HUNTER CAPITAL ADVISORS

ASX: ARL

ARDEA RESOURCES LIMITED

Equity Research

22nd June 2018

SPECULATIVE BUY

Price Target	$2.25
Share Price	$0.89

52-Week Range	$0.54 - $2.20
Market Capitalisation	$93.4m
Shares Outstanding	99.9m
IPO Options (25¢, 9th Feb 2020)	12.3m
Performance Rights	3.0m
Cash (after exercise of loyalty options)	~$21.0m
Enterprise Value	$72.4m
Major Shareholders:	
Ian Buchhorn	11.3%
Citicorp Nominees	9.8%
Brian O'Shannassy	8.5%
BNP Paribas Nominees	8.1%
JP Morgan Nominees	3.4%
HSBC Custody Nominees	2.5%
I&J Jones	2.2%
Top 20 Shareholders	57.3%

Ardea Resources Limited is a mineral exploration and development company with a portfolio of base and precious metals assets in Australia. Its flagship project is the Goongarrie nickel cobalt project 85km from Kalgoorlie.

Research Analyst: J-François Bertincourt

Initiation of Coverage: Asset Class Warrants Development Financing...

...and Development Financing should warrant significant re-rating.

World Class Asset: ARL holds the largest cobalt resource in the developed world. The KNP mineral resource amounts to 773 Mt at 0.05% cobalt and 0.70% nickel for 405,400 t contained cobalt and 5.5 million tonnes of contained nickel. Within that highly significant resource, ARL has delineated the higher grade Goongarrie cobalt zone of 83.1 Mt at 0.10% cobalt and 0.81% nickel for 81,700 t of contained cobalt and 672,300 t of contained nickel metal.

Proof of Concept: The Pre-Feasibility Study on the Goongarrie nickel cobalt project has confirmed its economic viability. Following the past commercial implementation failures seen in the 1990's and later, ARL is drawing on the more recent successes (Coral Bay, Ambatovy, Taganito) to refine the feasibility studies and develop the project.

Mineral Resource Options: While the current focus is on cobalt, HPAL projects are first and foremost nickel projects, with cobalt as a by-product. Their capital intensity is quite high, hence initial life of mine and potential extension needs to be significant to justify a decision to mine and built such projects. In that regard, the large KNP mineral resource offers many options, with expected operation over multiple decades.

Loyalty Options: While beneficial to the company and its shareholders, those options may have exacerbated the recent price correction. Nevertheless the last batch of loyalty options have now been exercised, simplifying the capital structure, removing the price pressure and bringing some additional cash.

Un-encumbered: All ARL mineral properties including the Mining Leases are own 100% and are not subject to any royalties other than legislated government loyalties.

News Flow: Beyond the advancement of development studies including scenarios with higher throughput bringing economies of scale, we anticipate the key catalyst to be one (or more) corporate transactions with strategic partners, assisting in funding the project capex. Other share price catalysts include results of a 16,000m drilling program currently underway and further positive developments in the cobalt and nickel markets.

Board and management has extensive mineral industry experience, and substantial shareholding in the company.

Funding: ARL is well funded with a cash balance in excess of $21 million after the exercise of over 90% of the loyalty options (at 77 cents each).

Valuation: Based on metal price assumptions taking into consideration the commodity cycles of each metal cobalt and nickel, we valued ARL's flagship project under various price scenarios. Overall, ARL should reach an estimated value of $264m within the next twelve months, or $2.25 per share.

De-Risking: Beyond the typical high sensitivity to metal prices, we see significant de-risking and corresponding re-rating with Ardea Resources finding a strategic partner to assist in the financial and/or technical development of the Goongarrie project.

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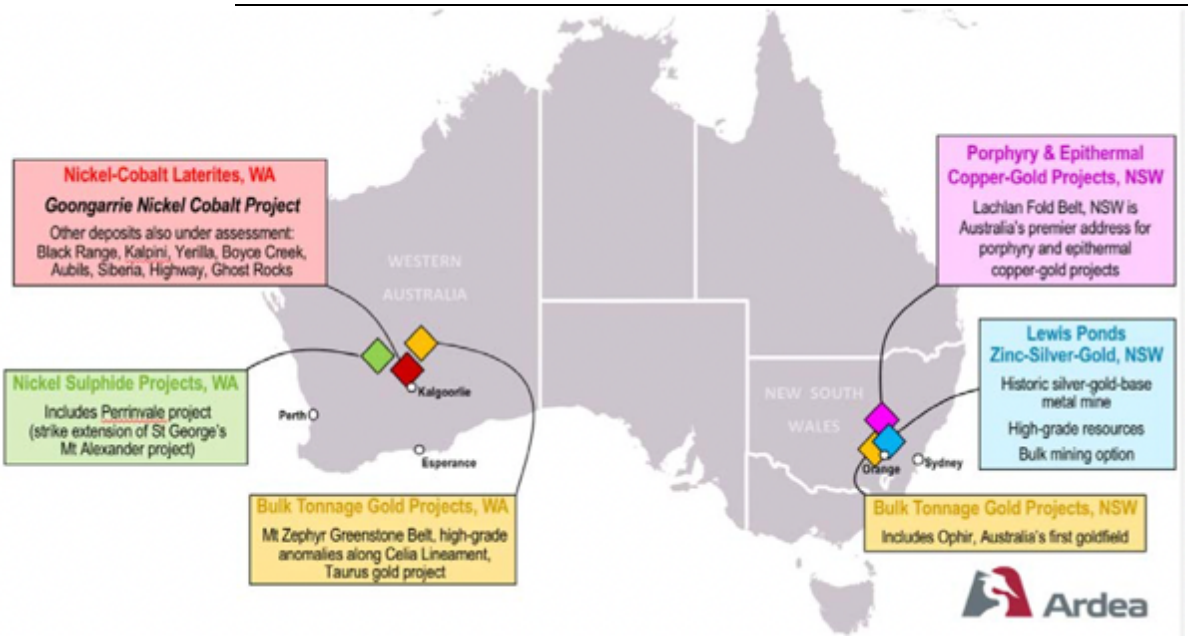
1. ARL Valuation

Project Portfolio

The following figure summarises the project portfolio of Ardea Resources Ltd.

Ardea Resources Project Portfolio

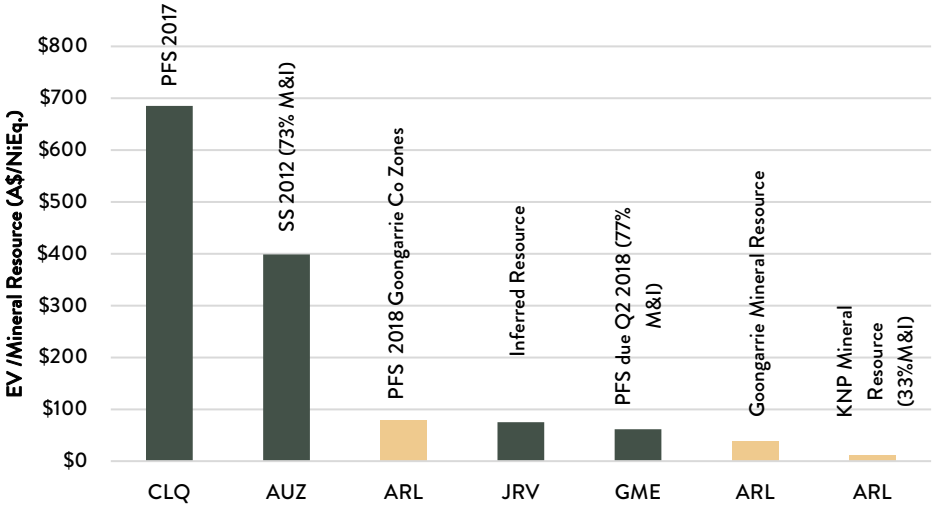


Source: ARL

Considering the current focus and stage of development of the Goongarrie nickel cobalt project, the other ARL projects are not covered by the research and analysis included in this report.

Peer Comparison

Figure 1.1 - Enterprise Value/Mineral Resource Multiple



Source: Terra Studio. M&I = Measured & Indicated, PFS = Pre Feasibility Study, SS = Scoping Study

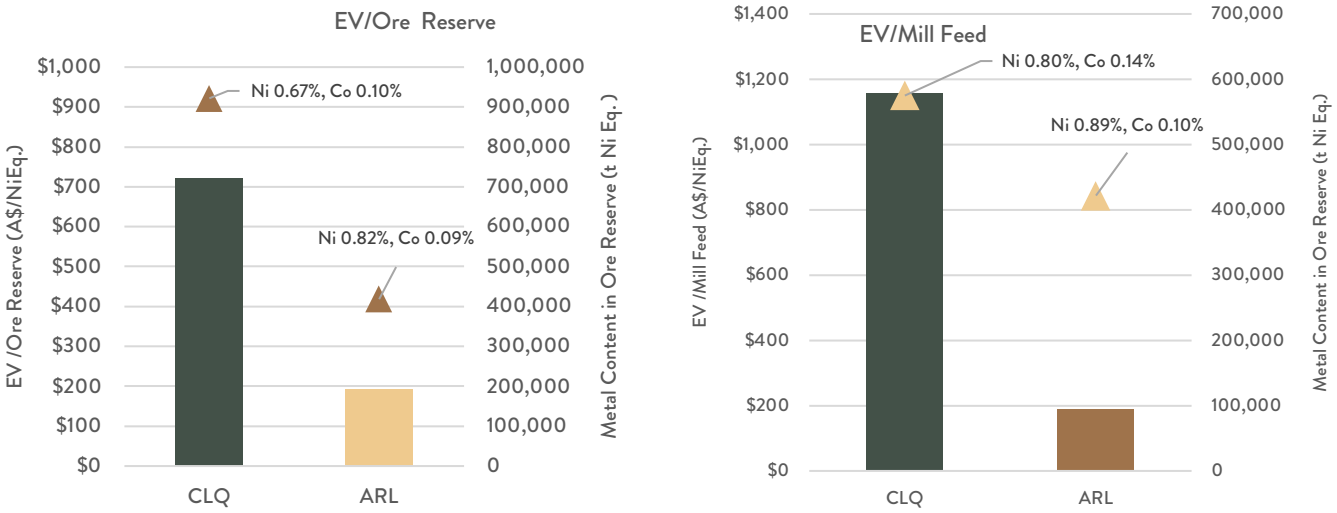
Notes: CLQ - CleanTeq Holdings, Sunrise project, New South Wales, DFS due June 2018
AUZ -Australian Mines: SCONI flagship project, Queensland, DFS due June 2018
ARL – Ardea Resourres, Goongarrie/KNP projects, Western Australia
JRV – Jervois Mining – Nico Young project, New South Wales, PFS due Q3 2018
GME – GME Resources – NiWest project, Western Australia, PFS due June 2018

The chart above focuses on companies listed on the Australian Securities Exchange developing large nickel cobalt laterite projects in Australia. Metals X (ASX: MLX) and its Wingellina nickel cobalt project has been omitted as it is first and foremost a copper and tin producer.

In terms of resource drilling, ARL, AUZ, CLQ, GME are the most advanced. In terms of development studies, CLQ is slightly ahead of ARL with just 5 months between the announcement of the relevant PFS. CLQ indicates that its DFS is on track for completion in June2018. GME is expected to release a PFS on the NiWest project in the June quarter. For AUZ, available studies include a scoping study on the SCONI project dated July/October 2012 and a PFS on the scandium mineral resource only dated March 2013. AUZ indicates that the DFS is due mid-2018. JRV indicates that the PFS on the Nico Young project is due end of Q3 2018.

Both ARL and GME appear significantly undervalued compared to CLQ and AUZ.

Enterprise Value/Ore Reserve and EV/Mill Feed Multiples



Source: Terra Studio

Looking at the EV/Ore Reserve multiple, only CLQ and ARL have stated some ore reserve. While the Sunrise project ore reserve appears significant, one should consider that the Goongarrie ore reserve represents only 5% of the KNP mineral resources. On the other hand, all mineral resource available on the Sunrise project has been converted to ore reserve, leaving CLQ less options should it require more high grade mineralisation.

The difference between Goongarrie and Sunrise reduces when mill feeds are compared.

Importantly, ARL has sufficient cash to cover the costs of the Goongarrie DFS

Dilution through a capital raising is unlikely unless a corporate transaction is undertaken with a strategic funding partner

Financial

ARL cash balance was $15.3m as at 31 March 2018.

With the conversion of over 90% of the loyalty options with an exercise price of 77 cents each bringing additional cash, the cash balance is currently over $21 million.

Those funds are sufficient to cover the costs of the definitive feasibility study as well as the exploration expenditure on the other Ardea's assets and working capital.

Valuation

Most of the market value of Ardea Resources Ltd currently resides with the Goongarrie and KNP projects. Using different price scenarios detailed in Section 4, we have derived a series of values for the Goongarrie Nickel Cobalt Project as follows:

Goongarrie Nickel Cobalt Project Valuation under Various Metal Price Assumptions

Scenario	Unit	100-year avg	Cycle One	Supercycle	SMM 19 Mar
Nickel	US$/t	$14,276 flat	$11k->2021, $23k	$11k->2020, $23k	$19,486 flat
Cobalt	US$/t	$51,342 flat	$75k->2024	$75k->2026	$91,773 flat
Pre-Tax NPV 8.0% (real)	A$m	$282	$643	$779	$1,428
Pre Tax IRR (real)	%	13%	22%	25%	29%
Post-Tax NPV, 8.0% (real)	A$m	$166	$449	$550	$1,037
Post-Tax IRR (real)	%	11%	19%	21%	25%
Payback	Years	8.8	5.8	5.3	5.3
Risked NPV (30%)	A$m	**$41**	**$135**	**$165**	$311
Pre-Tax NPV 8.0% (real)	A$m	$453	$896	$1,068	$1,930
Pre Tax IRR (real)	%	14%	22%	25%	29%
Post-Tax NPV, 8.0% (real)	A$m	$282	$630	$757	$1,404
Post-Tax IRR (real)	%	12%	19%	22%	25%
Payback	Years	8.6	5.8	5.3	5.6
Risked NPV (30%)	A$m	**$85**	**$189**	**$227**	$421

Source: ARL, Terra Studio. SMM 19 Mar are the prices sourced from Shanghai Metals Market on 19 March 2018 and used by ARL to publish the results of the Goongarrie PFS

NPV have been assigned a 30% risk factor to take into account the pre-financing stage of development of the Goongarrie project.

Considering the highly significant mineral resource of the Goongarrie and KNP projects and the current progress of the development studies, we consider that ARL should have a market value in the order of $264 million within the next twelve months.

Besides progressing towards a definitive feasibility study, project financing is seen as a key catalyst to de-risking the project and create shareholder value.

Assuming all in-the-money options being exercised, the resulting number of shares will be about 117.3 million by the end of February 2019, resulting in a price target of $2.35.

We have derived a sum of the parts valuation for Ardea Resources as follows:

ARL Sum of the Parts Valuation

Asset	Value Range	Preferred	A$/share	Basis
Goongarrie Cobalt Zones project	$135-421m	$200m	$1.71	Risked NPV
KNP/Goongarrie mineral resources/upside	$30-90m	$40m	$0.34	Market peers
Other projects	$10-20m	$13m	$0.11	Market peers
Cash (after exercise of loyalty options)		$21.0m	$0.18	
Exercise of IPO options (25¢, escrowed to 9-Feb-19, expiry Feb-20)		$3.1m	$0.03	
Goongarrie project DFS costs		($10.0m)	($0.09)	Estimate
Corporate costs		($3.5m)	($0.03)	NPV
Total		**$263.6m**	**$2.25**	

Source: Terra Studio

2. ARL Strategy

Ardea's aim is to advance its key development projects, the Goongarrie Cobalt Zones in WA and the Lewis Ponds zinc-gold-silver deposit in NSW, towards production for the benefit of shareholders. In addition, it will leverage its broad, high-quality exploration portfolio to drive value. This may mean exploration, development, spinning out or other divestment of projects as appropriate to the project's prospectivity and the Company's strategic requirements.

Ardea is seeking to become a significant producer of cobalt and nickel sulphate from the Goongarrie Cobalt Nickel Project, and zinc, gold and silver in concentrates from Lewis Ponds, for global commodity markets.

In addition to nickel and cobalt, Ardea's discovery of scandium at several deposits opens the possibility of payable accessory metals. Scandium-aluminium alloys are used as low weight / high strength metals in the aerospace sector and are increasingly touted for use in electrified vehicles. This further aligns Ardea with the Automobile Electrification Revolution.

The Goongarrie Cobalt Zone with the KNP Project is a world class multi-commodity deposit in a stable and mature mining location that is well-placed to deliver materials of accepted provenance into a rapidly expanding electrified vehicle and energy storage system sectors.

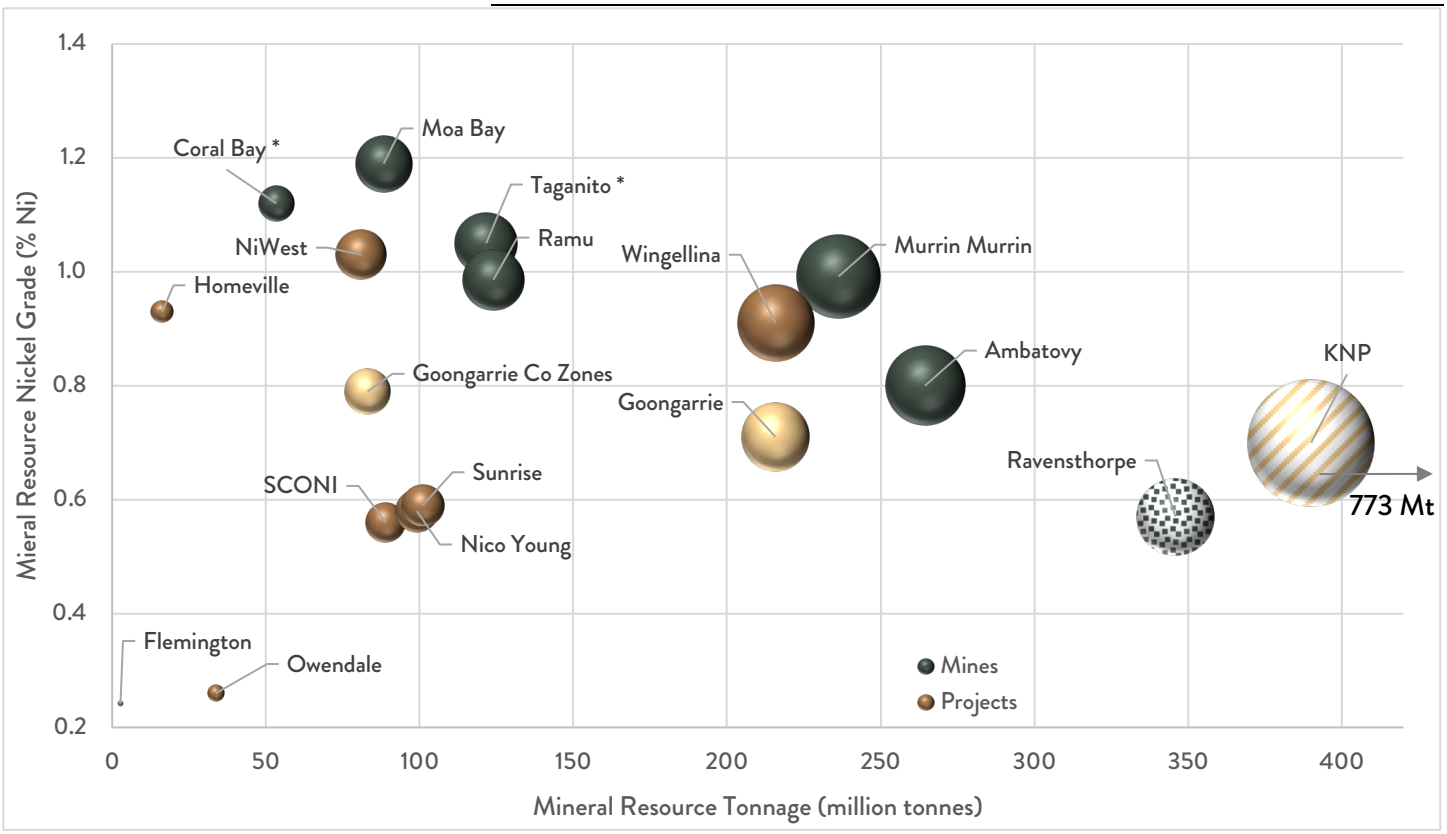
3. Goongarrie Nickel-Cobalt Project Benchmarking

Mineral Resource

Figure 3.1 displays the mineral resources of existing HPAL operations as wells as a number of Australian nickel cobalt lateritic projects.

The mineral resources estimated for Goongarrie and the Cobalt Zones subset sit relatively well within the project peers. Note that the mineral resources for both Goongarrie and Sunrise have been optimised to focus on cobalt rather than nickel at this point in time. The KNP mineral resource is of particular interest as its tremendous size should allow to define a number of higher subset to convert into ore reserves. The KNP mineral resource size is also supportive of a particularly capital intensive operation such as HPAL plants.

Figure 3.1 – Mineral Resource of Mines and Projects Peers



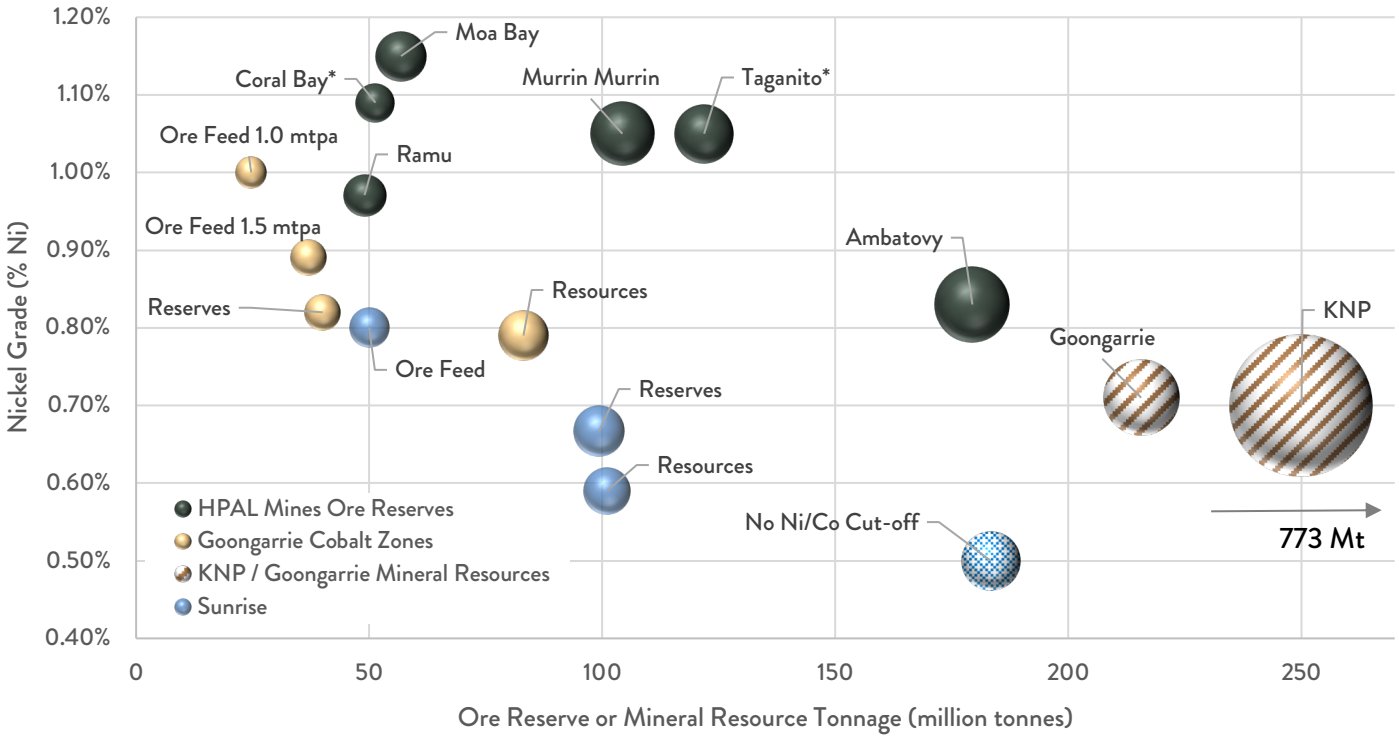
*Source: Terra Studio. * limonite only, Ravensthorpe on care & maintenance, KNP mineral resource is 773 Mt and sits outside the chart area.*

Ore Reserves / Ore Feed

Figure 3.2 displays the ore reserves of existing HPAL operations as wells as the "path" from mineral resources to ore feed for the Goongarrie Cobalt Zones (ARL) and Sunrise (CLQ) projects.

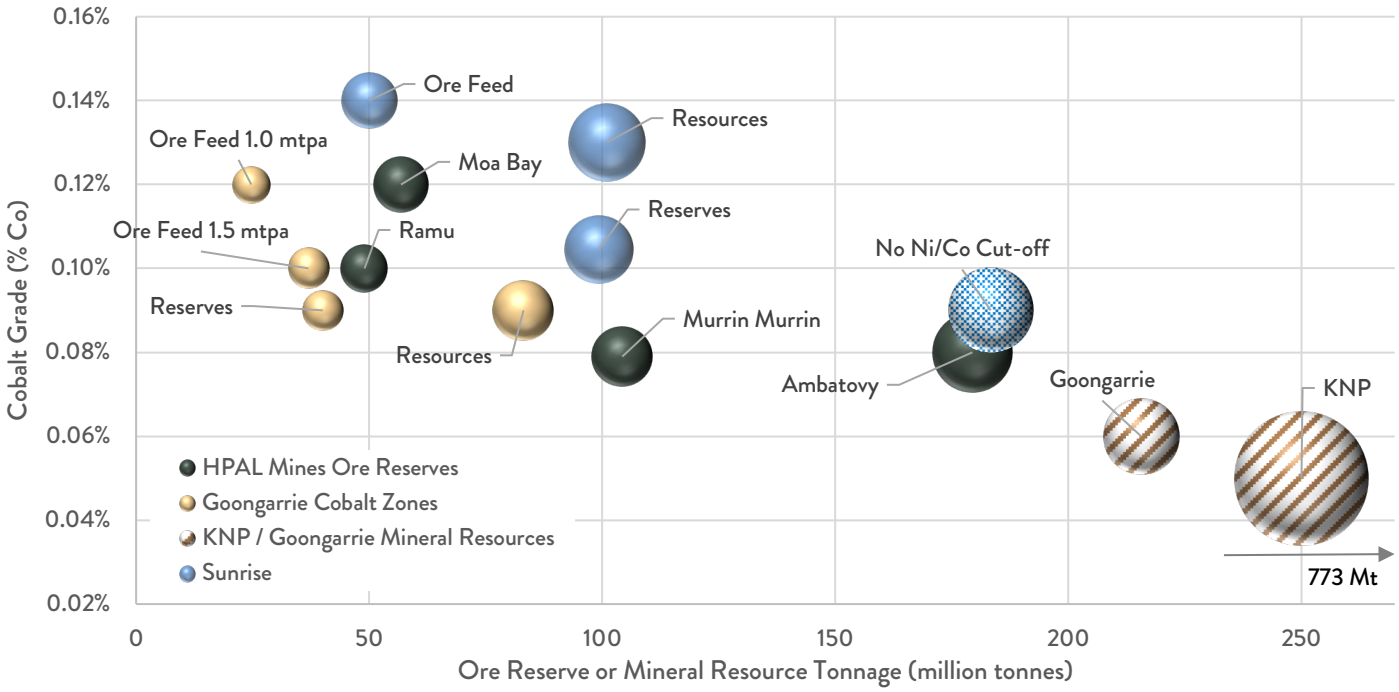
While the Goongarrie Co Zones ore reserve represents only 5% of the KNP mineral resource, the Sunrise upside appears limited, especially since the weathering profile is constrained by the extend of the underlying dunite core. In terms of nickel grade, the Goongarrie project is much better placed than Sunrise.

Figure 3.2– Nickel Ore Feed and Ore Reserves of Mines and Projects Peers



*Source: Terra Studio. * limonite only. Note the Sunrise ore reserves has been reduced to the mineralised horizons where mineral resources have been stated.*

Figure 3.3– Cobalt Ore Feed and Ore Reserves of Mines and Projects Peers



Source: Terra Studio.. Note the Sunrise ore reserves has been reduced to the mineralised horizons where mineral resources have been stated.

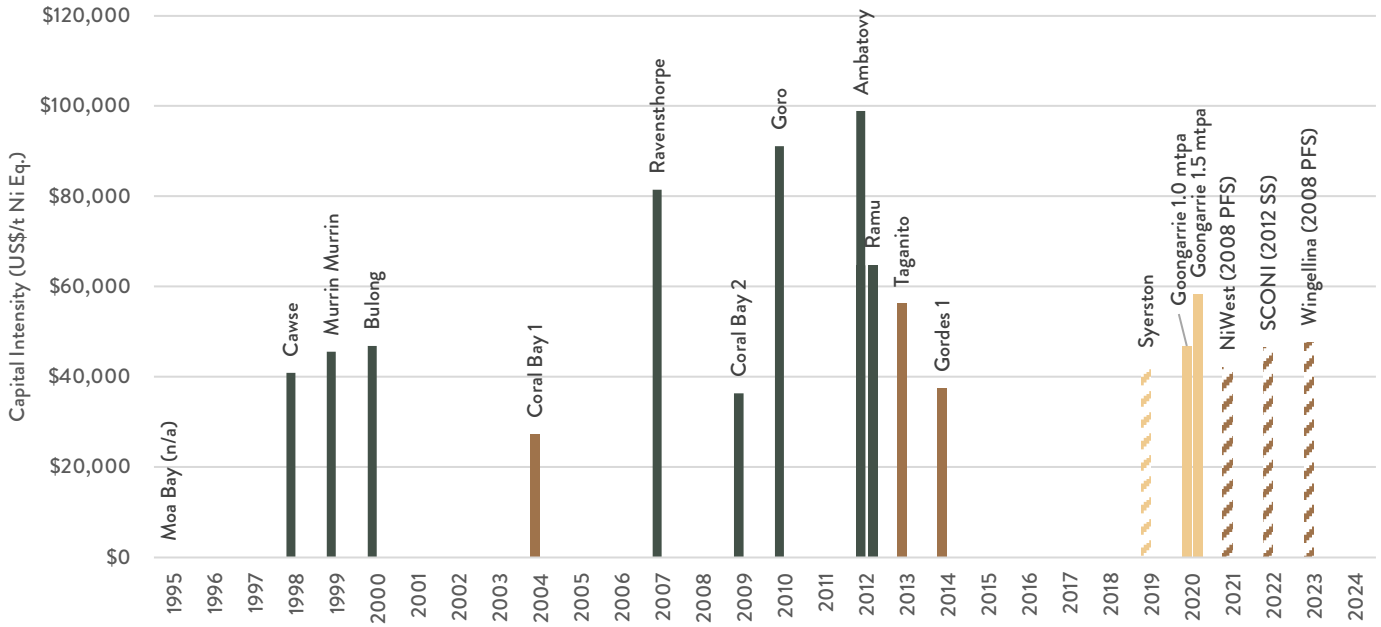
Figure 3.3 shows the same data in relation to cobalt. The KNP/Goongarrie data displays a logical progression from mineral resources to ore reserves and ore feed. Considering the focus on cobalt mineralisation, the resulting reserves and ore feed are typically better than the ore reserves stated by the

existing operations. The variation in grade across the Sunrise data is questionable.

Capital Intensity

The development of the HPAL technology at a commercial scale includes a number of notorious failures (Cawse, Bulong, Ravensthorpe and Goro), but also some successes (Moa Bay, Coral Bay, Ramu and Taganito). Among those Sumitomo appears to be the best operator being able to replicate the success of Coral Bay at Taganito. Sherritt, operator of Moa Bay has now managed to get the Ambatovy operation at a reasonable level of production (60-80% of capacity over the last four years).

Figure 3.4 – Capital Intensity of HPAL projects over time



Source: Terra Studio. Past capex figures have been adjusted for inflation (Australian CPI). Capex excluding an acid plant are indicated in brown.

Notes: *1. Start up dates for projects have been arbitrarily set*
2. An updated PFS for NiWest is expected in June 2018
3. A DFS for SCONI is expected in June 2018

The capital intensity of both development options of the Goongarrie project includes an acid plant and is in line with the capital intensity of recent successful HPAL operations. Sulphuric acid plants are now more modular than they used to be and pricing has come down.

4. Nickel and Cobalt Metal Prices

As for any other mining development, metal price assumptions have a strong impact on the economics of the project. Furthermore, the development timing in relation to the commodity cycle is critical (Dry M., 2018).

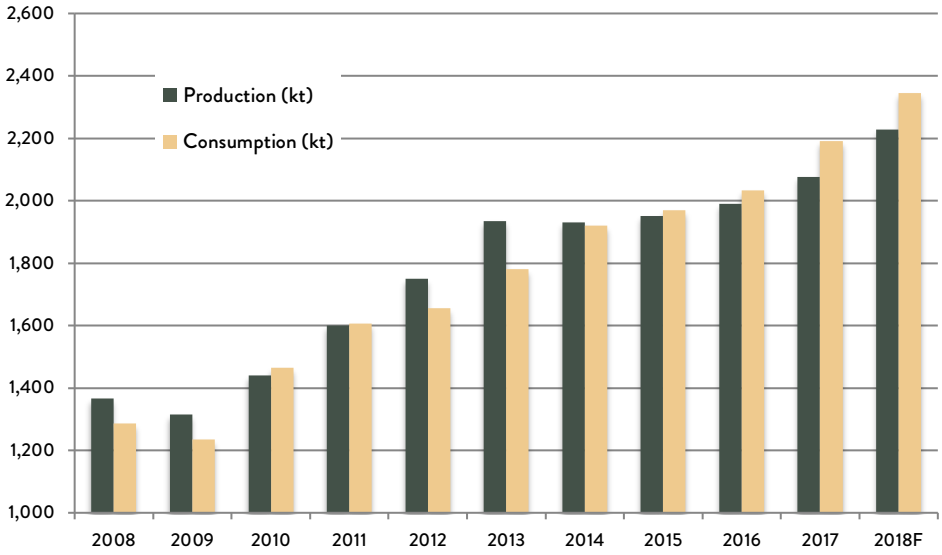
Nickel

Market fundamentals

Supply deficits have been recorded since 2015 and are forecasted again this year by the International Nickel Study Group.

Nickel market in deficit since 2015, continuing in 2018

Figure 4.1 - Nickel Production and Consumption

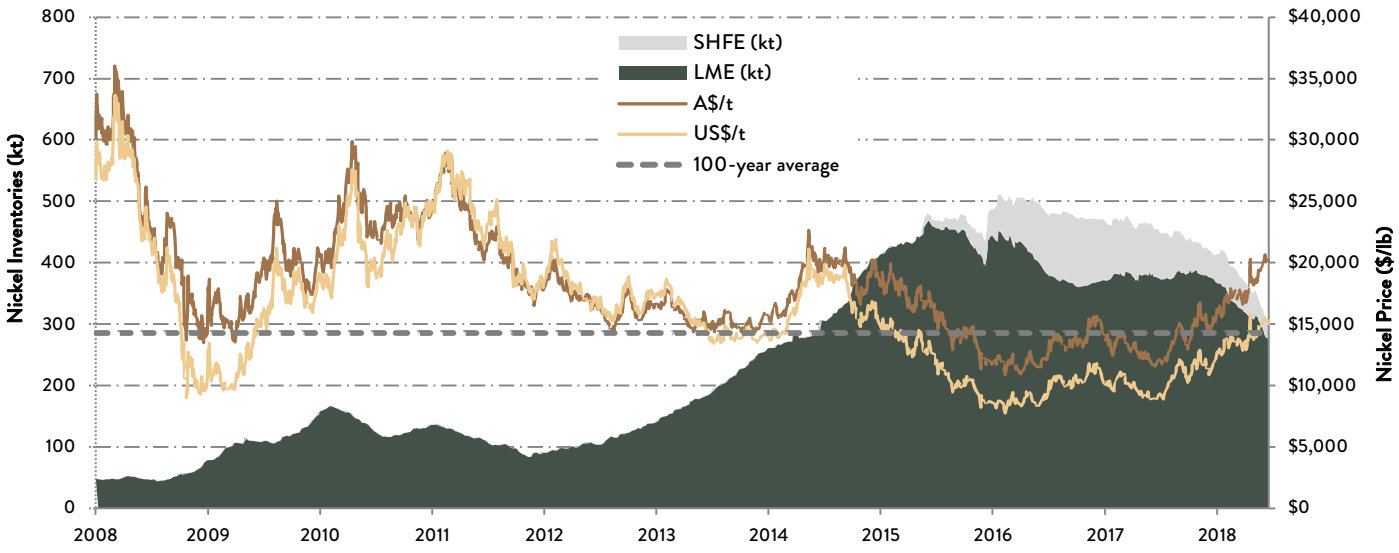


Source: INSG, Terra Studio

Supply deficits launch a trend in overall inventories reduction

Nickel prices have started to respond to market imbalances and the reduction of official inventories.

Figure 4.2 – Historical Nickel Price and Official Inventories



Source: LME, RBA, SHFE, Terra Studio

After reaching a peak in 2015, inventories have been decreasing, with a market deficit increasing to 116,000 tonnes in 2017 and expected to reach a similar amount in 2018F (117,000t).

Expressed differently, inventories currently represent about 10 weeks of consumption compared to six in 2010. Expected increases in market size will further reduce inventories relative to consumption.

All the nickel supply growth comes from NPI production

Nickel Pig Iron (NPI) production in China declined in 2016, but recovered in 2017 and is expected to increase further in 2018 due to more ore availability from Indonesia as the government loosened the ban on nickel ore exports in January 2017. Also the Philippines are revising production cuts.

Demand from China and the rest of the world has been accelerating to 5.5% in 2017 and is expected to increase at similar pace, 5.1% in 2018.

Rising nickel inventories from 2012 have generated significant downward pressure on nickel prices. Conversely, an accelerating reduction in inventories has seen the nickel price react positively towards the 100-year nickel price average (inflation adjusted). Terra Studio's view is that further reduction in inventories over the next couple of years should see the nickel market enter a new upturn cycle.

Downside risks

Nickel ore inventories last longer and more ores are imported from the Philippines.

Faster ramp up of the Indonesian NPI production and an increase of ore exports.

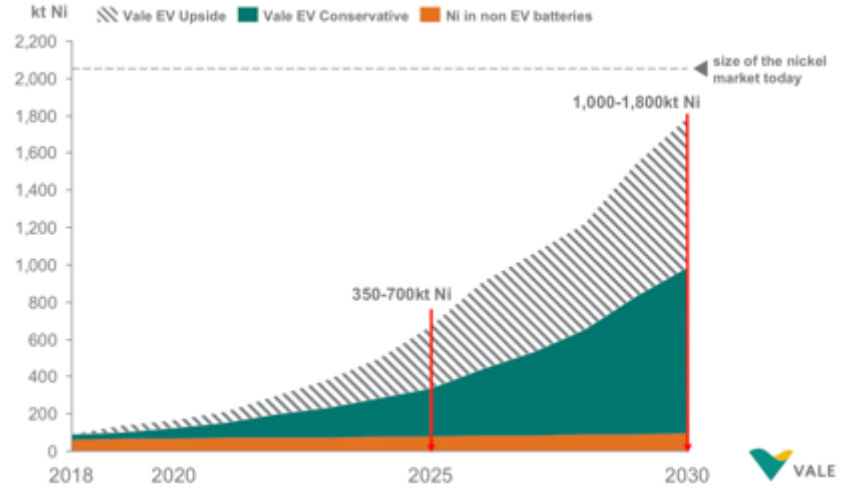
Stainless steel demand remains subdued.

Upside risks

Demand for nickel sulphate, predominant product used in manufacturing batteries is expected to soar. The nickel demand for the battery market in 2030 is expected to be equivalent to the current size of the nickel market today.

The nickel demand for battery manufacturing in 2030 is expected to the size of the nickel market today.

Figure 4.3 – Nickel demand for battery manufacturing



Source: Vale

The nickel market is made up of two very different classes of product

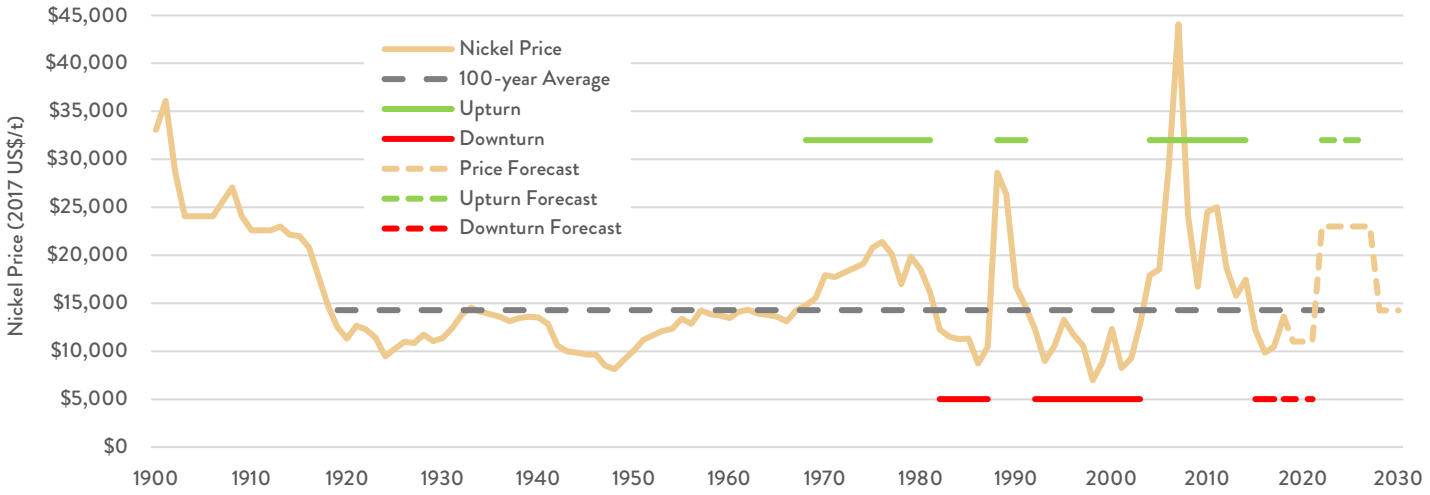
Nickel sulphate can only be produced from Class I nickel products with 99.98% nickel or higher, i.e. from roughly about half of the global nickel production. Class II products such as ferronickel (15-30% Ni), nickel oxide sinters (>70% Ni) and NPI (2-12% Ni) contain too much iron or impurities to qualify for nickel sulphate production and can only be used in stainless steel.

All new nickel supply growth is in NPI not suitable for battery use. Mines suitable to produce Class I products are closing (e.g. Ravensthorpe, Savanah) or capital expenditure is being deferred.

Nickel price cycles

Figure 4.4 displays inflation adjusted nickel prices since 1900. Price cycles have been defined as sustained periods of prices either above the 100-year average (upturn) or below the 100-year average (downturn). Following on the extended China-induced boom of the year 2000, nickel prices are currently in downturn since 2015 and we expect this to continue for another couple of years.

Figure 4.4 – Nickel Price Cycles



Source: Terra Studio. Nickel price adjusted for inflation

The table below summarises the various scenarios envisaged. The 100-year average can be seen as a low case, considering the project start-up time 2022 versus the assumed nickel price cycle. The "Cycle One" scenario should be considered as a base case. The "Super Cycle" scenario can be seen as an upside case and the last scenario is the recent prices case as announced by ARL.

Nickel Price Scenarios

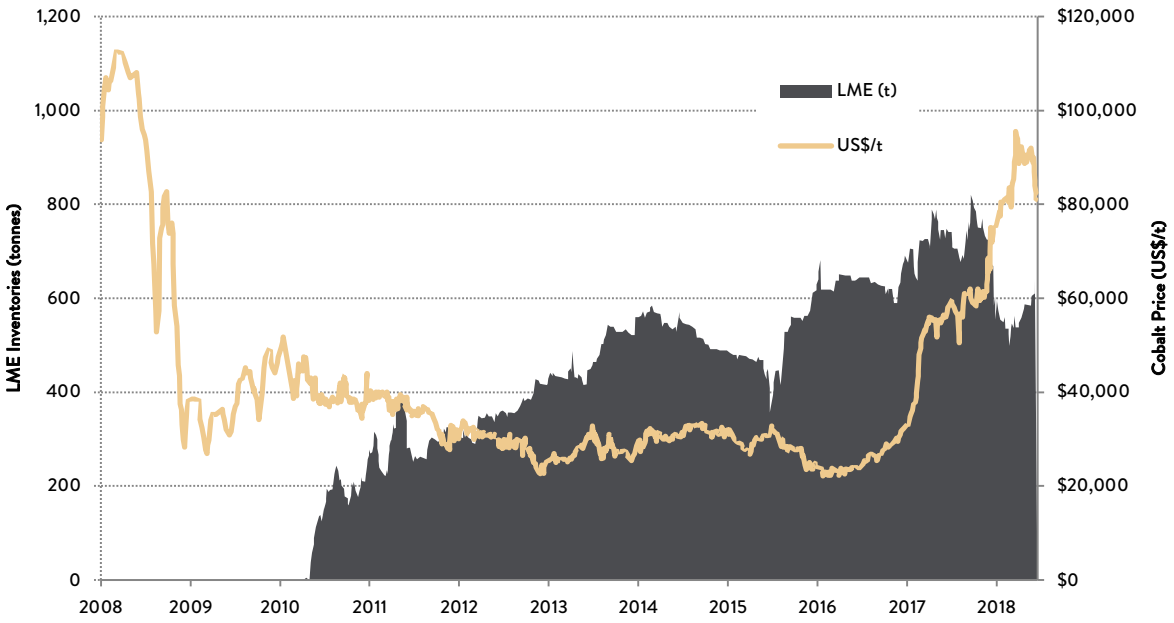
Scenario (US$/t)	2018 YTD	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
100-year average	$13,837	$14,276												
Cycle One	$13,837	$11,000			$23,000								$14,276	
Super Cycle	$13,837	$11,000					$23,000						$14,276	
SMM 19 March	$13,837	$19,486												

Source: Terra Studio.

Cobalt

Cobalt contributes up to 60% of the value of lithium ion batteries which in turn accounts for greater than 50% of demand for cobalt. The lithium ion battery is projected to become the world's most significant source of power with the use in electric vehicles ("EV") and energy storage systems ("ESS") being the key drivers.

Figure 4.5 – Historical Cobalt Price and Official Inventories



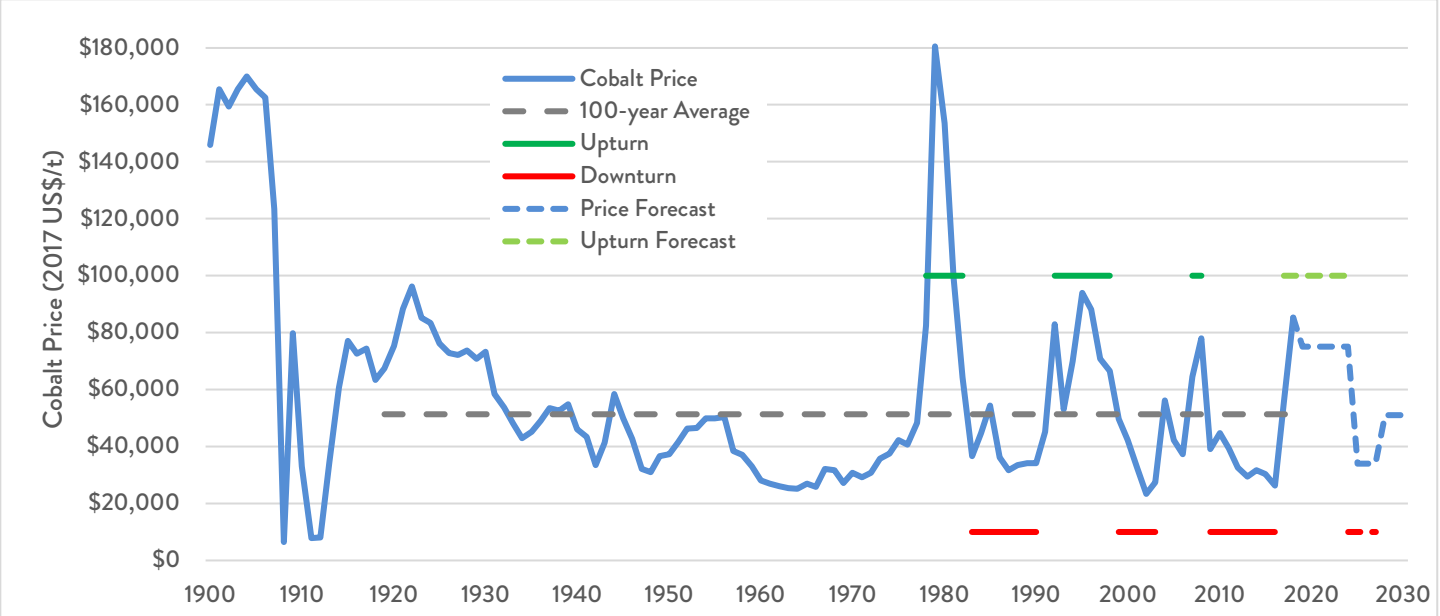
Source: Terra Studio

The cobalt market is experiencing boom times for the last 18 months. Considering its small market size, concerns about ethical supplies and the tremendous demand expected from lithium-ion batteries, the cobalt market is expected to boom for a number of years, maintaining upward pressure on prices.

A recent report from the International Energy Agency notes that the supply of cobalt was "especially critical" due to the concentration of mining (DRC 60%) and refining (China 90%) in a handful of countries. The energy agency acknowledged ongoing development in reducing the cobalt content of batteries — aimed at higher energy and power density at the expense of lower thermal stability. But even accounting for these efforts, cobalt demand in electric vehicles was expected to be ten to 25 times higher than current levels by 2030.

Our price scenarios include two cobalt price cycles called "Cycle One" and "Super Cycle" with varying length of the cobalt price upturn, seven and eight years respectively.

Figure 4.6 – Cobalt Price Cycles



Source: Terra Studio. Nickel price adjusted for inflation

The table above summarises the various scenarios envisaged. The 100-year average can be seen as a low case. The "Cycle One" scenario should be considered as a base case. The "Super Cycle" scenario can be seen as an upside case and the last scenario is the current prices case.

Cobalt Price Scenarios

Scenario (US$/t)	2018 YTD	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
100-year average	$85,539							$51,342						
Cycle One	$85,539				$75,000				$34,000				$51,342	
Super Cycle	$85,539					$75,000					$34,000		$51,342	
SMM 19 March	$85,539							$91,773						

Source: Terra Studio.

5. Goongarrie Nickel Cobalt Project

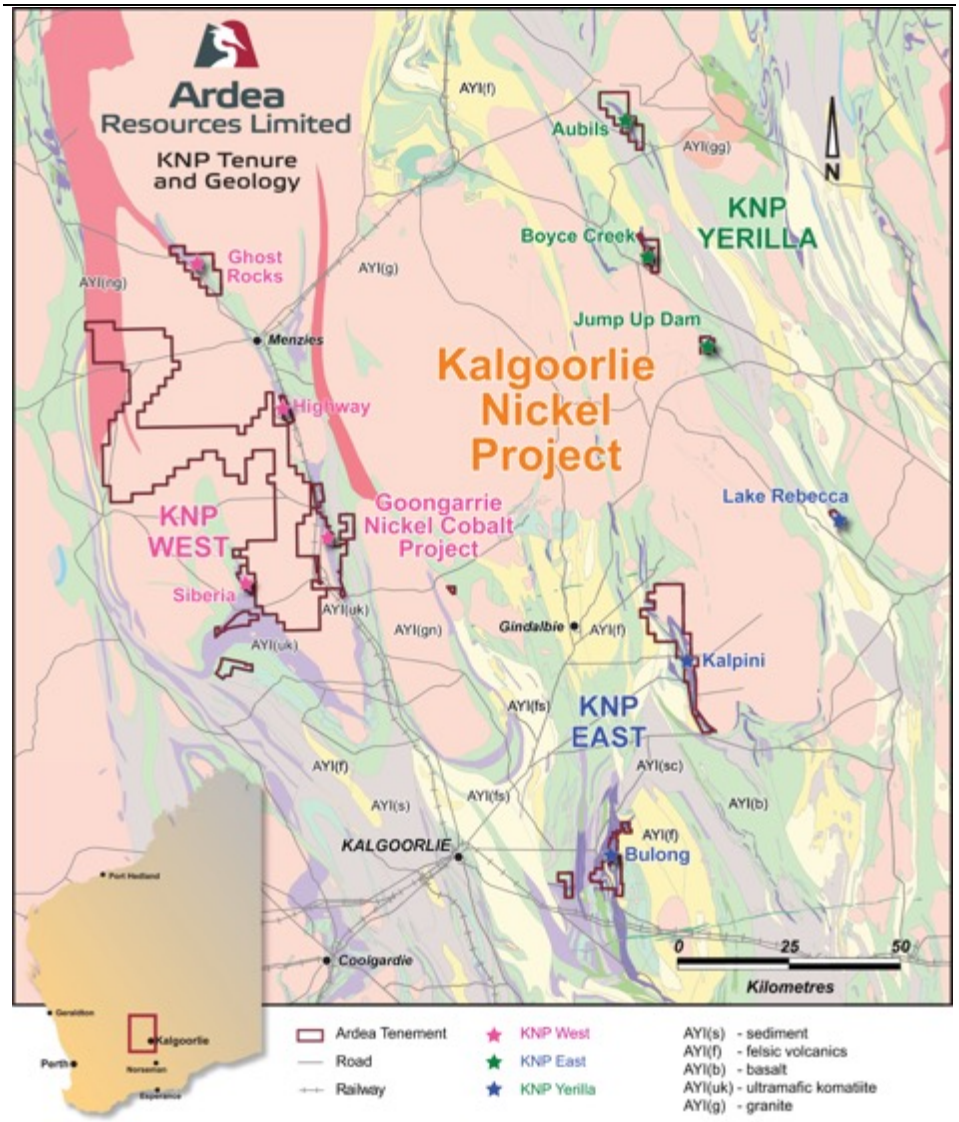
Location and infrastructure

The Goongarrie Nickel Cobalt Project covers 142 km² within the larger Kalgoorlie Nickel Project (KNP) which totals some 1,738 km².

The KNP is located in a stable mining region with resources largely concentrated on granted Mining Leases with established road, rail, port and gas infrastructure and a highly skilled work-force and support services available in nearby Kalgoorlie-Boulder.

Goongarrie tenements are close to road and rail.

Figure 5.1 – The Kalgoorlie Nickel Project Regional Geology



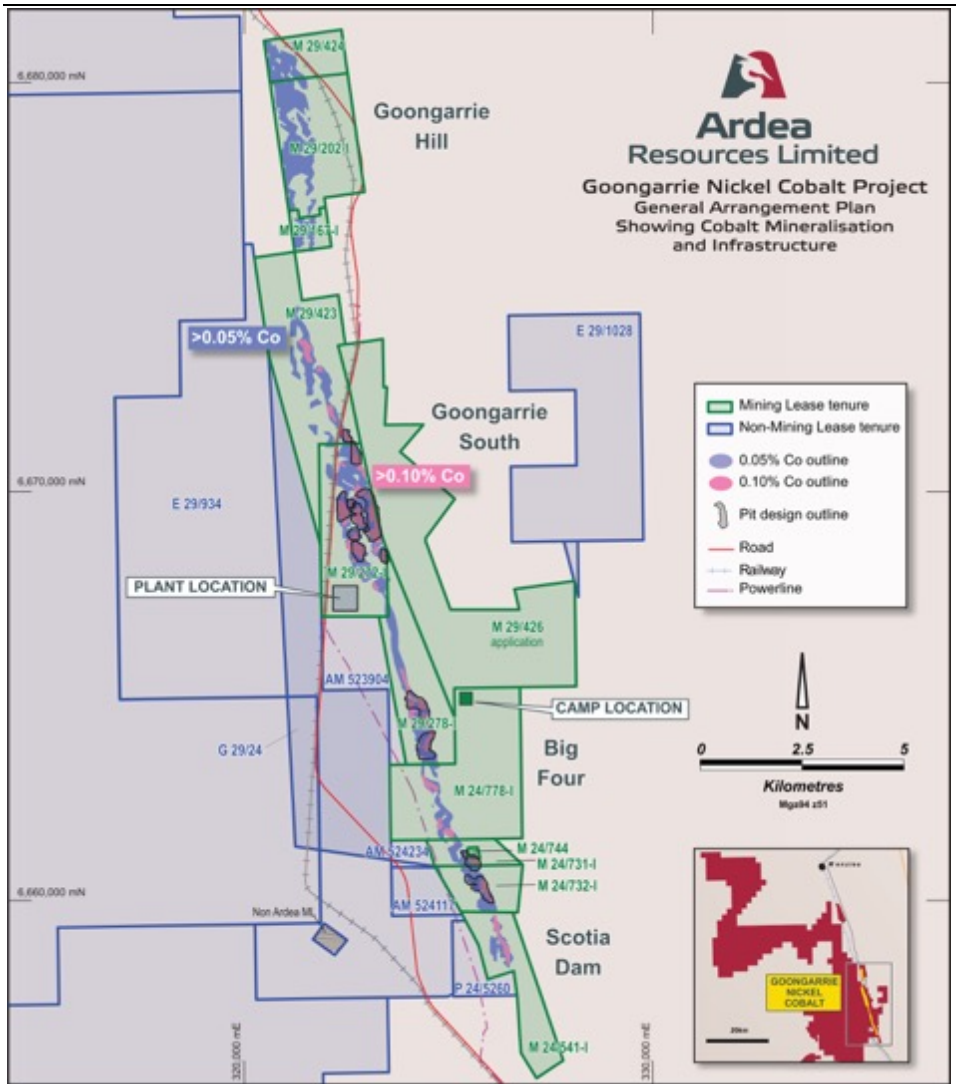
Source: ARL

Permitting

The majority of resources defined are located on granted Mining Leases, mainly granted in the early 2000s.

Mining Leases in place

Figure 5.2 – Goongarrie Nickel Cobalt Project



Source: ARL

Goongarrie tenements are close to road, rail and grid power.

Ardea retains 100% ownership of all Mining Leases at Goongarrie and, other than legislated government royalties, there are no encumbrances on the project.

Plant location is central to the project with mineral resources within 10 to 15km from the proposed plant site.

In comparison, the Sunrise (ASX: CLQ) project is subject to 2.5% royalty on gross revenue, to Ivanhoe Mines (TSX: IVN).

Geology and Mineralisation

The nickel laterite mineralisation within the KNP areas is developed from the weathering and near surface enrichment of Archaean-aged olivine-cumulate ultramafic units. The mineralisation is usually within 60 metres of surface and can be further sub divided on mineralogical and metallurgical characteristics into upper iron-rich material and lower magnesium-rich material based on the ratios of iron to magnesium. The deposits are analogous to many weathered ultramafic-hosted nickel-cobalt deposits both within Australia and world-wide.

Nickel and cobalt mineralisation is typical of West Australian laterite deposits

Mineral Resources

The total resource within the Cobalt Zones of the Goongarrie mineral resource is 83.1 Mt at 0.10 % cobalt and 0.81 % nickel, for 81,700 t of contained cobalt metal and 672,300 t of contained nickel metal. This is part of the overall Goongarrie resource, which is defined as 215.6 Mt at 0.06 % cobalt and 0.71 % nickel, and includes 130,700 t of contained cobalt metal, and 1,522,700 t contained nickel metal.

A full breakdown of the Goongarrie Resource is provided in the table below. This resource includes all of the Cobalt Zones resource and additionally the greater tonnes of lower grade material outside of the Cobalt Zone. It was this overall resource that was used to fully define the reserves for Goongarrie.

Camp	Domains	Cut-off %	Resource category	Size (Mt)	Cobalt (%)	Nickel (%)	Contained metal Co (t)	Contained metal Ni (t)
Goongarrie Hill	Ni & Co	≥ 0.5% Ni or > 0.08% Co	Inferred	52.5	0.04	0.65	21,600	340,400
			Subtotal	*52.5*	*0.04*	*0.65*	*21,600*	*340,400*
Goongarrie South	Ni & Co	≥ 0.5%Ni or > 0.08% Co	Measured	10.3	0.10	0.98	10,200	101,200
			Indicated	56.2	0.07	0.72	37,200	407,000
			Inferred	32.2	0.06	0.69	20,300	221,200
			Subtotal	*98.7*	*0.07*	*0.74*	*67,700*	*729,300*
Big Four	Ni & Co	≥ 0.5%Ni or > 0.08% Co	Indicated	45.5	0.06	0.71	28,200	320,700
			Inferred	9.9	0.06	0.63	6,100	61,900
			Subtotal	*55.4*	*0.06*	*0.69*	*34,300*	*382,700*
Scotia Dam	Ni & Co	≥ 0.5% Ni or > 0.08% Co	Indicated	3.3	0.09	0.81	3,000	26,900
			Inferred	5.7	0.07	0.76	4,100	43,300
			Subtotal	*9.0*	*0.08*	*0.78*	*7,100*	*70,200*
Total	All	≥ 0.5% Ni or > 0.08% Co	Measured	10.3	0.10	0.98	10,200	101,200
			Indicated	105.0	0.07	0.72	68,400	754,600
			Inferred	100.3	0.05	0.67	52,100	666,900
Goongarrie Resource Global			**TOTAL**	**215.6**	**0.06**	**0.71**	**130,700**	**1,522,700**

Note: All nickel and cobalt domains are included, and are encapsulated by an envelope defined by nickel grades equal to or greater than 0.5%. Note that figures are rounded to reflect degree of certainty and may not tally.

Mineral resource grade appears to increase with resource confidence. i.e. increased drilling density

The combined Goongarrie Hill, Goongarrie South, Big Four and Scotia Dam deposits (from north to south) form a continuous zone of mineralisation that extends over a strike length of more than 16 km, is up to 1 km wide and averages approximately 40m in thickness.

The mineral resource grade appears to increase with resource confidence, i.e. increased drilling density. Additional drilling should increase both the tonnage and grade of the mineral resource for the various deposits, particularly for Goongarrie Hill and Scotia Dam, which are not yet included in the ore reserves. In turn, this will increase the material to be included in the mine plan and ore feed.

Excellent infill drilling results

Recent drilling results support that view:

- AGSR0054: 14m at 0.27% Co, 1.18% Ni and 21 Sc from 6m
- AGSR0055: 42m at 0.16% Co, 1.43% Ni and 46 Sc from 2m
- AGSR0059: 26m at 0.18% Co, 1.13% Ni and 36 g/t Sc from 12m
- AGSR0061: 42m at 0.15% Co, 0.86% Ni and 35 g/t Sc from 8m, including 14m at 025% Co, 1.01% Ni and 46 g/t Sc from 10m.

Those high grade results close to surface are particularly important as they located in the expected start-up deposit, hence providing rapid payback opportunities.

Beyond the JORC code classification, the confidence in the mineral resource is particularly high given that:

- The 40m infill of historic RC drilling has returned very good consistency of cobalt and nickel grade between multiple drilling phases since 1998. This is most significant, in view of third party due diligence when considering project funding.
- the regolith interpretations have proved to be precise - which allows confident modelling of material types for plant feed
- The Ardea diamond drilling has validated both the historic and Ardea RC drilling to a high level of precision

The reserves reported represent only 5 % of the overall KNP resource.

Mining and Ore Reserves

The deposits lend themselves to simple open-pit mining with minimal dilution. The schedule assumes the development of 13 separate open pits. The PFS assumes that mining will be undertaken by conventional open pit methods, utilising truck and excavator fleets.

Mining risk is minimal

Deposits	Category	Size (Mt)	Cobalt (%)	Nickel (%)
Goongarrie South	Proven	8.95	0.10%	0.96%
	Probable	17.26	0.09%	0.79%
Big Four	Proven	–	–	–
	Probable	13.92	0.09%	0.77%
TOTAL	Proven	8.95	0.10%	0.96%
	Probable	31.18	0.09%	0.78%
	Total	40.13	0.09%	0.82%

Using a nickel equivalent cut of >0.81 %, which used inputs of A$18,900/t nickel and A$120,750/t cobalt. (US$15,120/t Ni and US$96,600/t Co, 0.8 exchange rate).

The Goongarrie ore is soft and is amenable to free digging by excavators with minimal blasting required only where surface hardcap deposits are present. The deposit is characterised by low strip ratios of around 1.5:1.

At 1.0 Mtpa or even 1.5 Mtpa the PFS presents an entry level type operation, to minimise the initial capital funding requirement and reduce technical risk.

A path similar to the Coral Bay HPAL operation in the Philippines managed by Sumitomo could be envisaged here.

Pre-Feasibility Study

Goongarrie Nickel Cobalt Project PFS outlines a manageable capital and low operating cost base case which utilises simple open pit mining and processing of 1.0 Mtpa of autoclave ore feed over an initial 25-year.

The PFS considered production levels of a 1.0 Mtpa base case and 1.5 Mtpa. The 1.0 Mtpa case represents a lower capital expenditure starter option that is readily expandable for greater throughput by the installation of additional modular processing trains. The production levels considered are viable on a single standalone process train design basis.

The 1.0 Mtpa base case was selected to minimise initial funding requirements given the current market capitalisation of Ardea. A larger scale project is potentially fundable with a consortium or strategic partners assisting in development of the project as the resource base at Goongarrie is large.

Goongarrie and the larger, encompassing Kalgoorlie Nickel Project (KNP) are sizeable, globally significant deposits that provide the potential capacity for high rates of production over many decades. There is considerable

opportunity to expand the mine life and annual production in the future by including additional open pit inventory which is not currently included in the mining schedule.

An A$:US$ exchange rate of 0.788 has been selected for the life of the project.

Metallurgy

Extensive test work was completed during the 2005-2009 Vale Inco PFS. The Vale Inco study focussed on the Goongarrie South deposit and used a Sherritt-style PAL flowsheet to produce a mixed sulphide product.

It is important to note that with two operations at Moa Bay, Cuba and Ambatovy in Madagascar, Sheritt is one of the most successful HPAL operators in the world.

To implement the Vale study, further testwork was completed by Simulus Engineers on composite drill core samples selected from Ardea's 2017 core drilling program at Goongarrie South. These samples have high iron and low magnesium content. These represent the scheduled geo-metallurgy for the first five years of mining and processing.

Following the selection of the PAL as the preferred leaching process, mixed sulphide (MS) precipitation has been selected as a suitable intermediate step to enable the following key attributes to be realised:

- Utilisation of an established unit operation in use at commercial scale
- Decoupling of the leach and refinery plants
- Production of a high grade intermediate product and reducing the size of the refinery process equipment
- Primary rejection of manganese and magnesium to achieve battery grade sulphate products

Flowsheet

The Company has selected proven technology for the processing of the Goongarrie laterites. The flowsheet comprises proven 5th generation HPAL process with MS precipitation, resulting in highly efficient extraction of cobalt and nickel from Goongarrie ore to produce cobalt sulphate crystals and nickel sulphate crystals for the battery industry.

The process comprises four basic sequential steps, all of which are well proven and commonly used in the wider metallurgical industry to provide high recoveries of base metals.

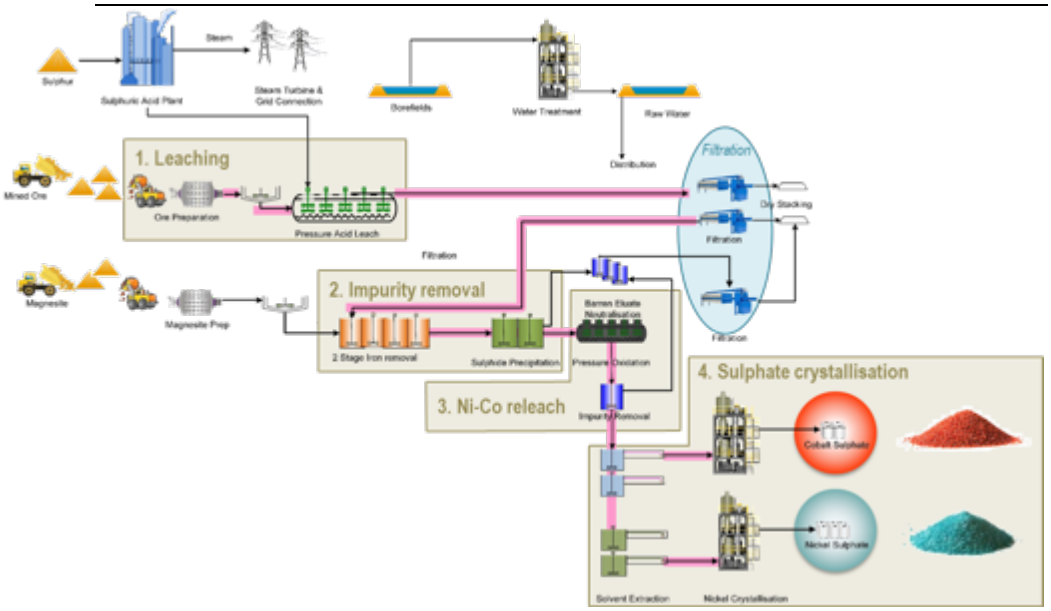
Stage 1 is an aqueous pressure leach in an acidic sulphate medium to dissolve the base metals while minimising dissolution of the iron and silica gangue. The conditions used are typical for base metal dissolution from lateritic ore sources. The discharge from the autoclave is filtered and the solids dry stacked.

Stage 2 is primary impurity removal and nickel/cobalt sulphide recovery from the autoclave filtered solution. The filtered pregnant liquor solution proceeds to two-stage neutralisation for removal of the free acid, iron and aluminium.

The iron-free solution is then exposed to sulphide precipitation to recover a high-grade nickel/cobalt sulphide product with minimal impurities.

The filtration of tailings provides an advantage over traditional flowsheets, in that the filtered solids are washed and dry stacked, negating the need for a tailings storage facility or counter current decantation that have caused operational issues and bottlenecks in earlier laterite flowsheets.

PAL-MS Flowsheet for the Goongarrie Nickel Cobalt PFS



Source: ARL

The ARL flowsheet has the key advantage to produce an intermediate product, hence reducing risk and offering an additional option to generate cash flows.

On the other hand, the Sunrise flowsheet, while simpler, does not allow for errors should the innovative ion exchange process experience issues during its implementation without an intermediate product.

Stage 3 is nickel and cobalt oxidative re-leach and secondary impurity removal. The nickel and cobalt- rich sulphide intermediate product is oxidised and re-leached under medium pressure and temperature to provide a high concentration, small volume metal stream.

Stage 4, the final stage, is the crystallisation of high-purity and separate nickel sulphate and cobalt sulphate, with solvent extraction being used to separate the nickel and cobalt. The separate nickel and cobalt sulphate streams are concentrated to saturation point via thermal and mechanical energy input. This causes the metals to begin crystallising from solution as metal sulphate hydrates. The specific form of crystal as required by off-takers is manipulated by controlling the temperature of crystallisation.

The nickel circuit uses a falling film evaporator followed by a mechanical vapour recompression crystalliser. For cobalt crystallisation this is achieved in a single unit operation due to the relatively small scale of production.

Reagents used include sulphur, liquefied oxygen, magnesite (mined on site), caustic, and minor reagents such a selective organic extractants, ion-exchange reagents, flocculants, and water treatment chemicals.

Tailings are mostly derived from the barren solution from base metal sulphide precipitation, and the final washed filter cake from the acid leach.

Reagents

Dolomite and magnesite Neutraliser resources have been identified within Tertiary-aged paleo-channels overlying the cobalt-nickel ore zones. Metallurgical programs are underway to settle a flowsheet for upgrading the neutraliser to hydrometallurgical grade. The discoveries were made by the Ardea team through precise geo-metallurgical programs, and had previously remained undiscovered despite pattern drilling at Goongarrie since the 1970s.

Pilot Plant

To, among other things, facilitate the due diligence of third party, ARL has engaged Simulus Group to conduct pilot plant trials and provide marketing samples of nickel sulphate and cobalt sulphate crystals to eager battery market end users.

Pilot Plant Autoclave at Simulus Group

Source: ARL

Upside

Firstly the KNP mineral resource already delineated for cobalt, nickel and scandium offers optionality for much larger throughput and longer mine life.

Furthermore, with Ardea's systematic assay of scandium, vanadium and chromium for the first time, substantial mineralisation has been discovered above and within the known cobalt-nickel mineralisation. Metallurgical programs have been scoped to further assess low opex recovery options for aluminium, vanadium and chromium (these are totally separate from the sulphuric acid HPAL-MS cobalt-nickel(-scandium) circuit).

Very pure kaolin has also been discovered as paleo-channel overbank deposits, with lateral continuity not yet quantified. In core logging, the material approaches "coating-grade kaolin" and appears from logging to be a potential feedstock for High Purity Alumina (HPA). Metallurgical programs are being scoped.

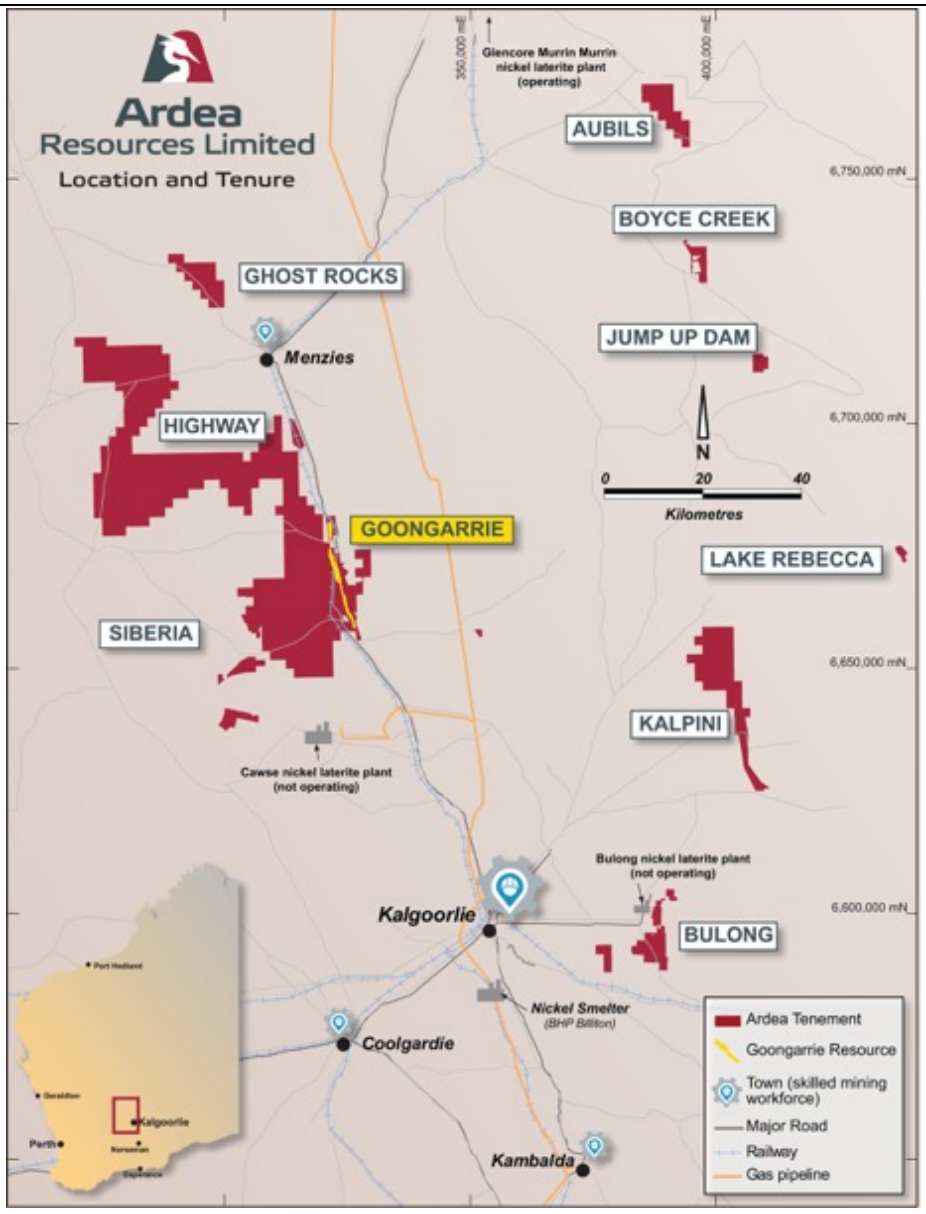
6. Kalgoorlie Nickel Project (KNP)

The ore reserves defined for the Goongarrie Nickel Cobalt Project constitute less than 5% of the larger, encompassing KNP mineral resources. These provide considerable upside for increased production and ongoing mine life and as such Ardea is focussing on a targeted plan of ongoing work to prove up and upgrade the resources at the following deposits:

- Siberia/Highway/Ghost Rocks
- Black Range
- Aubils/Boyce Creek/Jump-up Dam
- Kalpini/Bulong/Lake Rebecca

All of these deposits are within road haulage range of the proposed Goongarrie plant. These other deposits may provide potential satellite feed options for the Goongarrie plant or the possibility of additional processing hubs or have the potential to provide feed for local third party processors of lateritic nickel.

Ardea's West Australian Projects



Source: ARL

In order to support the regional strategy of building resources including water across the KNP, a program of aggressive lease acquisition was undertaken during the quarter. A total of 18 leases were acquired with a combined land area of 2,281km^2 including:

- Kalpini, KNP East – High grade, good continuity mineralisation has been identified in resource reviews. Accordingly, a Mining Lease application was lodged at Wellington East at Kalpini.
- Lake Rebecca, KNP East – High grade, good continuity mineralisation has been identified in Ardea tenure at Lake Rebecca whch has no published resource. Accordingly, a Mining Lease application was lodged.
- Boyce Creek, KNP Yerilla – High grade, good continuity cobalt-dominant mineralisation has been identified in resource reviews. A Mining Lease application was lodged at Boyce Creek, which consolidates Ardea Mining Lease tenure at Boyce Creek.
- Aubils, KNP Yerilla – Mineralisation interpretations commenced, to facilitate site design and consequent Mining Lease application.

7. Directors & Management Team

Katina Law, Non-Executive Chairman

BCom, CPA, MBA, GAICD

Katina Law has over 25 years' experience in the mining industry covering corporate and site based roles across several continents. Over the past ten years she has worked with a number of ASX listed resources companies in strategic financial advisory and general management roles. She has worked on a number of development and evaluation projects which were later subject to corporate transactions including the Deflector gold and copper project and the King Vol polymetallic zinc project. Ms Law was Executive Director and CEO of East Africa Resources Ltd from 2012 to 2015. Ms Law has also held senior positions at Newmont Mining Corporation's head office in Denver, USA producing the company's financial plans and providing financial information and analysis to the Board of Directors and the Executive Committee. She held the position of New Business Development Executive at LionOre International where she was responsible for the financial assessment of development projects.

Brett Clark, Managing Director

B Eng, Dip Fin

Mr Clark is a senior executive and engineer with 25 years' experience in operations, development and funding with corporate and operational expertise in nickel, gold and copper. Mr Clark has held domestic and international project development and operations management roles with WMC Resources, Tethyan Copper, Rio Tinto, Doonbeg Capital and Ernst and Young Corporate. He has extensive expertise as an investment banker in project finance and the capital markets in the US, Asia and the UK. More recently as a board member of a battery minerals company Mr Clark has been at the forefront of battery metals and minerals strategic supply development, achieving preferred supplier status with two major North American automotive manufacturers and suppliers.

Ian Buchhorn, Technical Executive Director

BSc (Hons), Dip GeoSci (Min Econ), MAusIMM

Ian Buchhorn is a mineral economist and geologist with over 35 years' experience. Prior to listing Heron in 1996 as founding Managing Director, Mr Buchhorn worked with Anglo American Corporation in southern Africa, and Comalco, Shell/Billiton and Elders Resources in Australia variously as a corporate and research geologist, as well as setting up and managing Australia's first specialist mining grade control consultancy. For the last 25 years Mr Buchhorn has developed mining projects throughout the Eastern Goldfields of Western Australia and operated as a Registered Mine Manager. Mr Buchhorn's role is to provide continuity from Heron's stewardship of the assets to Ardea's. Mr Buchhorn is a substantial shareholder of the company with more than 11% of the ARL shares.

Wayne Bramwell, Non-Executive Director

BSc, Grad Dip Bus, MSc, GAICD

Wayne Bramwell is an experienced mining executive with over 26 years of international and Australian project evaluation and development expertise across the base metals, precious metals and bulk commodity sectors. He is currently Chairman of the Bentley Branch of the WA School of Mines Alumni (WASMA). Mr Bramwell was previously the Managing Director of ASX listed Kasbah Resources Limited where he took the company from IPO through all stages of evaluation of the Achmmach Tin Project in Morocco and began the process of project financing. During his tenure he raised extensive funds from the capital markets, off-take partners and international trading houses including negotiating two project level strategic joint ventures with Japan's Toyota Tsusho Corporation and Nittetsu Mining Co. Ltd. Prior to this Wayne held senior executive roles with Iberian Resources Limited, Breakaway Resources Ltd, Harmony Gold (Australia) Pty Ltd, Hill 50 Ltd and several Australian engineering companies specialised in resource engineering.

The Directors and management have strong backgrounds in mineral exploration, mining and process engineering, mine management, finance and accounting

Sam Middlemas, CFO and Company Secretary

B.Com, ACA., Grad. Dip. Acc

Sam Middlemas is a chartered accountant with more than 20 years' experience in various financial and company secretarial roles with a number of listed public companies operating in the resources sector. He is the principal of a corporate advisory company which provides financial and secretarial services specializing in capital raisings and initial public offerings. Previously Mr Middlemas worked for an international accountancy firm. His fields of expertise include corporate secretarial practice, financial and management reporting in the mining industry, treasury and cash flow management and corporate governance. Mr Middlemas is currently CEO and Company Secretary of Bauxite Resources Ltd, and CFO/Company Secretary of RBR Group Ltd, Alto Metals Ltd and Enterprise Metals Ltd.

Matthew Painter, General Manager Gold

BSc (Hons), PhD

Matthew Painter is a geologist with over 20 years' professional experience including SRK Consulting, Sabre Resources, AngloGold Ashanti, Geological Survey of WA and MIM Exploration. His expertise is in ore deposit geology and structural geology, and his work has been instrumental in the successful discovery, exploration, and development of greenfields and brownfields deposits globally. Dr Painter has extensive on-ground experience throughout Australia and overseas including east, west, and southern Africa, central and south-eastern Asia, and South America, across a broad range of commodities including gold, copper, zinc-lead-silver, uranium, tin and manganese. Dr Painter has extensive managerial and ASX-listed company corporate experience.

Sarah Mitchell, General Manager Technical Services

BSc (Extractive Metallurgy), MBA

Ms Mitchell has 20 years' experience in mining and engineering projects, from evaluation through pre-feasibility, feasibility and detailed design stages across a series of cobalt and nickel projects, and copper, uranium, iron ore, mineral sands, and gold projects. Having worked on a broad project portfolio, ranging from small concentrators to complex, billion-dollar hydrometallurgical process plants, including:

- Níquel do Vermelho nickel laterite project, Brazil
- Syerston nickel-cobalt-scandium laterite project, NSW
- Tenke Fungurume copper-cobalt project, DRC
- Goro nickel laterite project, New Caledonia

8. Other Australian HPAL Projects

Sconi

The Sconi project mineral resource is summarised below:

Sconi Project Mineral Resource (0.7% NiEq. *and 1.0% NiEq.*)

Deposit	Mt	Ni Grade	Co Grade	Ni Metal	Co Metal
Kokomo	29.5	0.49%	0.08%	144,700t	22,500t
Greenvale	16.3	0.73%	0.05%	118,100t	8,800t
Greenvale dumps & stockpiles	11.1	0.42%	0.03%	46,000t	3,800t
Lucknow	13.8	0.31%	0.07%	42,200t	10,000t
Southern Deposits	70.7	0.50%	0.06%	351,800	45,200t
Bell Creek South	7.9	0.96%	0.07%	76,100t	5,200t
Bell Creek North	2.0	0.86%	0.03%	16,800t	500t
Bell Creek Northwest	2.5	0.81%	0.05%	20,100t	1,200t
The Neck	0.4	0.84%	0.03%	3,500t	100t
Minnamoolka	5.5	0.82%	0.04%	45,000t	2,400t
Northern Deposits	18.4	0.88%	0.05%	162,100t	9,400t
Total	**89.1**	**0.58%**	**0.06%**	**514,000t**	**54,500t**
Total (1.0% NiEq.)	*41.6*	*0.66%*	*0.08%*	*275,700t*	*33,800t*

Source: MLM, Scandium omitted (only reported for the Southern Deposits), NiEq = Ni + 1.5 Co +0.01 Sc

The overall grades of both cobalt and nickel mineralisation are significantly lower than Goongarrie or KNP mineral resources.

While all those deposits are similar in nature, there also display individual characteristics. For example, at Lucknow, high grade nickel-cobalt zones are patchy and only occur as discrete pods within a blanket of low grade nickel laterite. The iron content is generally higher than seen at Greenvale and averages between 25 to 40% iron. The scandium mineralisation predominantly occurs above or adjacent to the higher grade nickel cobalt mineralisation in the laterite profile. At the Bell Creek deposits, the nickel mineralisation occur throughout the laterite profile, which varies from a siliceous honeycombed laterite, to a clay rich ferruginous laterite, to a basal, strongly weathered serpentinite / saprolitic zone. The laterite material forms a blanket over the ultra-mafic rocks that can vary in thickness from 2 to 20 m. The contact with the fresher ultramafic rocks at the base of the laterite profile is uneven, where peaks and troughs can be identified in cross section. Boulders of serpentinite also occur within the laterite profile. These boulders can be between a few centimetres and in excess of 3 m in diameter.

Whether the mine schedule aims to mine those deposits successively or blend them, the variations of ore types could present some challenges to the HPAL operation.

Most of the Sconi project mineral resource is low grade in both nickel and cobalt. No ore reserves have been estimated. The following deposits have been assessed to provide processing feed material to the Sconi project:

- Greenvale remnant in-situ resources, a previous mine oversize stockpile and previous mine external waste dumps and is located 6 km west of the Greenvale township. The high grade nickel ore was mined from 1974 to 1992.
- Lucknow 6.5 km southeast of Greenvale
- Kokomo 53 km northeast of Greenvale
- Minnamoolka 91 km north-northeast of Greenvale
- Bell Creek 115 km north-northeast of Greenvale.

Sconi Project Location Map with its Five Deposits over 120km

Source: Metallica Minerals

In October 2012, Metallica Minerals (the previous owner) released the results of a revised Scoping Study (+/- 35% accuracy) for a 750,000tpa plant to produced 4,464tpa nickel, 675tpa cobalt and 93,000 kg of scandium oxide. Capital costs were estimated at $597m (excluding contingency) and the NPV (10%, pre-tax) amounted to $870m. The study was based on the Southern Deposits, i.e. Kokomo, Greenvale in situ and Lucknow with a combined mineral resource (at the time) of 59.5 Mt @ 0.51% Ni, 0.07% Co and 64 g/t Sc. The average feed grade was 15 Mt @ 0.69% Ni, 0.10% Co and 99 g/t Sc.

In March 2013, Metallica Minerals released the results of a PFS focused on the extraction and processing of the scandium mineralisation only (Phase 1) from the Lucknow deposit. Capital costs were estimated at $247m (including 20% contingency, no acid plant, no power plant) and the NPV (8%, pre-tax) amounted to $273m.

The Sconi project lies on Mining Leases with all environmental, mining and processing approvals in place.

In March 2017, Australian Mines released the results of the Scoping Study undertaken by Metallica Minerals (July and October 2012) based on the mineral resource estimated in October 2013. In October 2013, Golder Associates, who undertook the mineral resource estimate indicates that “No

Ore Reserves are reported or have been reported previously by Metallica for any of the SCONI deposits".

In parallel, Australian Mines website indicates on its Sconi project page (https://australianmines.com.au/sconi) some forecast production figures. At this time, we could not reconcile those figures with any public document released by Australian Mines or Metallica Minerals.

In September 2017/December 2017, the Sconi project was sold to Australian Mines for A$11 million in cash and shares:

- $1.0m in consideration of varying the initial Sep 2017 agreement
- $3.5m cash on completion (8th December 2017)
- $1.5m AUZ shares on DFS or 30 June 2018
- $5m cash or shares on production

The SCONI project is the flagship of Australian Mines, which currently has a market capitalisation of $246 million (as at 31 May 2018).

Syerston

The lateritic weathering profile in which Ni, Co and Pt accumulated, has developed preferentially over the dunite core of a mafic to ultramafic intrusive complex. The core is about 4km by 2km in area.

The lateritic weathering profile is divided into five zones. From top to bottom, these are termed:

- Residual Overburden (OVB), Ni<0.2%
- Transitional Zone (TZ), upper boundary defined by Ni ~2%; the mean values for Ni and Co and 0.36% and 0.04% respectively
- Goethite Zone (GZ), upper boundary defined by Mn>0.35% with Fe>33% or better 43%; the mean values for Ni and Co and 0.75% and 0.15% respectively
- Silicified Goethite Zone (SGZ), upper boundary defined by 15% Si; the mean values for Ni and Co and 0.60% and 0.07% respectively
- Saprolite Zone (SAP), upper boundary defined by 6% Mg; the mean values for Ni and Co and 0.25% and 0.025% respectively

Syserton Weatering Profile Typical Simplified Chemical Composition

Zone	Name	Definition	Ni	Co	Fe	Si	Al	Mn	Cr
AV	Alluvium Zone		n/a	n/a					
OVB	Overburden	Ni < 0.2% and Co <0.02%	0.11%	0.015%					
TZ	Transitional Zone	upper boundary defined by Ni ~2%	0.36%	0.04%	40%	7%	5%	0.2%	4,600ppm
GZ	Goethite Zone	upper boundary defined by Mn>0.35%	0.75%	0.15%	>40%	5-10%	4%	1.2%	4,100ppm
SGZ	Silicified Goethite Zone	with Fe>33% or better 43%; upper boundary defined by 15% Si	0.60%	0.07%	24%	>20%	1.3%	0.5%	4,400ppm
SAP	Saprolite Zone	upper boundary defined by 6% Mg	0.25%	0.025%	<10%	25%	<1.0%	0.17%	3,000ppm

Source: Syerston Ni43-101, November 2017

9. High Pressure Acid Leaching

Introduction

The high-pressure acid leaching (HPAL) process is one of the most effective solutions for extraction of nickel and cobalt in laterite ores due to its leach selectivity for these metals over iron.

It is the most widely adopted technology for processing lower grade limonite ores. It represents slightly more than 10% of global nickel supply and given the growing demand for nickel sulphate (and cobalt), its share is expected to increase in the future.

History

Historical applications of this technology have been marred by a number of start-up / ramp-up difficulties, challenges, and failures due to the extreme and aggressive operating conditions intrinsic to the process. However, over the years, the technology has evolved to maturity owing to lessons learned, relentless R&D, and the cooperation of equipment vendors, engineering companies, and owners. This has paved the way to overcoming some of the biggest issues in HPAL, and has resulted in progressively more successful HPAL operations.

The late 1950s saw the first application of HPAL technology for low-grade nickel laterites at Moa Bay, which used vertical pressure tanks called “Pachucas”. Since then, interest in HPAL technology started to increase due to the steady decline of global sulphide deposits and due to the growing perception that the lower-grade laterite ore was the next major source for global nickel supply. HPAL is the preferred technology for processing lower-grade laterites due to its selectivity to impurities like iron and aluminium that dominate the ore feed and its ability to minimise acid consumption by hydrolysis of these impurities at high temperatures and pressures.

In the late 1990s, the second generation of HPAL plants was built. Three Western Australian plants (Bulong, Cawse and Murrin-Murrin) revolutionised the application of HPAL technology using a horizontal multi-compartment titanium-clad autoclave vessel based on the concept of brick-lined autoclaves of gold pressure oxidation (POX) application.

The second generation HPAL plants proved to be the biggest learning ground due to numerous technical difficulties in start-up and ramp-up, and equipment and material failures typically not encountered in gold POX technology, which involves much lower acidity and lower temperatures. Owners, engineers, and vendors have since pulled together in a relentless pursuit of design and materials improvements, operational practice improvements, and R&D. All combined, these efforts have contributed to significant developments and improved maturity of the HPAL technology.

Ore Feed

HPAL processes require ores that are predominantly limonitic; in the case of the dry laterites they contain nontronite and/or smectite. In general the ores:

- contain some saprolite
- have lower Mg- usually limited to <4 % (At higher Mg acid consumption is higher)
- require lower Al content (clays are high acid consumers; therefore the Al content should not be too high)

The pressure leaching is carried out either in pachuka tanks (Moa Bay) or titanium lined autoclaves (all modern plants). Leach temperatures vary in the range 245 to 270°C. Solid-liquid separation is carried out by Counter-Current Decantation (CCD). There are various ways of purifying the nickel- containing solution and separating nickel and cobalt. In modern plants such separation is carried out by solvent extraction (SX). Final products produced are electro-nickel, nickel oxide or nickel briquettes. Some plants produce intermediate materials (mixed sulfides or mixed hydroxides) that are refined elsewhere.

HPAL Plants

The table below presents the existing HPAL operations and the Australian projects.

HPAL Existing and Past Operating Plants and Australian projects

Operation	Country	Operator	Flowsheet	Capacity Ni	Start Up	Generation
Moa Bay	Cuba	Sheritt (50%)	HPAL-MS	25,000t	1995	1st
Cawse	Australia		HPAL	9,200t	1998	2nd
Murrin Murrin	Australia	Glencore	HPAL-MS-Hydrogen Red.	45,000t	1999	2nd
Bulong	Australia	Preston	HPAL-DSX-EW	9,000t	2000	2nd
Coral Bay 1	Philippines	Sumitomo (54%)	HPAL-MS	10,000t	2005	3rd
Ravensthorpe	Australia	First Quantum	HPAL	55,000t	2007	3rd
Coral Bay 2	Philippines	Sumitomo (54%)	HPAL-MS	10,000t	2009	3rd
Goro	New Caledonia	Vale	HPAL-DSX-Pyrohydrolysis	57,000t	2010	4th
Ambatovy	Madagascar	Sheritt (12%)	HPAL-MS-Hydrogen Red.	60,000t	2012	4th
Ramu	Papua New Guinea	MCC	HPAL	35,000t	2012	4th
Taganito	Philippines	Sumitomo (75%)	HPAL-MS	30,000t	2013	4th
Gördes	Turkey	Meta Nikel Kobalt	HPAL-MHP	10,000t	2014	4th
Syerston	Australia	CleanTeq	HPAL-Ion Exchange	18,700t	2019F	5th
Goongarrie	Australia	Ardea Resources	HPAL-MS	9,300t-	2020F	5th
				12,350t	2020F	5th
Sconi	Australia	Australian Mines	HPAL	tbd	tbd	-
Wingellina	Australia	Metals X	HPAL-MHP	tbd	tbd	-

Source: various. Terra Studio. MS: mixed sulphide, DSX: direct solvent extraction, MHP: mixed hybrid precipitate, tbd: to be determined.

Although all the above plants used HPAL technology for leaching, they adopted various ore-processing circuits, which were tailored to the specific characteristics of their ore feed, and selected different downstream processing routes, which were significantly influenced by the technical experience and market requirement of the owner.

Bulong, Cawse and Murrin Murrin all made decisions to proceed with construction during 1995/1996. Commissioning of all plants commenced in the second half of 1998. Processing varies between the Western Australian producers influenced by the nature of the ores (how much sulphuric acid is consumed by alkaline minerals present) and the quality of available process

water as well as the downstream processing route (post HPAL) selected and final products as there are several options.

Murrin Murrin, which is still in operation, adopted the Sherritt process which precipitates the metals as sulphides, re-dissolution in an oxidative leach with oxygen under pressure followed by solvent extraction and hydrogen reduction. Bulong processing did not involve precipitation of the sulphide, using direct solvent extraction of the nickel and cobalt from the HPAL discharge liquor (after partial neutralisation and counter current decantation), with the metals produced by electrowinning (electrode depositing); and Cawse precipitated the nickel and cobalt as a hydroxide, originally re-dissolving with ammonia and refining using solvent extraction and production of nickel metal cathodes by electrowinning and precipitation of a cobalt sulphide product through addition of sodium hydrosulphide (NaHS).

The Ravensthorpe project in Western Australia uses enhanced pressure acid leach technology (similar to the Cawse flowsheet. Similarly, the Goro project in New Caledonia utilises a process route similar to the Cawse design. While the Sumitomo's Coral Bay and Sherrit's Ambatovy projects utilise the Moa/Murrin flowsheets producing a mixed sulphide. The HPAL processing technology is no longer new, generally being considered to be in its fifth generation and is much improved by the experience gained in operating plants, as experienced by the fast commissioning and ramp up time for the Taganito Project in the Philippines (2013). There are still challenges in commissioning and ramping up HPAL operations as experienced by Highland Pacific's Ramu Operation in Papua New Guinea but these challenges are well understood.

The majority of HPAL laterite plants worldwide have experienced various levels of technical difficulties during commissioning and start-up, leading to slow ramp-up, poor operational reliability, and financial difficulties. This in turn has led to financial write-downs, changes of ownership, and ultimately closures. Combined with the high capital costs associated with HPAL, this assortment of problems has contributed to a negative perception of the technology, earning it a reputation as the "bad boy poster child" of nickel hydrometallurgy processing.

While this negative reputation stuck with the second generation plants, the mining industry is now recognizing the various relative levels of success being achieved in the succeeding generation (represented by Coral Bay, Taganito HPAL, and Ambatovy). Progress has largely been due to design improvements, successful application of lessons learned from the second generation, and owners' operational excellence. Successful HPAL technology application has been demonstrated in the fast ramp-up of Coral Bay Nickel L1 and the major progress observed in Ambatovy several years after start-up.

Sumitomo is one of the few companies with the technological know-how and proven execution capability to successfully develop HPAL facilities.

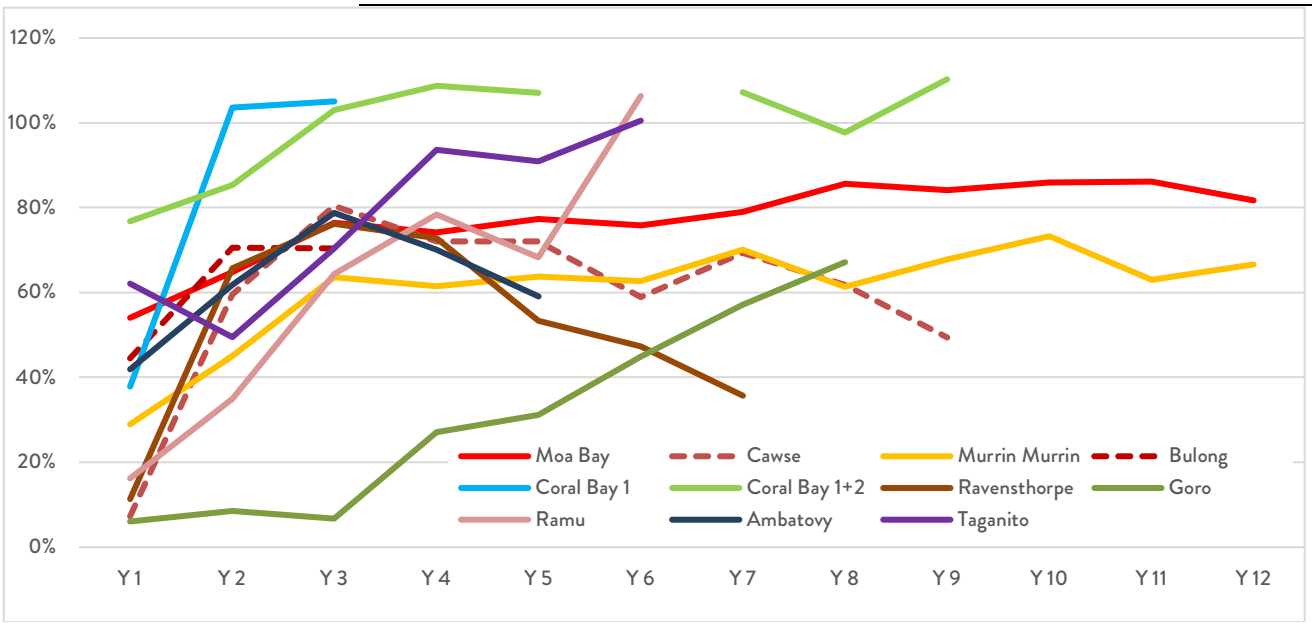
Autoclaves

The hydrometallurgical pressure acid leach (HPAL) processes for nickel laterite ore containing higher saprolite content in Indonesia and Western Australia involve 5-7 wt.% sulfuric acid liquors at 240-270°C to achieve reasonable nickel and cobalt recovery. Corrosivity of these acid liquors is further enhanced by substantial chloride levels (as high as 1-2 wt%) which are introduced by the saline process water.

Ramp Up

Figure 9.1 displays the operational performance of HPAL operations during the first few years of operations.

Figure 9.1 – Ramp up of HPAL operations over time



Source: Terra Studio

The successes of some operations (Moa Bay, Coral Bay and Taganito) are in strong contrast with the failure of others such as Goro and Ravensthorpe.

10. Investment Risks

ARL is exposed to a number of risks including:

- **Geological risk**: the actual characteristics of an ore deposit may differ significantly from initial interpretations.
- **Resource risk:** all resource estimates are expressions of judgment based on knowledge, experience and industry practice. Estimates, which were valid when originally calculated may alter significantly when new information or techniques become available. In addition, by their very nature, resource estimates are imprecise and depend to some extent on interpretations, which may prove to be inaccurate.
- **Feasibility risk:** once mineral deposits are discovered, it take a number of years from the initial phases of drilling until production is possible, during which the economic feasibility of production may change. Substantial time and expenditures are required to:
  - establish mineral reserves through drilling;
  - determine appropriate mining and metallurgical processes for optimizing the recovery of metal contained in ore;
  - obtain environmental and other licenses;
  - construct mining, processing facilities and infrastructure required for greenfield properties; and
  - obtain the ore or extract the minerals from the ore.

- **Commodity price risk:** the revenues ARL will derive through the sale of cobalt and nickel sulfates expose the potential income to cobalt and nickel price risk. The cobalt and nickel prices fluctuate and are affected by many factors beyond the control of ARL. Such factors include supply and demand fluctuations, technological advancements and macro-economic factors.
- **Exchange Rate risk:** The revenue ARL derives from the sale of of cobalt and nickel sulfates exposes the potential income to exchange rate risk. International prices of various commodities are denominated in United States dollars, whereas the costs base and the financial reporting currency of ARL is the Australian dollar, exposing the company to the fluctuations and volatility of the rate of exchange between the USD and AUD as determined by international markets.
- **Mining risk:** A reduction in mine production would result in reduced revenue.
- **Processing risks:** A reduction in plant throughput would result in reduced revenue. In all processing plants, some metal is lost rather than reporting to the valuable product. If the recovery of metal is less than forecast, then revenue will be reduced.
- **Operational cost risk:** an increase in operating costs will reduce the profitability and free cash generation of the project.
- **Management and labour risk**: an experienced and skilled management team is essential to the successful development and operation of mining projects.

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