including an assumption of US$10/kg for toll downstream mineral separation charges) at US$26.4/kg.

Figure 30: Prefeasibility headline parameters and outcomes

Item	Unit	Value
Reserve	Mt	8.5
TREO grade	%	1.6
Life of mine (LoM)	Years	18
Strip ratio	t ore: t waste	4.5
Annual ore throughput	kt pa	500
Plant overall metallurgical recovery	%	34
Average annual TREO production (in concentrate)	kt pa	2.8
Average annual 'magnet'* REO (in concentrate)	Kt pa	1.0
TREO basket price assumption	US$/kg TREO	60
On-site cash operating costs	US$/kg REO	16.4
Total cash costs (incl toll separation costs, excl royalties)	US$/kg	26.4
Capex (incl 10% contingency)	US$m	216
Post-tax IRR	%	37

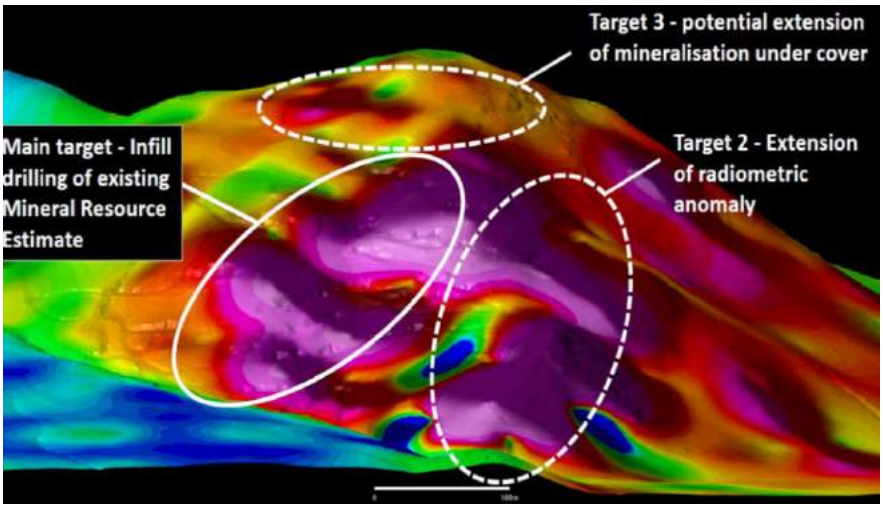
**Neodymium, Praseodymium, Dysprosium and Terbium* *Source: Mkango Resources*

Bankable feasibility study and upside potential

BFS programme now underway with 5,000m drilling campaign

Following the initial £5m investment in the project holding company by Talaxis in January 2018, Mkango has commenced a BFS of Songwe Hill, which it aims to complete by the end of 2019. The first phase of the BFS has a significant focus on drilling, with a minimum 5,000m programme having started in June. This includes in-fill and step-out drilling, with the drill plan based on a refined geological model aided by radiometric data. An updated NI 43-101 compliant resource statement is targeted by end the of 2018 on conclusion of the drilling (which will trigger the next instalment of investment from Talaxis).

Figure 31: Radiometric survey highlights potential to expand resources

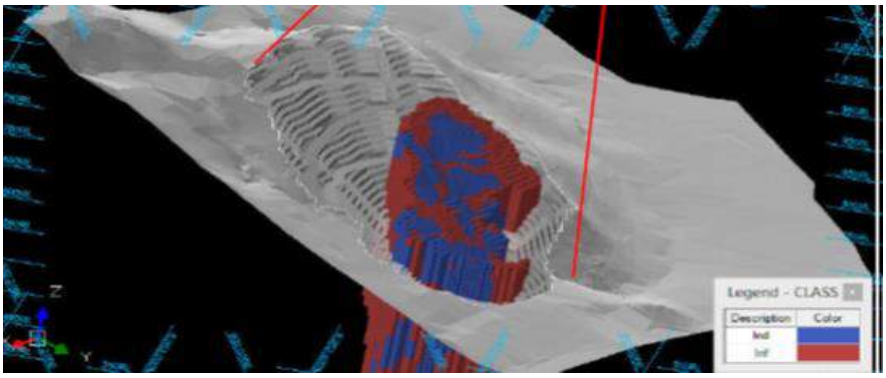


Source: Mkango Resources

Upgrading of inferred-category resources could increase reserves and reduce the open-pit strip ratio

Inferred category resources comprise 55% of the currently delineated resource, with a significant amount lying within the conceptual open-pit that was modelled to calculate the maiden reserve. Assuming closer-spaced drilling successfully upgrades much of these inferred resources to indicated category, and that those indicated resources subsequently make the cut as reserves, we believe it is highly likely that there will be a material reduction on the 4.5:1 strip ratio that was assumed in the PFS, which in turn is likely to impact positively on operating costs. If planned step-out resource drilling (mineralisation is untested to the northeast and southwest beyond the limits of the present drilling, but is considered open) is similarly successful, we believe that the life of mine could be extended beyond the 18 years envisaged in the PFS, and/or annual production rates increased.

Figure 32: A key focus of current drilling is upgrading inferred category resources



Source: Mkango Resources

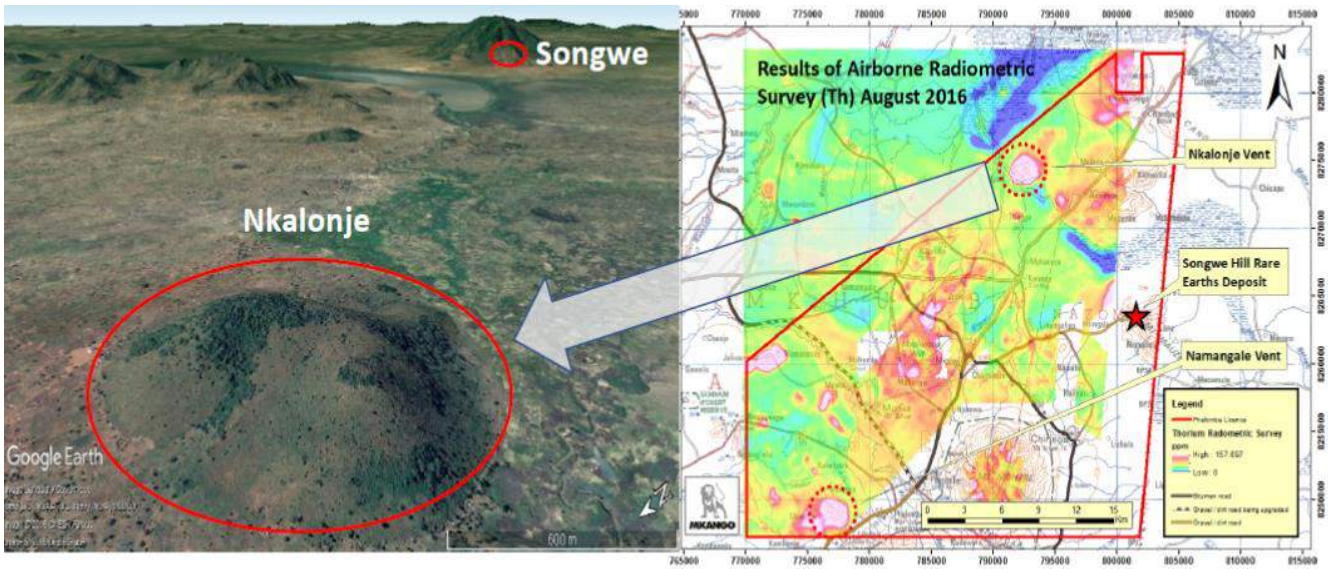
Figure 33: Resource drilling at Songwe commenced in June, with two rigs on site

Source: ARC

Nkalonje points to wider exploration potential

And Mkango sees potential for further REE potential in the wider Phalombe licence, with the Nkalonje target of particular interest. Like Songwe Hill, which lies just 15km to the south east, the Nkalonje vent forms a steep hill co-incident with a distinct radiometric anomaly. REE-bearing carbonatite dykes at surface suggest there is potential for an underlying carbonatite body to exist.

Figure 34: The Nkalonje project is located just 15km northwest of Songwe Hill



Source: Mkango Resources

The BFS will also look to optimise REE process recovery....

On the process metallurgical front, optimisation test work is also underway, focused on flotation, hydrometallurgy and acid regeneration. Potential areas of upside versus the PFS include optimising the flotation flowsheet (management believes optimising the flotation regime could see recoveries increase to over 80%, versus the 67% assumed in the PFS) and the possibility of a pre-treatment ahead of leaching (roasting or caustic conversion) and selective processing of synchysite versus apatite (which carries the less economically important HREE) to improve overall leach recovery of the key 'magnet' LREE (most importantly Nd and Pr) and lower acid consumption.

...and evaluate the potential of developing REE separation capability

We understand that the BFS work programme will also evaluate the potential for partial separation of the mixed REO chemical concentrate product from the hydrometallurgical plant. If successful, this could see the BFS development plan deviate from the PFS plan to incorporate downstream facilities, enabling Mkango to produce a more refined Nd-Pr product 'in house'.

We note that REE separation is a more specialist endeavour requiring skilled and experienced operators (hence why several REO developers, including Mkango previously, have opted to instead to look at directly marketing a REO concentrate or pay a third-party to toll process it on their behalf). However, if it can be brought in-house viably (without a prohibitively high addition to capex), owning and operating a separation facility could materially enhance Songwe Hill's overall project economics (as toll processing accounted for US$10/kg of the PFS total cash cost estimate of US$26/kg). Moreover, producing a more downstream, beneficiated product would enhance Mkango's strategic position in the REE market, opening up a wider customer base.

The environmental, social and health impact assessment (ESHIA) is also now well underway, and is being completed in accordance with World Bank Standards and the Equator Principles.

Mkango is targeting completion of the Songwe Hill BFS and ESHIA by the end of 2019.

ARC estimates

We have attempted to incorporate some of these areas of potential optimisation in our own cash-flow model of Songwe Hill, as well as taking a more conservative view on product pricing. We have used the PFS operating and cost estimates as a starting base for our model, but have adjusted for our some of own assumptions as follows:

- Assumed LOM average REE basket price assumption of US$45/kg (-25% vs PFS)
- Mineable reserve of 12.7Mt (+50% vs PFS) at 1.6% REE, increasing the LOM to 26 years (vs 18 years in the PFS)
- LOM waste-to-ore strip ratio of 3:1 (vs 4.5:1 in PFS)
- Improvement in flotation circuit recoveries to 80% (vs 67% in PFS)
- Inclusion of a REE separation plant in the process flowsheet, at an assumed capital cost of US$35m (benchmarked against peers)
- Assumed 'in-house' separation operating costs of US$3/kg (vs US$10/kg 'toll' separation costs assumed in PFS)

On this basis we estimate a real (2018 money) project IRR of 30% and NPV (at 10% real discount rate) of US$283m. The latter compares to our estimate of the PFS operating scenario (using the same US$60/kg REE basket price assumed in the PFS) of US$249m. We therefore see the potential benefits of the reserve and process flow

sheet optimisation arising from the ongoing BFS work (which we estimate could increase average annual REE output by c20% and lower unit opex) more than offsetting the negative impacts of potentially lower REE pricing assumptions.

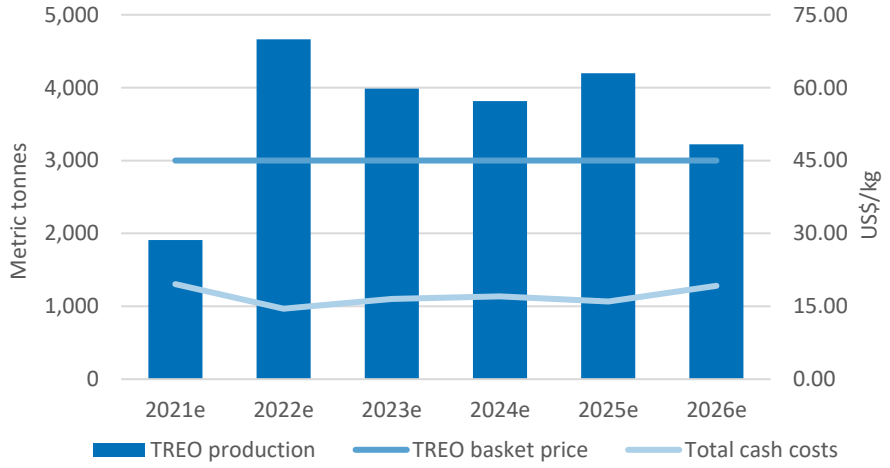
We believe Songwe Hill could be capable of total cash costs of <US$20/kg...

Our model points to potential LOM average total cash operating costs of US$18/kg REE (vs the US$26/kg estimated in the PFS), the savings compared with the PFS arising from our assumed lower strip ratio (reducing mining costs), improved flotation recovery rates (reducing processing costs and lifting final REE production by c20%) and in-house REE separation (which should be materially lower cost than outsourcing).

...sustaining margins of c60% for operational EBITDA of >US$90m pa

Despite our 25% lower assumed REE basket price assumption, this would see LOM operating margins widen to around 60% (versus our estimate of c50% using the PFS pricing and cost assumptions). On this basis we estimate LOM average operational EBITDA for the project at over US$90m (and over US$100m pa in the early years when forecast head grades are highest).

Figure 35: Songwe Hill forecast production, revenue and costs (first six years)



Source: ARC estimates

Maginito venture

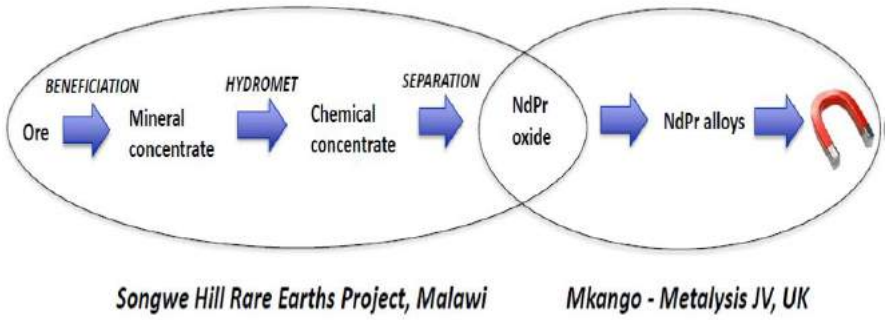
Maginito is Mkango's 75.5% owned subsidiary (Talaxis holds the 24.5% balance of interest, and can earn up to an ultimate 49% stake – see pp21-22), established to pursue downstream opportunities in the rare earths supply chain.

Maginito is focused on developing NdPr alloys and magnets

Maginito's main focus is developing NdPr alloys, magnet and other technologies geared to accelerating growth in the electric vehicle market. Its first initiative is a research and development partnership with Metalysis, a UK-based research company that has developed solid-state alloy powder technology which it believes is lower-cost and more environmentally friendly than traditional alloying methods

Under a joint venture principles and exclusivity agreement for advanced alloys using neodymium or praseodymium with other elements for magnet development, Maginito will look to commercialise intellectual property rights and/or a licence agreement with Metalysis for the production of neodymium and/or praseodymium alloy powders. Under the terms of the agreement, Mkango will hold an 85% interest in the JV, with Metalysis receiving a 15% carried interest.

Figure 36: The Metalysis JV offers potential route to vertical integration



Source: Mkango Resources

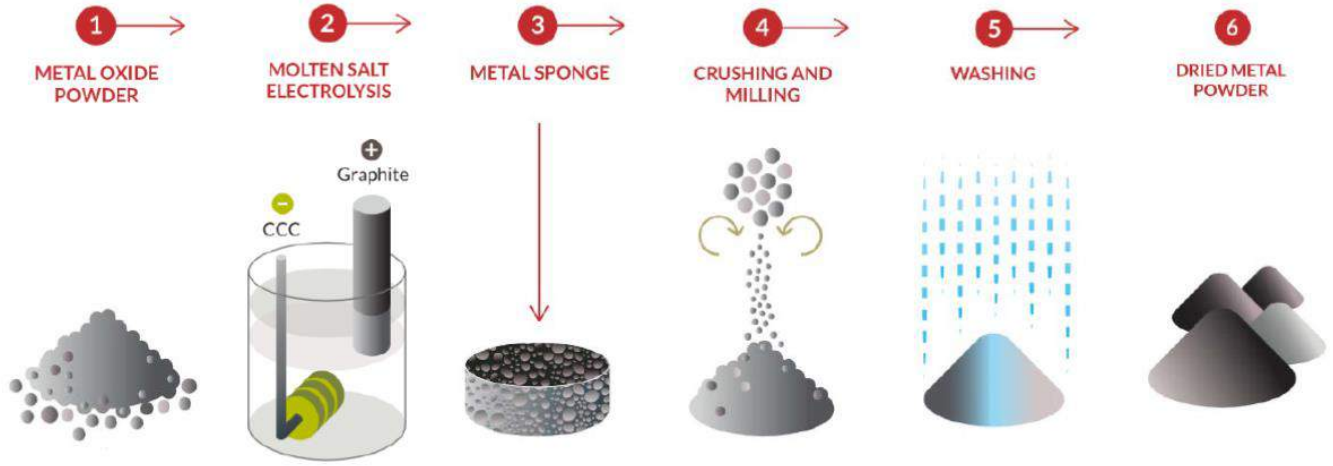
Metalysis can produce metal alloys directly from oxide feedstock without melting, reducing processing steps and enabling optimised control of metal powder characteristics. Metalysis' powders have proven particularly well suited to 3D printing, one of a number of attributes to be further evaluated under the JV.

Initial work under Metalysis JV has demonstrated the ability to generate an NdFeB alloy using Metalysis' proprietary process

The initial phase of work under the research and development JV successfully demonstrated that a NdFeB alloy can be generated using Metalysis' process from a mixed feedstock containing oxides of neodymium, iron and boron. NdFeB alloys are used to make permanent magnets, critical components of most electric vehicles, direct drive wind turbines and many other high growth applications.

The next stage of the work programme now underway includes product quality optimisation, test work scale-up, and further analyses of the alloy to determine characteristics such as its morphology, chemical composition, and physical and magnetic properties. This phase of work will also seek customer appraisal of the product and further investigation of opportunities in relation to 3D printing of magnets.

Figure 37: Metalysis' solid state process to produce alloys holds significant potential advantages over traditional alloying routes



Source: Mkango Resources

Other projects

Thambani uranium-niobium-tantalum project

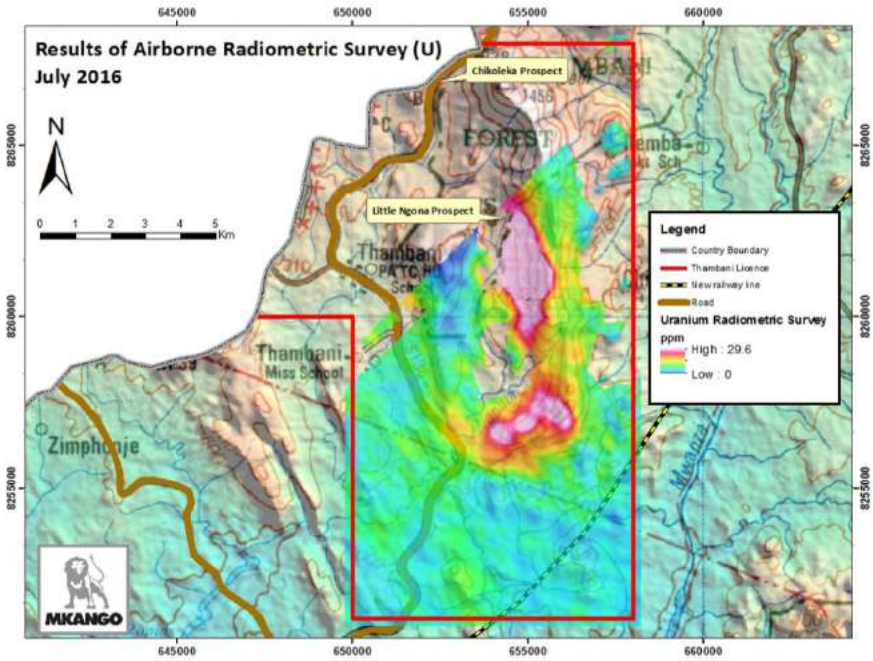
The Thambani project is a 331km^2 exploration licence in the Mwanza District that holds significant potential for uranium, niobium and tantalum mineralisation.

Exploration activities undertaken at Thambani to date include satellite imaging of the licence area, ground radiometric surveying (which confirmed previously-known airborne anomalies), reconnaissance geological mapping, and geochemical sampling.

Significant Nb-Ta anomalies have been identified at Thambani

This work has led to the identification of several uranium and associated Nb-Ta targets being identified across two major anomalies – the Thambani East and West Ridges – on the Thambani Massif, a nepheline-bearing syenite gneiss geological body. Thambani East is a strong north-south trending uranium anomaly measuring approximately 3km by 1.5km. Thambani West is 1.5km by 0.4km uranium anomaly along the western contact of the nepheline-bearing syenite body with biotite-hornblende gneisses.

Figure 38: Airborne radiometric survey of Thambani



Source: Mkango Resources

The trenching programme was focused primarily on two sites of historical uranium exploration – the Chikoleka and Little Ngona targets. An initial set of nine trenches, selected from anomalous ground radiometric results, were re-examined and geochemically sampled. The first set of assay results (from 142 soil and rock chip samples) returned variably anomalous U, Nb and Ta values in most trenches, ranging up to 4.7% U_3O_8, 3.25% Nb_2O_5 in soil and up to 0.42% U_3O_8, 0.78% Nb_2O_5 and 972ppm Ta_2O_5 in rock chips. A further exploration and sampling programme was undertaken during April 2017, with assay results from 85 rock grab samples returning similarly high-grade values, ranging up to 3.3% U_3O_8, 6.0% Nb_2O_5 and 1.9% Ta_2O_5. Preliminary

mineralogical work undertaken on six rock samples from the Little Ngona River and Chikoleka targets indicates that pyrochlore group minerals are the principal carriers of U, Nb and Ta.

The radiometric surveying also identified new areas of high-grade uranium, tantalum and niobium mineralisation at the foot of the West Ridge and on the East Ridge. Indeed, a radiometric high at the foot of the West Ridge yielded two of the four highest-grade rock chip samples to date.

Thambani may hold potential for early production of columbite ore for direct sale

Mkango is currently evaluating strategic options to progress Thambani, including assessing the potential for fast-tracking production of niobium-enriched columbite ore for direct sale. This may either be within Mkango, as part of a JV, or in a spun-out standalone vehicle.

Chimimbe Hill nickel-cobalt project

Granted in November 2017, Mkango's Chimimbe Hill exploration licence in the Mchinji district of central Malawi comprises 98.5km^2 of ground containing laterite and saprolite-hosted nickel, cobalt and chrome mineralisation. The licence has an initial three-year term, after which it can be renewed twice for further two-year periods (with a 50% reduction in the licence area required with each renewal).

Historical exploration work completed prior to Mkango taking ownership includes pitting, drilling and preliminary metallurgical testing, and this together with magnetic anomalies detected over the licence area indicates the potential for nickel-cobalt mineralisation within the laterite and saprolite sequences.

Mkango is now re-evaluating the historical exploration work in the context of more recent geophysical data gleaned from a wider World Bank sponsored airborne geophysical survey of Malawi. Given recent infrastructure developments in the region and the potential for synergies with the company's Songwe Hill REE and Thambani uranium-tantalum-niobium projects, Mkango believes Chimimbe Hill may have potential for future supply of nickel and cobalt products for the EV battery market.

Board and Senior Management

Derek Linfield – Non-Executive Chairman

Derek Linfield is a legal consultant and former Managing Partner of Stikeman Elliott (London) LLP, the London office of Canadian law firm Stikeman Elliott LLP, between 2005 and 2015. He practiced as a Canadian lawyer in London for 20 years, where he focused on cross-border financings and M&A in the mining and oil & gas sectors, including taking internationally managed companies to the TSX and the TSX-V as well as Canadian companies to the London Stock Exchange. A former educator, Mr Linfield holds BA(Ed) and BSc degree from Memorial University of Newfoundland as well as LLB and MBA degree from McGill University. He is a Director of MUN (UK) Limited, the UK campus of Memorial 32 University of Newfoundland, as well as immediate past chairman of Canada Day in London and the Foundation for Canadian Studies in the UK as well as a former Director of the Canada UK Chamber of Commerce where he is now an advisor to the Board.

William Dawes – Chief Executive Officer

Will Dawes is a graduate of Bristol University (BSc Geology) and Royal School of Mines, Imperial College, London (MSc Mineral Exploration with distinction). Having trained as a geologist in South Africa, he worked as a mining analyst based in London and then for Rio Tinto's exploration division. Subsequently, he gained significant global mining transaction experience in the metals and mining team of Robert Fleming & Co, Chase Manhattan Bank and JPMorgan. Mr Dawes is a founding Director of Mkango and its 8% shareholder Leominex, and since 2004 has been involved in the exploration and evaluation of a variety of projects throughout Central Asia, the Middle East and Africa. He has 13 years' experience in exploration and business development and nine years' experience in mining finance, mergers and acquisitions. He is a Fellow of the Geological Society, a Professional Member of the Institute of Materials, Minerals and Mining, and holds the Chartered Financial Analyst designation.

Alexander Lemon – President and Executive Director

Alex Lemon is a graduate of the Royal School of Mines, Imperial College, London (MSc DIC in Mineral Exploration) and Oxford Brookes University (BSc Geological Sciences). He has 21 years' experience in mineral exploration and business development. Mr Lemon is a founding Director and President of Mkango and its 8% shareholder Leominex. From 1994 to 2001 Mr Lemon was the Managing Director of a gold mining company, which owned and operated a producing gold mine in Central Asia, where he gained extensive operating experience in emerging markets including government negotiations and project management. From 2001 to 2005, he worked for a family office, Allied Commercial Exporters as an investment adviser. Since 2005 Mr Lemon has been involved in the exploration and evaluation of a variety of projects throughout Central Asia and Africa. He is a Fellow of the Geological Society and a Member of the Southern African Institute of Mining & Metallurgy.

Sandra Evans – Chief Financial Officer

Sandra Evans is a financial professional based in Calgary, Alberta, Canada with over 20 years' experience in the resource sector, both domestically and internationally. Her skills include controllership, treasury and internal control governance with extensive experience in North America. Mrs Evans has held positions with international resource companies requiring her to oversee sound financial controls, and her familiarity with and guidance of financial system implementation, upgrading

and maintenance has given her a distinct advantage when advising and assisting emerging enterprises. As a consultant, Mrs Evans has managed the entire financial function for several listed and/or quoted companies, TSX-V capital pool companies and sole proprietorships.

Adrian Reynolds – Non-Executive Director

Adrian Reynolds has an MSc in Geology, a Graduate Diploma of Mining Engineering and over 30 years' experience in the natural resources sector, including more than 15 years' experience with Randgold Resources Ltd. At Randgold, he was part of the executive team that developed that company's original successful strategy whereby it grew from an exploration company to a very profitable mid-tier mining company. His key responsibilities included technical oversight of the mining operations including feasibility studies, audits, compliance and evaluation of new opportunities. He was also a Director of Morila Ltd and Société des Mines de Loulo S.A. Mr Reynolds initially built his experience in both oil and coal exploration and then moved into deep-level gold mining with Gencor Ltd in the Free State Goldfields. Joining Rand Mines Ltd in 1985, he held positions in geological management in that company and its successor, Randgold & Exploration Co Ltd. Mr Reynolds is currently an independent consultant and Non-Executive Chairman of Digby Wells Environmental, one of the foremost mining environmental consultancies in Africa. He is also a Non-Executive Director of Geodrill Ltd.

David Berg – Company Secretary and Non-Executive Director

David Berg is currently an independent businessman. He spent 28 years of consecutive service with one of Canada's largest publicly traded companies, serving in the capacity of vice president of operations. Mr Berg has managed a business unit with over C$1.5bn in annual revenue and a total of 8,500 employees. His corporate experience has encompassed financial, retail services and petroleum businesses. As a former chairman and Director of Potash One, he actively contributed to its successful development from an early stage exploration company to its acquisition by K&S of Germany for C$434m in 2011. He is also the adviser, founder and director of numerous other private and publicly traded companies. Mr Berg currently operates a private consulting business specialising in the provision of management services and the development of business models for public and private companies.

Eugene Chen – Non-Executive Director

Eugene Chen is currently a partner at Shea Nerland Law, practicing corporate finance and securities law. Previous experience includes two years with McMillan LLP in Calgary, Alberta, Canada, six months with Heenan Blaikie LLP (subsequently dissolved), three years with Gowling Lafleur Henderson LLP, five years with Fraser Milner Casgrain LLP and nine years with McLeod & Company LLP.

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