Orior Capital
HONG KONG

Lake Resources LKE.AX, OTC: LLKKF

A great solution

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Executive summary

Lake Resources is developing five lithium projects in Argentina. The company has the largest lithium lease holding in the country, amounting to more than 2,000 km^2, all of which it owns 100%. The most advanced of the five projects is Kachi, where the company announced a maiden resource of 4.4 million tonnes lithium carbonate equivalent (LCE) in November 2018, and a pre-feasibility study (PFS) in April 2020.

Lake looks incredibly undervalued: The Kachi project has a post-tax, unlevered NPV_8 of US$748m (A$1,148m), and a post-tax IRR of 22%. Despite robust financial metrics, the advantages of direct extraction, and the excellent long-term outlook for lithium, Lake Resources is trading at less than 2% of NPV. Canadian company Standard Lithium, which is also developing a direct extraction project is trading at ~20% of attributable NPV. In February 2020, Orocobre paid an estimated 16% of NPV to acquire Advantage Lithium. Valuing Kachi at 15% of NPV, and Lake's other projects at say, A$25m, suggests a **valuation of A$0.29 (29 cents) per share. This is ~9x the current share price.**

A compelling, significantly cash generative project: The PFS envisages production of 25,500 tpa of high-grade, 99.9% lithium carbonate. Once fully up and running, the project is expected to generate EBITDA of US$155m pa, and an EBITDA margin of 55%, based on a lithium carbonate price of US$11,000/t, and after export taxes and royalties. Accumulative EBITDA is forecast at US$442m over the first three years of operation (2024 to 2026). Earnings and discounted cash flow based valuations are sensitive to selling prices. At a lithium carbonate price of US$13,000/t, the project would generate annual EBITDA of US$202m, and boast a post-tax NPV_8 of US$1,122m (A$1,722m), and an IRR of 28%.

Upside potential from further development: There are a number of development options to be examined through the DFS stage that may improve the economics of the project even further. One option is to stage development, with an initial say 10,000 tpa lithium carbonate plant, and the chlor-alkali plant built as part of stage two. This would reduce upfront capex. Another option, given the very high concentrations of lithium chloride produced so far, maybe to sell lithium chloride as an intermediate product. This would negate the need for a carbonate plant, substantially reducing operating costs. Yet another option, depending on interest from potential off-takers, might to increase capacity to take advantage of the substantial resources available. **Improving the NPV_8 by US$100m, would add ~A$0.034 (3.4 cents per share) to the valuation.**

Why not just extract the lithium? Predicated on ion exchange direct extraction, the **Kachi project has significant and sustainable competitive advantages**. Grades of 99.9% lithium carbonate can be produced, more quickly, and with higher recoveries. Impurities are at a low. The plant will be more readily scalable. After lithium is removed, the brine will be returned to the aquifer without residual chemicals from the processing. Ion exchange technologies are well-established in the water industry, and used by Livent at its Hombre Muerto project in Argentina. As the application of the technology to lithium becomes more prevalent, **the energy storage sector, where low impurities and product consistency are of paramount importance, will increasingly demand these higher purities.**

It's not about the resource grade: Perhaps more familiar with the evaporation pond model, the market seems overly focused on resource grade, and magnesium-to-lithium (Mg/Li) and sulphates-to-lithium (SO_4/Li) ratios. This misses the point. As direct extraction in lithium matures, these factors will become irrelevant. The Kachi project will produce a

99.9% lithium carbonate with low impurities from a feedstock of 250 mg/L lithium. Standard Lithium will do so from a tail brine grading 168 mg/L lithium. **In industrial chemistry, ‘low impurities’ is king.**

Lithium demand to grow rapidly as EV penetration takes off: Lithium demand, including industrial demand, is expected to rise by ~20% pa over the next several years, to 1.0m tpa LCE by 2027. In its New Policies Scenario, the International Energy Agency (IEA) estimates that the global stock of electric vehicles will rise by ~30% pa over the next decade, exceeding 55m vehicles in 2025, and reaching ~135m vehicles in 2030. In this scenario, lithium demand from the battery sector alone could reach ~825,000 tpa LCE by 2030. This represents ~3x the entire global market in 2019. In the IEA’s alternative EV30@30 Scenario, based on EVs reaching 30% market share by 2030, lithium demand would be double that of the New Policies Scenario; about 1.65m tpa LCE.

Meeting this demand will be challenging. The global EV market is already a significant power market in its own right. In 2018, EV penetration was still only ~2%, yet the global EV fleet consumed ~58 terawatt-hours (TWh) of electricity, according to the IEA. This is about the same as Switzerland.

Supply-side issues: A number of lithium projects have been cut back or delayed over the past year or so. Evaporation pond projects are coming under greater environmental scrutiny. Reuters reported, May 2019, that no new players have secured production permits in Chile since lithium prices took off in 2014.

This combination of robust demand growth and supply-side challenges means the outlook for lithium prices is excellent; the market is facing supply-side deficits by the mid-2020s.

Argentina, open and focusing on lithium: Argentina hosts a number of lithium projects, including Cauchari-Olaroz (Ganfeng Lithium, Lithium America), Hombre Muerto (Livent), and Olaroz (Orocobre). Signalling that Argentina is serious about capitalising on its vast minerals endowment, Alberto Hensel, the former Minister of Mining of San Juan province was appointed Secretary of Mining in President Alberto Fernandez’s new government. In January, he highlighted the potential for US$3.6bn of investment in Argentina’s lithium industry over the next four years.

Potential share price catalysts: With the pilot plant close to commissioning, Lake Resources is at an inflection point. Catalysts for the shares include producing lithium carbonate samples for delivery to potential off-takers over the next few weeks, announcing product specifications from the samples, successfully financing the next stage of development including the DFS, the pilot plant and up to the construction finance stage, and a greater recognition amongst investors of the advantages of direct extraction.

Direct extraction is the future for lithium. It produces a better product, more quickly. Lake Resources offers one of the very few ways to gain exposure to the technology globally. There is a huge disconnect between the company’s valuation, and its prospects. That presents an opportunity.

Simon Francis May 2020

Key financial data

Figure 1: Shareholding structure

ASX code		LKE
Share price, 22 May 2020	A$/share	0.032
Shares on issue	Millions	671.5
Options, listed (10 cents)	Millions	52.5
Options, unlisted (4.6-28 cents)	Millions	48.5
Fully diluted shares	Millions	772.5
Market capitalisation	A$ millions	21.5
Net cash, 31 March 2020	A$ millions	1.2
Enterprise value	A$ millions	20.3
Top 20 shareholders:		31%

Source: Lake Resources

Key Management:

Mr Stephen Promnitz, Managing Director: Stephen Promnitz joined Lake as Managing Director in November 2016. Prior to Lake Resources, Stephen was CEO of listed Australian gold explorer Indochine Mining, and 2IC of Kingsgate Consolidated, a listed Pacific Rim gold producer with assets in Chile. Before this time, he held senior corporate finance roles with Westpac and Citigroup. He started his career as a geologist with Rio Tinto before managing Western Mining Corp's mining operations in Argentina. He holds a Bachelor of Science Honours (Natural Resources) from Monash University and is fluent in Spanish.

Mr Stuart Crow, Chairman and Non-Executive Director: Stuart has global experience in financial services, corporate finance, investor relations, international markets, salary packaging and stock broking. Stuart is passionate about assisting emerging listed companies to attract investors and capital and has owned and operated his own businesses.

Dr Nick Lindsay, Non-Executive Director: Dr Lindsay has over 30 years' experience in Argentina, Chile and Peru in technical and commercial roles in the resources sector with major and mid-tier companies, as well as start-ups. A fluent Spanish speaker, he has successfully taken companies in South America, such as Laguna Resources which he led as Managing Director, from inception to listing, development and acquisition. He is currently Technical Director of Valor Resources Ltd, a listed company with copper-silver assets in Peru, having previously held the position of CEO Manuka Resources (unlisted) and prior to that President – Chilean Operations for Kingsgate Consolidated Ltd. Nick is a member of the AusIMM and the AIG and holds a Bachelor of Science (Honours) in Geology, a PhD in Metallurgy and Materials Engineering as well as an MBA.

Figure 2: Lake Resources share price chart

Source: ASX

Lake looks incredibly undervalued

- Trading at less than 2% of the Kachi post-tax NPV_8, Lake Resources looks cheap both in absolute terms and relative to peers
- Valuing the Kachi project in line with peers, and the company's other projects at A$25m, suggests a valuation of A$0.29 (29 cents) per share
- There is huge upside potential to this valuation from further developments at Kachi, from developing other projects, and from a recovery in the lithium market

The market is valuing Lake Resources at less than 2% of the Kachi post-tax NPV_8 of US$748m. This is an astonishingly cheap valuation, especially given:

- The project generates a high purity 99.9% lithium carbonate product with very low impurities as will increasingly become demanded by global battery makers
- Direct extraction is an established technology, used by Livent at the Hombre Muerto project in Argentina, and widely in the water industry
- Project partner Lilac Solutions has the backing of a number of the world's leading business people
- The PFS is based on a conservative price assumption of US$11,000/t LCE throughout the project life; other companies have used prices that are 16% to 40% higher than this
- Capex and operating costs are competitive and there is scope to further reduce both

There are a number of factors that might explain this low valuation:

- The PFS was only announced on 30 April 2020, and has probably not been fully absorbed by the market
- Investors do not yet fully appreciate the importance of product purity, and why a 99.9% pure product is of greater commercial value than one that is less pure
- Investors may be less familiar with direct extraction technologies than with the evaporation pond model; after all, man's earliest source of salt – it was first added to food some 5,000 years ago – was from solar evaporation
- A number of lithium development companies have released feasibility studies over the past year or so, making it difficult for individual companies to gain attention
- Companies adopt different price forecasts in their feasibility studies, making it difficult for investors to meaningfully differentiate between projects
- The initial capex for the Kachi project is high compared to the company's current market capitalisation (though it is commensurate with other projects of similar scale)
- Lithium prices have been weak
- Markets generally

Valuation of 29 cents

Valuing the Kachi project at 15% of NPV_8, broadly in line with the current market valuation of Standard Lithium, and the valuations of the Orocobre – Advantage Lithium deal and the Pluspetrol – LSC Lithium deal, suggests a current valuation for Kachi of A$172m. Valuing Lake's other projects at say, A$25m, suggests a valuation of A$197m, or A$0.29 (29 cents) per share. **This is ~9x the current share price.**

Figure 3: Lake Resources valuation of A$0.29 (29 cents) per share

Project	Methodology	Value A$ m
Kachi	15% of NPV_8, A$1.535:US$	172
Other projects		25
Enterprise value		197
Net cash		1
Market cap.		196
Shares o/s, millions		671.5
Value per share, A$/share		**0.29**

Source: Orior Capital

Lake's other projects include Cauchari, where last year the company intersected 343m at 493 mg/L lithium from 117m depth, and which neighbours the Ganfeng/Lithium Americas project (resource of 24.6m tonnes LCE at 592 mg/L), and Catamarca, which hosts a series of pegmatite swarms over a belt of 150 km, an enormous target with compelling geology, and historical mining.

Further upside potential

There are a number of potential development options that could improve the already compelling economics of the project. One option may be to sell a very high-grade lithium chloride (LiCl) eluate as a feedstock. Lilac has already demonstrated the ability to produce eluate from Kachi brines at concentrations of up to 60,000 mg/L. This would negate the need for the reverse osmosis circuit and the carbonate plant. Carbonate plants are relatively energy intensive; according to the PFS, the carbonate plant will account for ~40% of operating costs.

Another option might be to split the project into two phases, with an initial stage of say, 10,000 tpa lithium carbonate. The chlor-alkali plant could be built as part of stage two. This would reduce the initial capex costs.

The company is examining the use a solar hybrid energy supply to cut operating costs.

Recognising the substantial, low impurity resource at Kachi, and depending on demand, yet another option may be to scale up the plant. Based on management's exploration target, the resource could potentially be developed to support an operation of as much as 100,000 tpa LCE.

None of these are set in stone; rather they are development options that management may consider as the company progresses though the DFS stage over the next 12-15 months.

Another factor, would be a recovery in the lithium market. **A lithium price of US$13,000/t would mean a higher NPV_8 of US$1,122m, raising our valuation to A$0.38 (38 cents) per share.**

Improving the NPV_8 by US$100m, would add ~A$0.034 (3.4 cents per share) to the valuation.

Peer valuations

There are a number of lithium development companies with recently completed feasibility studies (PEA, PFS, DFS), and also two recent transactions in the sector.

Standard Lithium

The most obvious comparable company is Standard Lithium, listed on the TSX.V. Standard Lithium is developing the South Arkansas Lithium Project, a joint venture with leading speciality chemicals producer Lanxess AG. The project will utilise direct extraction, and targets production of a 99.9% battery grade lithium carbonate. Standard Lithium has a 30% stake in the venture, with Lanxess holding the remaining 70%. Standard Lithium announced, 19 May 2020, the successful start-up of its demonstration plant.

Lanxess processes brine at three bromine extraction plants in El Dorado, Arkansas, with the tail brines being re-injected to the aquifer. Standard Lithium's aim is to intercept these tail brines for further processing. In August 2019, Standard Lithium released a PEA targeting production capacity of 20,900 tpa LCE, and boasting a post-tax NPV_8 of US$989m and an IRR of 36% at a lithium carbonate price of US$13,550/t. (This price is US$2,550/t (23%) higher than the price adopted by Lake Resources in the Kachi PFS). **Standard Lithium is currently trading at ~20% of its attributable post-tax NPV_8.**

Lanxess was formed in 2004 from the spin-off of Bayer AG's chemicals division. It has 60 chemical production sites worldwide, including 21 in North America, has ~14,300 employees, and achieved revenues of €6.8bn in 2019.

Orocobre – Advantage Lithium

Another valuation reference point is the Orocobre-Advantage Lithium deal. In February 2020, Orocobre announced plans to acquire the 65.3% of Advantage Lithium that it did not already own in an all-share deal valued at ~C$69m (~A$78m at the time), and which valued Advantage Lithium at ~A$119m on a 100% basis. The deal was completed in April 2020.

Advantage Lithium owns 75% of the Cauchari lithium project, located in Jujuy Province, Argentina (with Orocobre owning the remaining 25%), as well as various lithium exploration properties in Argentina. In April 2019, Advantage Lithium announced an increased resource of 6.3m tonnes LCE (on a 100% basis). In October 2019, the company published a PFS with a post-tax NPV_8 of US$671m, initial capex of US$446m (including a 20% contingency), and an IRR of 20.9%. **On these figures, and based on US$:C$1.33, Orocobre paid ~16% of post-tax NPV_8.**

Given Orocobre already owned a 25% stake in the project as well as a significant stake in Advantage lithium, Advantage Lithium was unlikely to attract other bidders; there is probably no takeover premium built into the acquisition price.

Pluspetrol Resources – LSC Lithium

In March 2019, Pluspetrol, a Latin-America based oil and gas company, acquired LSC Lithium in an all-cash C$111m deal. LSC Lithium had 100% stakes in three projects in northern Argentina. Together the Pastos Grandes, Pozuelos, and Rio Grande projects had aggregate NI43-101 compliant resources of 5.2m tonnes LCE.

In January 2019, LSC Lithium completed a PEA for the combined Pozuelos-Pastos Grandes Project with a post-tax NPV_8 of US$762m. The Pluspetrol acquisition of LSC Lithium was done at ~11% of NPV_8, and viewed at the time as being a good deal for Pluspetrol.

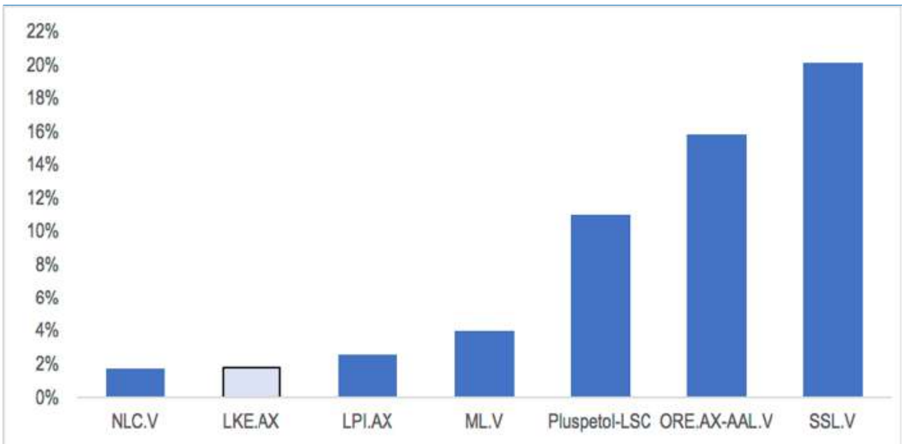
This deal is perhaps a sign of things to come; the oil and gas industry is increasingly looking at ways of entering the 'new energy' market.

As an admittedly rather broad rule of thumb, companies with attractive pre-feasibility studies with good economics can trade at around 15% of post-tax NPV. Taken together, these examples are around that level.

Other companies

Some other lithium development companies that have recently completed feasibility studies have been excluded from comparison. This includes Lithium Power International, Millennial Lithium and Neo Lithium. These companies are all developing evaporation pond operations, aim to produce 99.4% to 99.5% lithium carbonate, and are located at higher altitude than the Kachi project. High altitudes cause significant power de-rating in fossil fuel generators. The lithium carbonate price adopted in these companies' studies, over the first ten years of production, ranges from US$12,770/t to US$15,452/t LCE. This represents premiums of 16% to 40% over the price of US$11,000/t adopted by Lake Resources in the Kachi PFS.

Figure 4: EV/post-tax NPV_8 valuations for selected lithium developers and transactions



Source: Company data, Orior Capital estimates

EV per tonne of capacity preferred, EV per tonne of resource less useful

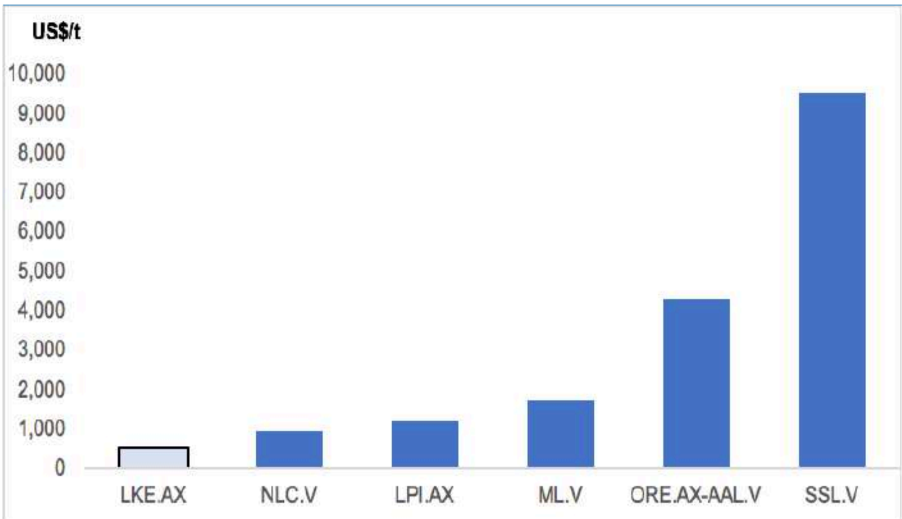
In the junior gold space, EV/oz of resource is a common valuation metric. This works because most resource ounces can be recovered, and in the relatively short-term. This is not necessarily the case in lithium. Brine salars are voluminous. It takes relatively little drilling to demonstrate large resources. Companies don't always have to mine the entire resource, even to produce at reasonable scale over a long period. In evaporation ponds, net recoveries are lower, typically ~50%. Kachi is a good example of this. The PFS is based on Lake producing 25,500 tpa LCE, a quantity that represents ~9% of 2019 global demand, for 25 years, whilst utilising just less than one-fifth of its total resource.

Another difficulty arises from different recovery rates. According to the feasibility studies of six lithium developers, recovery rates vary from 52% (Neo Lithium) to 90% (Standard Lithium). The expected recovery rate at Kachi is 83%. Lake Resources is expected to recover a third more of their lithium resource than Neo Lithium will theirs.

With long project lifetimes, different recovery rates, and differing portions of resource being mined, it is difficult to draw meaningful conclusions from EV per resource metrics. The preferred approach, EV per tonne of production capacity, largely eliminates these issues.

Lake Resources is currently trading at an estimated EV/t capacity of US$518. This represents an 85% discount to the average valuation of four lithium developers (excluding Advantage Lithium) and a discount of 88% to the valuation that Orocobre paid for Advantage Lithium. (That is with no value attached to the Lake's other assets).

Figure 5: EV per tonne of attributable capacity



Source: Company data, Orior Capital estimates

Figure 6: Selected lithium projects, key feasibility study details

	Lake Resources	Standard Lithium	Lithium Power Int'l	Millennial Lithium	Neo Lithium	Advantage Lithium
Stock code	LKE.AX	SLL.V	LPI.AX	ML.V	NLC.V	AAL.V
Project	Kachi	Lanxess	Maricunga	Pastos Grandes	Tres Quebradas	Cauchari
Location	Catamarca Argentina	Arkansas USA	Maricunga Chile	Salta Argentina	Catamarca Argentina	Jujuy Argentina
Altitude, masl	3,000	80 (est.)	3,750	3,785	4,100	3,900
Altitude, feet asl	9,843	262	12,303	12,418	13,451	12,795
Ownership, %	100	30	51	100	100	75
Market cap, US$ m	14	62	23	57	40	n.a.
Enterprise value, US$ m	13	60	12	41	19	79
EV/t attrib. capacity, US$	518	9,524	1,165	1,690	941	4,237
EV/post-tax NPV_8	1.8%	20.1%	2.6%	3.9%	1.6%	15.8%
Feasibility Study	PFS	PEA	DFS	DFS	PFS	PFS
Date	Apr-20	Aug-19	Jan-19	Jul-19	May-19	Oct-19
Technology	Direct Extraction	Direct Extraction	Evap. Pond	Evap. Pond	Evap. Pond	Evap. Pond
Capacity, tpa LCE	25,500	20,900	20,000	24,000	20,000	25,000
Grade, $LiCO_3$ %	99.9	99.9	99.4	99.5	99.4	See notes
Production period	2024-2048	2022-2046	2023-2044	2023-2063	2021-2055	2023-2053
Production years	25	25	22	41	35	41
First year of full output	2025	2026	2025	2025	2022	2026
NPV_8, post-tax, US$ m	**748**	**989**	**908**	**1,030**	**1,144**	**671**
IRR, %	22	36	21	24	50	21
Prices used in study						
High, US$/t LCE	11,000	13,550	17,616	16,182	16,000	13,255
Low, US$/t LCE	11,000	13,550	13,263	11,484	9,800	10,132
Avg. yrs 1-10, US$/t LCE	**11,000**	**13,550**	**15,452**	**13,937**	**12,770**	**11,580**
Initial capex, US$ m	**544**	**437**	**563**	**448**	**319**	**446**
Inc. contingency, US$ m	91	87	63	50	47	74
Initial capex/t, US$	21,333	20,917	28,150	18,667	15,950	17,840
Operating costs, US$/t LCE	**4,178**	**4,319**	**3,772**	**3,388**	**2,914**	**3,569**
Resources, tonnes 000s LCE	**4,400**	**3,140**	**2,070**	**4,948**	**6,922**	**6,300**
Measured, indicated	1,005	3,140	2,070	4,150	4,005	4,800
Inferred	3,394	-	-	798	2,917	1,500
Planned extraction	**768**	**522**	**692**	**1,709**	**1,294**	**1,018**
Extraction/M+I resource, %	76	17	33	41	32	21
Total production	635	470	401	943	667	672
Apparent recovery rate, %	83	90	58	55	52	66

Notes:

Neo Lithium grade based on most recent tests

Advantage Lithium enterprise value based on Orocobre acquisition price

Advantage Lithium capex comprises initial capex of US$446m, plus US$158m capex deferred to years 5, 6 and 9 described in PFS as necessary "in order to maintain stable lithium production over the life of mine"

Advantage Lithium "battery grade" not defined in the PFS

Prices taken from first year of actual production

Lithium Power Int'l total production includes 42,400 tonnes technical grade lithium carbonate

MASL is metres above sea level

Source: Company data, Orior Capital estimates

Snapshot of the Kachi PFS

- The Kachi PFS boasts a post-tax NPV_8 of US$748m, and an IRR of 22% based on production of 25,500 tonnes LCE pa for 25 years, and US$11,000/t LCE
- The PFS is based on processing less than one-fifth of the total resource, suggesting ample scope to extend the project life, or increase output
- There is plenty of scope to further improve the project economics

The Kachi project is based on the Salar de Carachi Pampa, located in Argentina's Catamarca province, towards the southern end of the 'Lithium Triangle'. It is 100% owned by Lake Resources. The Salar is hosted in a 700m to 800m deep, fault bounded, northwest oriented depression filled with brine saturated sand, interbedded with silt and clay, and capped by a salt crust, and a small lake. The project comprises some 705 km^2 of leases and lease applications over a brine basin that measures 20 km by 15 km, and with depths of 400m to 800m.

In November 2018, the company announced a maiden JORC resource at Kachi of 4.4m tonnes contained LCE, ranking it among the world's ten largest lithium resources. The resource remains open at depth and laterally. Management has an exploration target of 8m tonnes to 17m tonnes LCE. The Kachi brines are generally low in impurities, and are demonstrably suitable for beneficiation into a high-grade, 99.9%, lithium carbonate product.

Project viability is predicated on the use of direct extraction technology to selectively remove lithium ions from the brine. After the lithium is removed the brine is returned to the aquifer without chemical change. This does not generate large quantities of salt waste products. The eluate from the process is upgraded by reverse osmosis to concentrations as high as 60,000 mg/L lithium feed stock which is reacted with sodium carbonate to produce lithium carbonate.

Tests at Lilac's facility in Oakland, California have been hugely successful, producing a 99.9% lithium carbonate product with low impurities.

The PFS is based on the project being constructed in 2022-2023, with initial brines being treated in 2024. Production is slated at 21,700 tonnes in 2024, reaching full capacity of 25,500 tpa by 2025.

Strong financials

The Kachi project is expected to generate accumulative EBITDA of US$442m over the first three years of operation (2024 to 2026). EBITDA, correctly accounted for in the PFS as being after royalties and export taxes, is expected to be US$155m pa. **Once fully up and running, based on a lithium carbonate price of US$11,000/t and C1 cash costs of US$4,178/t, the project is expected to generate a margin of US$174m pa over C1 costs, representing a margin of 62%.** The post-tax NPV_8 is US$748m.

Figure 7: Key parameters of the Kachi PFS

Production parameters	Units	
Annual production	Tonnes LCE	25,500
Annual production	Tonnes contained lithium	4,801
Life of project production	Tonnes LCE	638,000
Project life	Years	25
Brines extracted and treated	Million m^3 per annum	23
Lithium grade to Direct Extraction plant	Mg/litre	250
Average recovery rate	%	83.2
Lithium carbonate grade	%	99.9
Indicated mineral resource	Million tonnes LCE	1.01
Financial parameters		
Initial capital costs	US$ millions	544
Operating costs	US$/t	4,178
All-in sustaining costs	US$/t	5,100
Lithium carbonate price (99.9%)	US$/t	11,000
Margin over C1 cash costs	US$/t	6,822
Revenues, at full production	US$ millions per annum	280
Revenues, life of project	US$ millions	7,030
EBITDA, cumulative first 3 years	US$ millions	442
EBITDA at full production	US$ millions per annum	155
EBITDA, life of project	US$ millions	3,890
NPV_8, pre-tax	US$ millions	1,050
NPV_8, post-tax	US$ millions	748
IRR, pre-tax	%	25
IRR, post-tax	%	22
Payback period from first production	Years	5

Source: Lake Resources

Battery grade

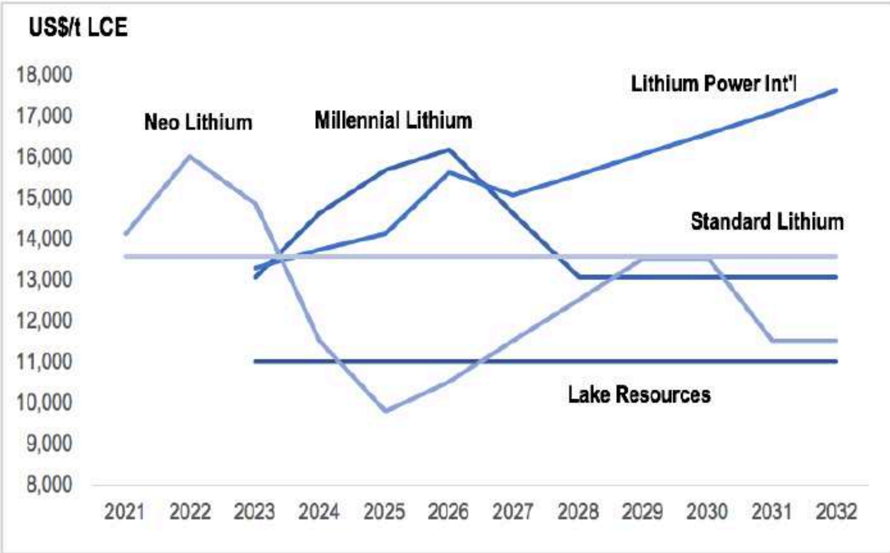
Tests done at Lilac Solutions' facility in Oakland California, demonstrate that Kachi brines can render a 99.9% lithium carbonate product, with low impurities. As in many industrial minerals, the level of purity goes a long way to determining product price. A 99% product contains ten times the impurities of a 99.9% product. Current price indications from Chinese traders are US$5,500/t for 99% product, ~US$10,000/t for 99.9% and US$25,000+/t for 99.99%.

Direct extraction technologies are now able to provide 99.9% purities. It seems likely that the energy storage sector, where low impurities and product consistency are of paramount importance, will increasingly demand these higher grades. As direct extraction technologies become more widely applied in the lithium space, products with grades of around 99.5% LCE, including those from many evaporation pond operations, are likely to become 'technical' grade.

Price assumptions

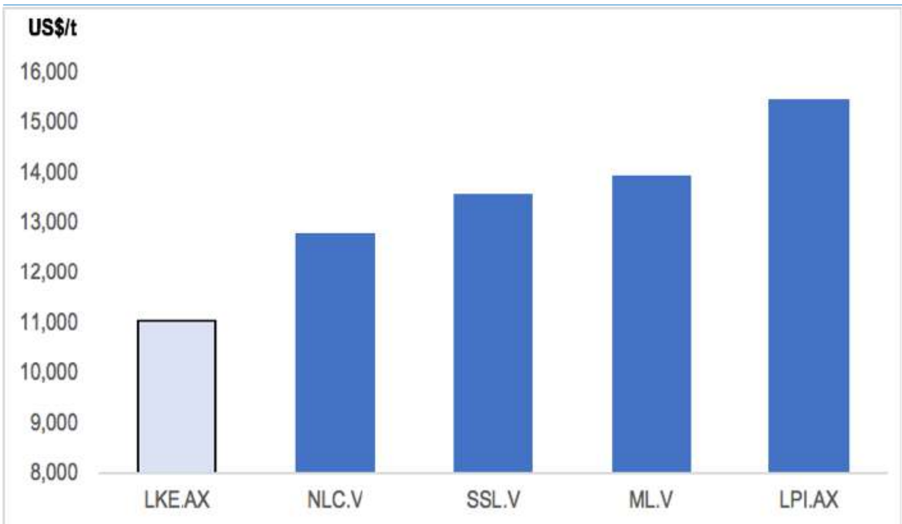
Lake's management team took an über-conservative approach to pricing. The Kachi PFS is based on a price for 99.9% lithium carbonate of US$11,000/t. Despite utilising a chemical (as opposed to meteorological) process, and producing the highest purity product, **Lake Resources' pricing assumptions are the most conservative among the five studies in the sample.**

Figure 8: Various price assumptions used in feasibility studies



Source: Company data

Figure 9: Average prices, first ten years of production, selected feasibility studies



Source: Company data

One of the issues facing investors is that lithium is not an exchange traded commodity. There is little publicly available price information. Prices that are available are often based on illiquid contracts. This gives companies something of a licence to 'print their own price deck'. Given earnings and cash-flow based valuations are highly sensitive to selling prices, this makes it more difficult for investors to compare projects.

Sensitivity

The Kachi project is sensitive to selling prices. An increase in selling prices to a constant US$12,000/t throughout the project life would increase annual EBITDA by US$24m to US$179m, raise the EBITDA margin from 55% to 58%, and increase the post-tax NPV_8 to US$935m (A$1,435m), and the IRR to 25%.

At a lithium carbonate price of US$13,000/t, annual EBITDA would increase to US$202m, the EBITDA margin to 61%, the post-tax NPV_8 to US$1,122m (A$1,722m), and the IRR to 28%.

Competitive capital and operating costs

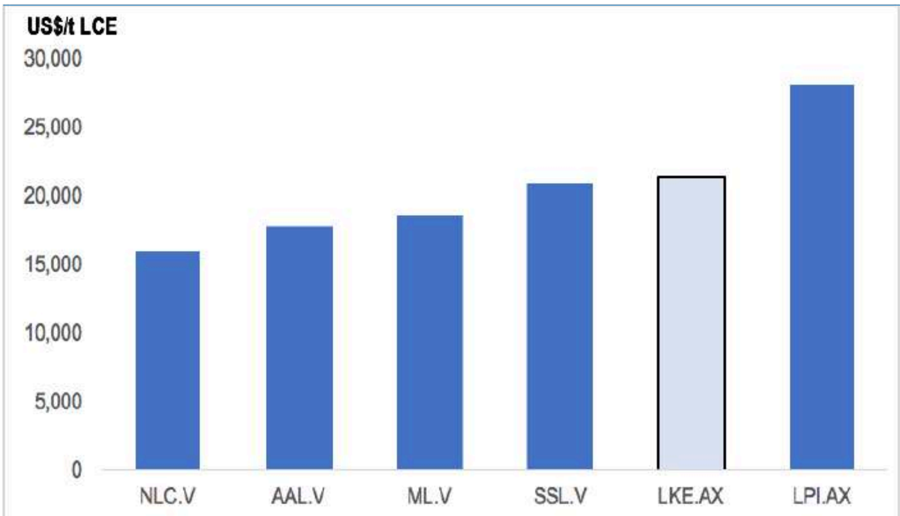
Initial capex for the Kachi project is estimated at US$544m. This comprises direct costs of US$399m, EPCM costs of US$54m, and a contingency of US$91m, which represents 20% of the other costs combined. These upfront capital costs are broadly in line with the cost of other projects with similar scale.

Figure 10: Kachi initial capital costs

	US$ m	%
Wellfield	**25.3**	**4.6**
Processing	**161.1**	**29.6**
Direct Extraction	67.3	12.4
Chlor-alkali plant Reagent regeneration)	69.7	12.8
Carbonate plant	24.1	4.4
Site infrastructure and support	**17.9**	**3.3**
Site works (construction)	**194.9**	**35.8**
Earthworks, construction materials and services	126.6	23.3
Other construction costs	68.3	12.6
Total direct costs	**399.2**	**73.4**
EPCM	54.1	9.9
Contingency	90.9	16.7
Total indirect costs	**145.0**	**26.6**
Total	**544.2**	**100.0**

Source: Lake Resources

Figure 11: Initial capex costs per tonne of capacity, selected projects

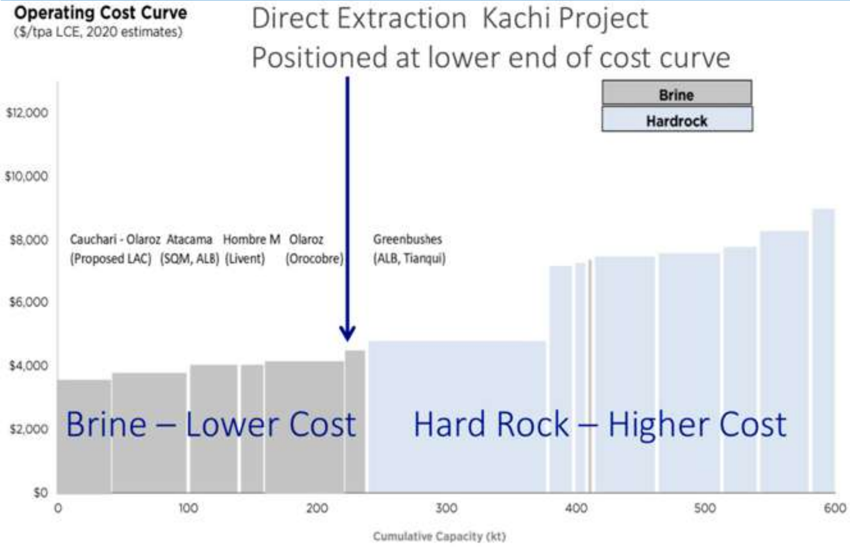


Source: Company data, Orior Capital estimates

Despite the obvious advantages in terms of chemical purity, and production times, the Kachi project has similar capital intensity as evaporation pond projects. Also, there is further scope to reduce capital costs through the DFS stage over the next 12-15 months.

In terms of operating costs. the project has C1 cash costs of US$4,178/t. This is similar to expected costs at Standard Lithium's direct extraction project at Lanxess. It is higher than many evaporation pond operations, though these typically produce a 99.4-99.5% lithium carbonate product.

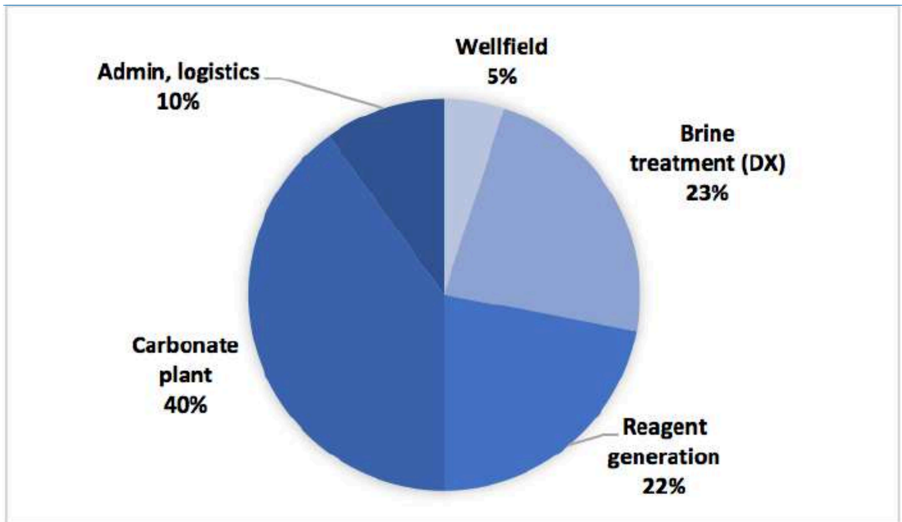
Figure 12: Operating costs



Source: Lake Resources

Arguably, **it is less important to be cost competitive with evaporation pond operations** because evaporation ponds are difficult to scale-up, face increasing environmental questions, and are unlikely to be able to meet the expected rapid growth in lithium demand. This is born out in the global lithium production data over the past 3-4 years. Growth in output from Australian hard-rock sources has far outstripped production growth from evaporation ponds. **It is much more important to be cost competitive when measured against hard-rock sources. Kachi achieves this.**

Figure 13: Operating costs by area



Source: Lake Resources

Substantial resource

In November 2018, Lake Resources announced a maiden resource of 4.4m tonnes contained LCE, at Kachi. The resource is one of the top ten largest reported resources globally. The resource comprises an indicated resource of 1.1m tonnes LCE located in the central area of the Kachi project, and an inferred resource of 3.4m tonnes LCE located in the surrounding area.

Brine bearing sediments remain open at depth and laterally; there is an opportunity to expand the resource with additional drilling both to depth, and to cover a wider area. Management has an exploration target of 8m tonnes to 17m tonnes LCE, which would be of a similar scale to globally significant lithium players.

Figure 14: Kachi resource estimate, JORC 2012

		Indicated	Inferred	Total
Area	km^2	17.1	158.3	175.4
Aquifer volume	km^3	6.0	41.0	47.0
Brine volume	km^3	0.7	3.2	3.8
Mean drainable porosity (yield)		10.9%	3.2%	7.9%
Lithium, Li				
Weighted mean concentration	mg/L	289	209	211
Resource	Tonnes	188,000	638,000	826,000
Lithium Carbonate equivalent	**Tonnes**	**1,005,000**	**3,394,000**	**4,400,000**

Source: Lake Resources

Next steps

There are a number of steps that will need to be completed as part of the DFS. This includes upgrading the resource to a reserve, trial production wells, pumping tests, an environmental impact report to underpin permitting, and geotechnical tests. Product samples will need to be delivered to potential off-takers for evaluation. Management may consider other product avenues including lithium sulphate, and selling a lithium chloride eluate, and study the ‘value in use’ of different strategies to maximise the value of the project.

There is scope to refine the direct extraction process. Lilac is working to improve process recoveries, the final lithium concentration in the eluate, and reagent consumption. Improvements in these parameters could result in significant capital and operating cost savings compared to the PFS.

The ion exchange pilot plant at Lilac’s facility in Oakland, California was commissioned using replicate brines (synthetic material). The plant has been running since December 2019. Commissioning with Kachi brines is expected in June to July. The pilot plant will have roughly 1,000x the scale of earlier bench tests carried out on Kachi brines. The commercial plant modules will be only 3x the scale of the pilot plant modules.

In March 2020, Lake announced it had delivered 20,000 litres of Kachi brines to Lilac. Lilac will process the brines into high-purity lithium chloride, for further conversion to lithium carbonate. Citing increased interest from EV manufacturers and battery makers, and also looking to test brines from a number of different wells, Lake Resources sent a further 20,000 litres of brines to Lilac in April 2020. The first batch of this material is being used to complete commissioning of the pilot plant modules.

It is expected to produce several kilograms of lithium carbonate that **will enable prospective off-takers to evaluate the product.** The first samples are expected to be available in June to August, shortly after the 'shelter-in-place' restrictions are lifted in California, and when customers can take deliveries.

In 4Q20, management plans to build a second pilot plant onsite at Kachi. This will enable the two plants to be run concurrently. This onsite plant will provide Lilac with the first commercial scale proof of concept of their ion exchange process.

As part of the DFS, management will also consider a staged development approach. This would lower both initial capital costs, and technical risks. A staged development could see an initial capacity of 10,000 tpa LCE, with the carbonate plant located offsite, perhaps at Güemes (Salta), close to the reagent manufacturer and regional power and gas networks. A subsequent expansion to 25,500 tpa LCE could locate the carbonate plant and the chlor-alkali plant onsite.

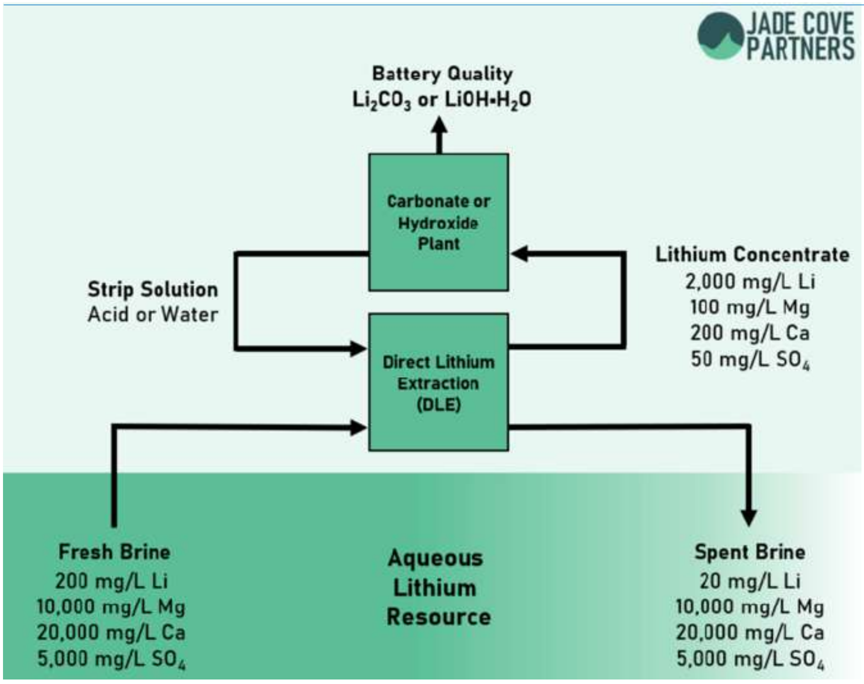
Why not just extract the lithium?

- Direct extraction technologies have major advantages over evaporation ponds
- Lilac Solutions is commercialising a novel ion exchange technology for lithium extraction that is faster, and more scalable than existing methods
- Lilac has produced battery grade 99.9% lithium carbonate from Kachi brines with minimal impurities; a bulk sample test is currently underway

The evaporation pond model seems fundamentally inefficient. Brine is pumped to the surface, left to sit in giant ponds for months (or years) while the water evaporates, and then chemical reagents are used to remove the impurities. Start-up times are slow. It is difficult to expand capacity. It is partly dependent on the weather. With electric vehicle penetration expected to rise rapidly over the next decades, evaporation ponds seem unlikely to be able to meet demand. Companies adopting this model often focus on lithium grades, and magnesium to lithium (Mg/Li) and sulphates to lithium (SO_4/Li) ratios because these determine how much chemistry is needed. Every brine is different, meaning that a new flowsheet has to be developed for each project.

Direct extraction negates these issues. It allows lithium to be removed from brine without first being concentrated. Chemical reagents are not required to remove impurities from the concentrate, thus making Mg/Li and SO_4/Li ratios essentially irrelevant. The brine, together with impurities, is returned to the ground without chemical interference. All this has obvious advantages. Although many of the recent developments in direct extraction as applied to lithium are new, direct extraction itself is well established.

Figure 15: Generalised schematic of direct extraction



Source: Jade Cove Partners

Jade Cove Partners, a superb resource for direct extraction information, https://www.jadecove.com

Lilac Solutions

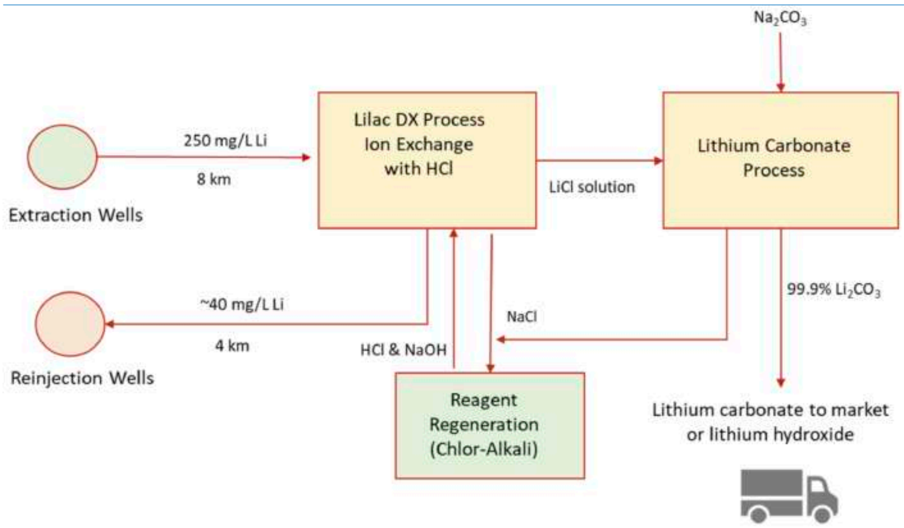
Lilac is commercialising a novel ion exchange technology that enables lithium to be extracted from brine resources. The technology is significantly faster than conventional evaporation methods, and more readily scalable. The process boosts lithium recovery, and has the potential to unlock new lithium resources. The process is modular, and can be ramped up quickly. These advantages are important if global lithium production is to be able to meet rapidly growing demand. Lilac has successfully demonstrated its technology at pilot plant scale, with dozens of brine resources from around the world.

In February 2020, Lilac announced it had secured US$20m from investors including Breakthrough Energy Ventures, a US$1.0bn fund established by many of the world's top business leaders. Breakthrough aims to support companies that have the potential to reduce greenhouse emissions. Other investors included The Engine, Lowercarbon Capital, and The Grantham Foundation. **This new funding is aimed at allowing the company to scale up production of its ion exchange beads, and deploy the technology around the world.**

Essentially, pumped brine enters the direct extraction plant where lithium is recovered by ion exchange beads. These are later stripped to produce a lithium chloride eluate which is concentrated and then treated with sodium carbonate to produce lithium carbonate. Once the lithium is removed, the brine is reinjected into the salar 20 km to the east of the extraction wells.

Major reagents consumed include sodium carbonate, sodium hydroxide and hydrochloric acid. Major consumables include natural gas for electrical power.

Figure 16: Kachi lithium brine project, chloride stream to lithium carbonate



Source: Lake Resources

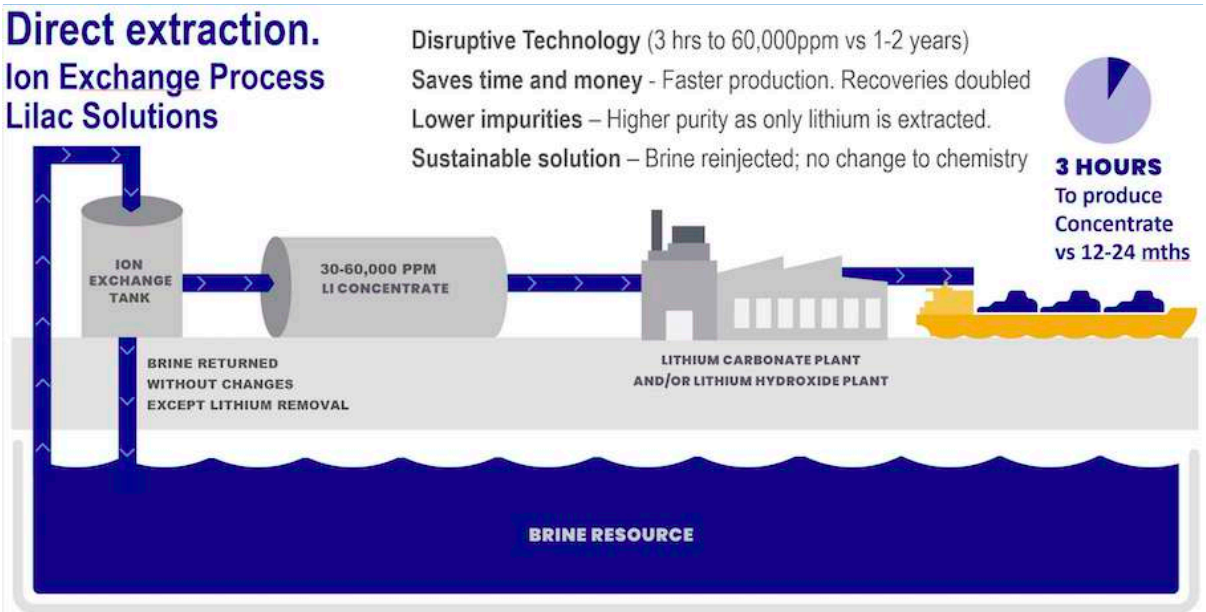
The basic reaction to produce lithium chloride, LiCl, in eluate for lithium carbonate production is:

Loading:	**Li^+ (brine) + $H\text{-}R_{IX} \rightarrow H^+ + Li\text{-}R_{IX}$**	R_{IX} being the ion exchange resin
Stripping:	**$Li\text{-}R_{IX} + H^+ \rightarrow Li^+$ (eluate) + $H\text{-}R_{IX}$**	where H^+ is delivered as HCl
That is:	**$Li\text{-}R_{IX}$ + HCl $\rightarrow$ LiCl (eluate) + $H\text{-}R_{IX}$**	

Lilac's technology has significant advantages compared to brine evaporation:

- Lithium recoveries are as high as 80-90%, compared to 50-60% for evaporation ponds
- This means lower grade brines can be used and still produce high-grade eluate feedstock grading 50,000 to 60,000 mg/L lithium
- The processing time is 2-3 hours, not 9-18 months
- The process is repeatable; it is essential for battery makers to have consistent product
- It is not subject to the vagaries of the weather such as rain which can dilute ponds, or prolonged cloudy periods which can impact the rate of evaporation
- The environmental footprint is substantially smaller
- The brine is returned to the aquifer, after the lithium is removed, without being chemically modified
- The technology can be scaled easily and quickly

Figure 17: Lilac's ion exchange process



Source: Lake Resources / Lilac Solutions

In short, the Lilac process addresses increasing interest from electric vehicle makers (OEM's) and battery makers to gain access to a sustainable and scalable supply chain.

Elution is the process of washing a substance with a solvent in order to extract one material from another. An example is the washing of loaded ion-exchange resins with a solvent to remove captured ions. An eluate is a solution obtained by elution.

A high-purity product

A comprehensive series of bench tests undertaken at Lilac's facility in Oakland, California have demonstrated that lithium concentrations of up to 60,000 mg/L can be produced from Kachi brine samples using the Lilac process in just three hours. Lithium recoveries of 80-90% were achieved, whilst 99.6% of the sodium, 99.8% of the potassium and 99.9% of the boron were rejected. This lack of impurities bodes well for the production of a battery grade product.

Based on Lilac's testing, use of reagents is typically 2 tonnes of sodium hydroxide and 4-5 tonnes of concentrated HCl per tonne of lithium carbonate produced. Reagents can be produced on-site using conventional chlor-alkali facilities.

Figure 18: Chemical specifications of un-milled lithium carbonate produced by Lilac IX extraction

Component	Analysis Wt %	Target Wt %
Lithium (Li)	99.9	99.5 min
Sodium (Na)	0.024	0.025 max
Magnesium (Mg)	<0.001	0.008 max
Calcium (Ca)	0.0046	0.005 max
Iron (Fe)	<0.001	0.001 max
Silicon (Si)	<0.001	0.003 max
Boron (B)	<0.001	0.005 max

Source: Lake Resources

Figure 19: Lithium carbonate (battery grade) produced by Lilac IX process

Source: Lake Resources

Other direct extraction technologies

Lilac is not the only company developing direct extraction technologies.

Livent, E3 Metals

Livent has been using been using a direct extraction process based on hydrated alumina sorption at its Hombre Muerto operation to produce lithium products for decades.

In September 2019, Livent joined forces with E3 Metals, a Canadian company, to advance the development of E3 Metals' proprietary direct lithium extraction process. The venture will focus on E3 Metals' petro-lithium brines in Alberta Canada, where E3 has inferred resources of 6.7m tonnes LCE. Livent will contribute technical expertise and US$5.5m in funding aimed at demonstrating technical feasibility, and have the option to convert its investment into a 19.9% equity stake in E3 Metals. According to E3 Metals January 2020 presentation, the raw lithium brine feedstock for the process has a grade of 86 mg/L lithium.

Anson Resources

Anson Resources is developing an industrial scale in-field pilot plant to produce bromine, iodine, boron and lithium carbonate at its Paradox Basin Brine Project in Utah, USA. Lilac is responsible for the ion exchange process that extracts the lithium directly from the brine, and other engineering partners are working to extract bromine, iodine and boron from the same brines.

In December 2019, Anson announced it had successfully completed a small-scale demonstration of the complete process to produce a 99.9% lithium carbonate product from concentrated lithium chloride via a lithium hydroxide electrolysis process, achieving an 85.7% recovery. In March 2020, the company announced that Veolia Water Technologies had successfully produced battery grade lithium hydroxide monohydrate ($LiOH.H_2O$) from its brines. In May 2020, Anson announced an upgraded mineral resource of 192,000 tonnes contained LCE and 1,176,000 tonnes of contained bromine. The company is expected to release a PEA for the project over the next few weeks.

Standard Lithium

The brine supply wells at the Standard Lithium–Lanxass project have a lithium grade of 168 mg/L, and E3 Metals' feedstock is at a grade of 86 mg/L lithium. Lake's indicated resource at Kachi has a grade of 289 mg/L. Compared to other brine resources, these might be considered 'low-grade'. That misses the point. **In industrial chemistry, 'low impurities' is king.**

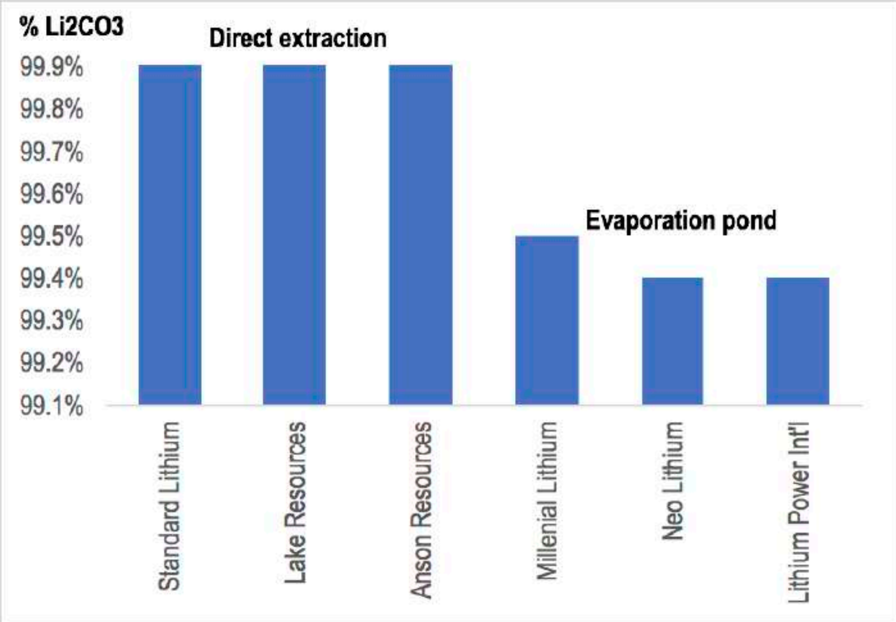
Eramet

French mining group Eramet has been developing a direct extraction process at its Centario project in Argentina. In April 2020, Eramet put the project on hold citing an uncertain outlook. Management said that the pilot plant, which had been running onsite for four months will continue to complete process studies.

A number of companies in China are also using direct extraction technologies.

While these projects are at the feasibility stage, **there is a clear trend in companies demonstrating that direct extraction technologies can produce 99.9% lithium carbonate products with low impurities.** These products will see increasing demand from battery makers in future.

Figure 20: Different production methods, different purities



Source: Company data, Orior Capital estimates

Ion exchange is common in the water industry

Ion exchange (IX) relies on that fact that when ionic compounds dissolve in water they break apart ('disassociate') into the ions (charged atoms) that make them up. This chemistry can be used to replace undesirable ions with other ions of a similar electrical charge. The reaction occurs in an IX column, with the ion exchange facilitated by a specialised resin. While some aspects of ion-exchange direct extraction as applied to lithium are novel, **the basic process is widely used in the water industry for a number of purposes including purification, water softening, and separation.**

In water softeners, the aim is to remove cations (positively charged ions) such as calcium or magnesium because these can form scale. This is done by passing the solution through an IX resin composed of sodium ions. The resin captures the calcium and magnesium ions, and releases sodium ions to the effluent stream. Another example, is the removal of anions (negatively charged ions) such as arsenic, and nitrate, replacing them with chloride.

IX resins are usually fashioned from organic polymers, such as polystyrene, that can electrostatically bind a large number of ionisable groups, and are usually formed into tiny 'microbeads'. Resins are also available as sheet-like membranes. As the solution flows through the IX resin, ions on the surface of the resin are replaced by ions with that have a greater affinity for the resin material. Chloride and hydroxide ions are the most commonly used materials on the resin beads.

The process has been used in the water industry for more than 100 years. It is used in everything from home water purifiers at one extreme, to treating industrial liquid waste at the other.

http://wcponline.com/2014/02/21/a-brief-history-of-ion-exchange-water-treatment/
https://www.samcotech.com/ion-exchange-system-work/
https://drinking-water.extension.org/drinking-water-treatment-anion-exchange-units/

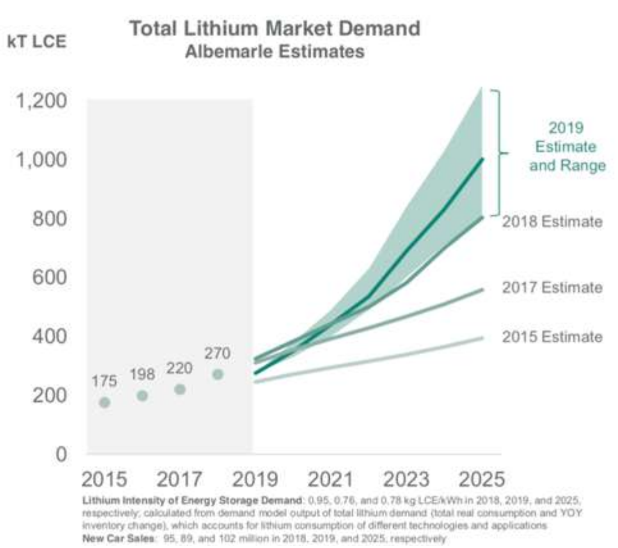
Demand to surge over coming decades

- Lithium demand is expected to grow by ~20% pa over the next few years, increasing almost 4-fold to 1.0m tonnes LCE by 2027
- Supply will struggle to keep up; lithium is facing supply-side deficits by the mid-2020s which will underpin better prices
- Lithium is increasingly recognised as a critical and strategic raw material in the US and Europe, both of which are looking to secure new sources of supply

Electric revolution

In its March 2020 Investor Presentation, Albemarle set out some forecasts for lithium demand. The company estimated 2019 consumption, on a LCE basis, at 275,000 tonnes, roughly flat YoY. Albemarle forecast demand to reach 1.0m tonnes by 2025, suggesting demand growth of some 24% pa. These forecasts are built off the assumptions that EV penetration will rise from an estimated 3.2% of global new car sales in 2019, to 18% of new car sales by 2025, and that battery sizes will increase from an average of 41 kWh per EV in 2019 to 48 kWh per EV in 2025.

Figure 21: Energy storage continues to drive lithium demand



Demand by Application (kT LCE)	2018 Estimate	2019 Estimate	'19 – '25 CAGR	2025 Forecast
Electric Vehicles	59	93	38%	650
Other Mobility	25	26	7%	40
Consumer Electronics	36	38	11%	70
Grid Storage	6	9	37%	60
All Other/Industrial	114	119	3%	140
Total Real Consumption	**240**	**285**	**22%**	**960**
YOY Inventory Change	+30	-10		+40
Total Lithium Demand	**270**	**275**	**24%**	**1,000**

EV Consumption Buildup		2018 Estimate	2019 Estimate	2025 Forecast
EV Penetration % of New Car Sales	PHEV	0.5%	0.9%	6%
	BEV	1.5%	2.3%	12%
	All EVs	**2.0%**	**3.2%**	**18%**
Battery Size kWh per EV	PHEV	12	12	14
	BEV	44	53	65
	Average	**32**	**41**	**48**
Lithium Consumption kT LCE	PHEV	5	8	65
	BEV	54	85	585
	Total	**59**	**93**	**650**

Source: Albemarle Corp, March 2020

These forecasts were prepared before the full onset of COVID-19. Some forecasts now call for demand to reach 1.0m tonnes LCE by 2027. This would still represent a 4-fold increase in the size of the market over the next 7 years, and annual demand growth of ~20% pa. Albemarle's lithium demand forecasts, and also those of other forecasters, have risen each year since 2015.

China is the biggest market for EVs, accounting for ~60% of production in 2019. In 2019, a weaker economy, and lower subsidies meant sales dropped from 2% YoY to 1.24m vehicles. China has now extended its subsidies until 2022.

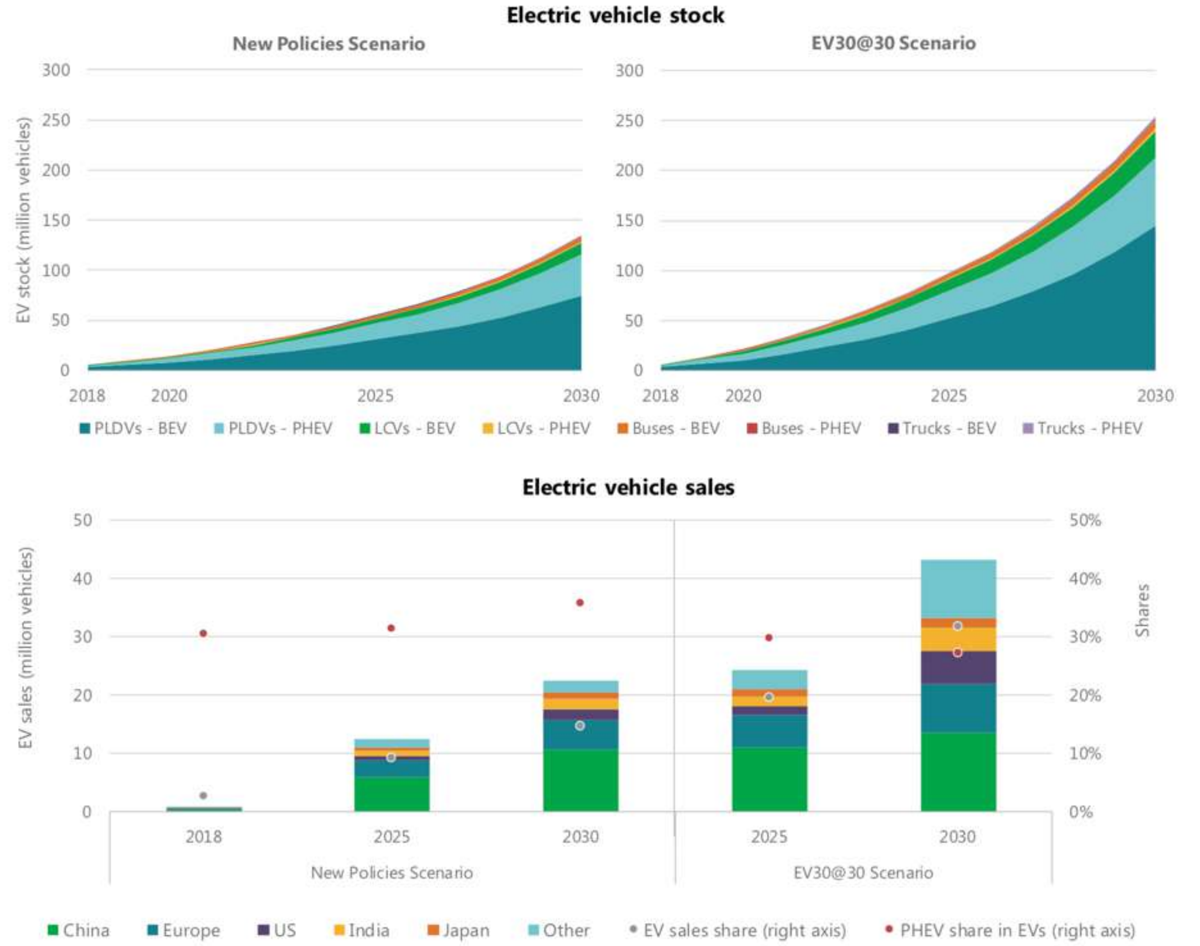
Global EV Outlook

According to the International Energy Agency (IEA), the global stock of passenger vehicles reached 5.1m units at the end of 2018. About 45% of this stock is in China, with a further 24% in Europe. In addition to passenger cars, there were almost 250,000 electric light commercial vehicles on the roads in 2018.

In its Global EV Outlook, 2019, the IEA has two scenarios for future EV demand, based on different policy outcomes. In the New Policies Scenario, which takes into account existing policy announcements by various governments, the IEA predicts that the global stock of electric vehicles will exceed 55m vehicles in 2025, and reach about 135m vehicles in 2030. This represents an average annual growth rate of ~30% pa.

The 'EV30@30' scenario is more ambitious. It takes into account the pledges of the Electric Vehicle Initiative's EV30@30 Campaign to reach a 30% market share for EVs in all modes except two-wheelers by 2030. In this scenario, global EV stock and sales are nearly double that of the New Policies Scenario, with the EV stock reaching 250m units by 2030. For this to happen, countries will need to rapidly implement policy measures to promote EV adoption.

Figure 22: Global EV stock and sales by scenario, 2018-30



Note: PLDVs = passenger light-duty vehicles; LCVs = light-commercial vehicles; BEV = battery electric vehicle; PHEV = plug-in hybrid vehicle.

Source: IEA, Global EV Outlook, 2019

This rapid growth in demand is being facilitated by a number of factors including greater availability, and technological and policy developments.

There's more on offer

Global automakers have recently taken on far greater electrification strategies.

Figure 23: OEM announcements related to electric cars

Company	Announcement
BMW	15-25% of the BMW Group's sales in 2025 and 25 new EV models by 2025
BJEV-BAIC	0.5 million electric car sales in 2020 and 1.3 million electric car sales in 2025
BYD	0.6 million electric car sales in 2020
Chongqing Changan	21 new BEVs, 12 new PHEVs by 2025, 1.7m sales by 2025 (100% of group's sales)
Dongfeng Motor CO	6 new EV models by 2020 and 30% electric sales share in 2022
FCA	28 new EV models by 2022
Ford	40 new EV models by 2022
Geely	1 million sales and 90% of sales in 2020
GM	20 new EV models by 2023
Honda	15% EV sales share in 2030 (part of two-thirds of electrified vehicles globally by 2030)
Hyundai-Kia	12 new EV models by 2020
Mahindra & Mahindra	0.036 million electric car sales in 2020
Mazda	One new EV model in 2020 and 5% of Mazda sales to be fully electric by 2030
Mercedes-Benz	0.1 million sales in 2020, 10 new EV models by 2022 and 25% of the group's sales in 2025
Other Chinese OEMs	7m sales in 2020
PSA	0.9 million sales in 2022
Renault-Nissan-Mitsubishi	12 new EV models by 2022
Maruti-Suzuki	A new EV models in 2020, 35 000 electric car sales in 2021 up to 1.5 million in 2030
Tesla	~500,000 sales in 2019, and a new EV model in 2030

Source: IEA, Global EV Outlook, 2019

If these plans are to come to fruition, auto makers will need to be able to secure supplies of key raw materials, including lithium.

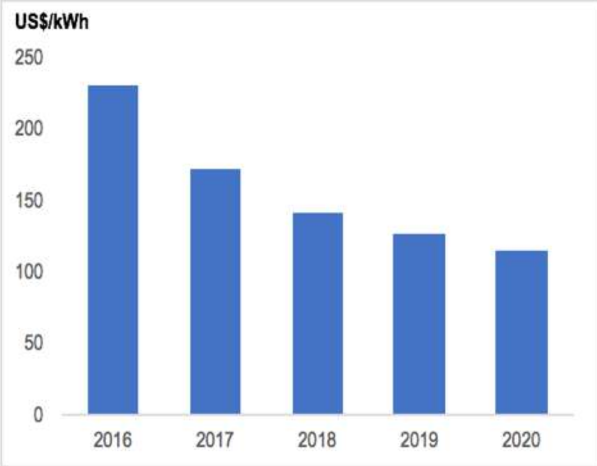
Batteries are getting better, and cheaper

Battery capacity is increasing, allowing greater range. According to the IEA, battery pack capacity in battery electric vehicles (BEVs) rose from 20-30 kWh in 2012 to 35-70 kWh in 2018. Some models are already equipped with 100 kWh batteries.

Another factor is that battery costs are declining. Battery packs are a significant portion of vehicle costs. According to Bloomberg New Energy Finance (BNEF), the cost of lithium-ion batteries fell from US$1,100/kWh in 2010 to US$156/kWh in 2019, a fall of 87% through the decade. The International Energy Agency (IEA) believes that battery costs of ~US$100/kWh are necessary for battery electric vehicles (BEVs) to be competitive with internal combustion engine ones. BNEF reckons the US$100/kWh mark could be reached by 2023, and that prices will fall to as low as US$61/kWh by 2030, accelerating take up.

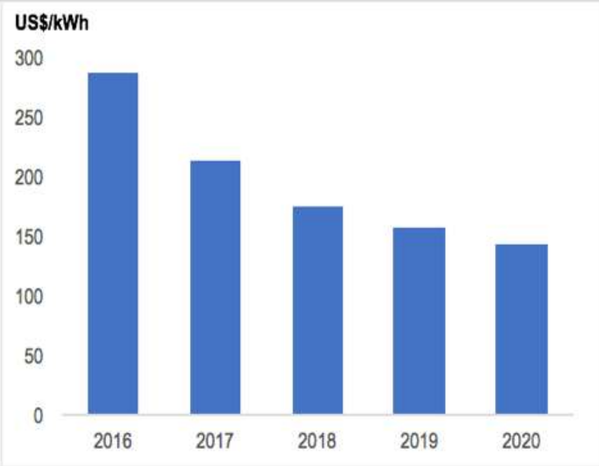
In January 2020, Forbes estimated that Tesla's battery costs had fallen from US$230/kWh in 2016 to US$127/kWh in 2019, and that they could decline further to US$114/kWh this year. Tesla's Model S and Model X both come with 100 kWh batteries suggesting a battery cost of US$12,700 per vehicle in 2019, down from US$23,000 per vehicle in 2016.

Figure 24: Tesla battery costs



Source: Forbes, January 2020

Figure 25: Industry average battery costs

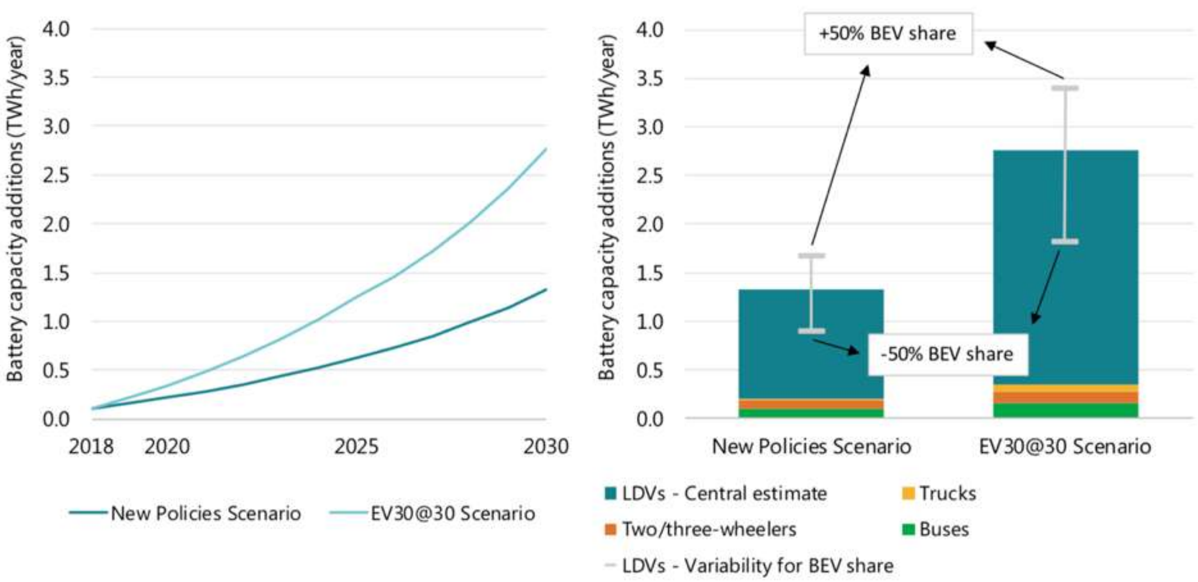


Source: Forbes, January 2020

EV battery capacity is also expected to rise substantially. In the New Policies Scenario, global EV battery capacity (for all transport modes) is estimated to increase from ~100 GWh per annum in 2019, to 1.3 TWh per annum (a 13-fold increase) by 2030. In the EV30@30 Scenario, global battery capacity needs to increase even more quickly, reaching ~2.8 TWh per annum by 2030.

The global EV market is already a significant power market in its own right. In 2018, the global EV fleet consumed ~58 TWh of electricity, about the same as Switzerland.

Figure 26: Annual global battery capacity addition for EV sales by scenario, 2018-30



Source: IEA, Global EV Outlook, 2019

Figure 27: Announced battery manufacturing facilities

Company	Region	Announcement
Panasonic	United States	35 GWh/year factory by 2020
CATL	China European Union	24 GWh/year and 18 GWh factories in 2020 14 GWh/year factory in 2021 98 GWh/year factory (date to be determined) to be launched
BYD	China	24 GWh/year factory in 2019 20 GWh/year and 30 GWh factories in 2023 10 GWh/year factory (date to be determined)
LG Chem	European Union China	15 GWh/year factory in 2022 32 GWh/year factory in 2023
SK Innovation	China European Union United States	7.5 GWh/year factory in 2020 7.5 GWh/year factory in 2021 9.8 GWh/year factory in 2022
LIBCOIN/BHEL	India	30 GWh/year factories, in 2025, 2026 and 2027
Samsung SDI	European Union	1.65 GWh/year factory in 2020
Northvolt	European Union	32 GWh/year factory in 2023
Lithium Werks	China	8 GWh/year factory in 2021
Terra E	European Union	4 GWh/year factory in 2020

Source: IEA, Global EV Outlook, 2019

Substantial materials demand

This increase in power demand will drive increased demand for battery materials, including lithium. The IEA's central assumption in the New Policies Scenario is for a battery chemistry mix of 10% NCA, 40% NMC 622 and 50% NMC 811 by 2030. **On this basis, lithium demand is expected to reach ~155,000 tpa. This is ~825,000 tpa on a LCE basis. It represents ~3x estimated 2019 global demand.** In the EV30@30 scenario, lithium demand would be about double this amount, that is, ~1.65m tonnes LCE per annum, 6x the whole of the global market in 2019.

Supply-side will struggle to meet demand

While the pipeline of announced projects looked sufficient to meet this predicted rise in demand, there has recently been a number of setbacks. A number of companies have announced delays to expected projects.

In 2019, a number of companies cut back investment plans. In September 2019, Mining Weekly reported that Tianqi Lithium would defer expenditure on Stage 2 of its Kwinana project, in Western Australia. In January 2020, SQM and Westfarmers said they would delay a final investment decision at Mount Holland, Western Australia, having completed a DFS in late-2019. Last year, SQM delayed its 50,000 tpa expansion at Atacama to 2H21, versus 2H20 previously. Also in January 2020, Galaxy Lithium said it would scale back its operations at Mt Cattlin by approximately 60% in 2020. In April 2020, Eramet decided to put its Centario project in Argentina on hold citing an uncertain outlook.

https://m.miningweekly.com/article/tianqi-slows-production-plans-in-wa-2019-09-11
http://s1.q4cdn.com/793210788/files/doc_news/2020/1/PR_MtHollandUpdate_23jan2020_eng.pdf
http://s1.q4cdn.com/793210788/files/doc_news/2019/May/PR_1Q19_ing_FINAL.pdf
http://www.gxy.com/media/announcements/44dg93tsk2fpkt.pdf
https://www.bnamericas.com/en/news/eramet-abandons-us600mn-argentina-lithium-project

Evaporation ponds are also coming under greater environmental scrutiny. In December 2019, Chile's First Environmental Court in the city of Antofagasta, upheld a complaint by indigenous communities close to SQM´s operations in the Atacama Desert and ruled that SQM should be prosecuted over excessive water use. SQM disputed the decision. The decision seems to call into question SQM's plans to expand in the area, according to Reuters.

Lithium becoming critical

Although the world is not short of lithium, lithium supply is concentrated amongst a small number of countries, with China the dominate producer of lithium hydroxide. China produced about 79% of the lithium hydroxide used in electric car batteries last year, according to CRU. COVID-19 has disrupted this supply, highlighting to western automakers and governments the need to secure supply chains.

The European Commission's report on Raw Materials for Battery Applications, November 2018, notes the EU relies on imports for 86% of its lithium needs. Lithium is expected to be added to the EU's list of critical raw materials. Recognising lithium's strategic value and classifying it as a 'critical raw material' should lead to new initiatives aimed at lithium mining within the EU, as well as recycling.

In December 2017, US Presidential Executive Order on a Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals recognised the US' reliance on imports of some materials, and aimed to identify new sources, to increase activity throughout the supply change, and to ease permitting. In June 2019, the US published A Federal Strategy to Ensure a Reliable Supply of Critical Minerals, directing the US Department of Interior to identify domestic supply sources for 35 critical materials, including lithium. In May 2020, the US Dept. of Energy announced US$30m in new funding for research in critical materials processing technologies, including 'next-generation extraction'.

General Motors has said it is looking to source battery minerals including lithium for its new range of electric cars, from North America. The vehicles will use battery cells made in Ohio by LG Chem. Companies such as Standard Lithium and Livent are looking at ways of extracting lithium from chemical and oil and gas field brines as well as from geothermal sources.

https://www.reuters.com/article/us-chile-sqm/chilean-lithium-miner-sqm-dealt-blow-by-environmental-court-ruling-idUSKBN1YV05T

https://ec.europa.eu/transport/sites/transport/files/3rd-mobility-pack/swd20180245.pdf

https://www.whitehouse.gov/presidential-actions/presidential-executive-order-federal-strategy-ensure-secure-reliable-supplies-critical-minerals/

https://www.energy.gov/articles/department-energy-announces-30-million-innovation-critical-materials-processing

https://www.commerce.gov/news/reports/2019/06/federal-strategy-ensure-secure-and-reliable-supplies-critical-minerals

Appendix 1: Lake Resources' assets

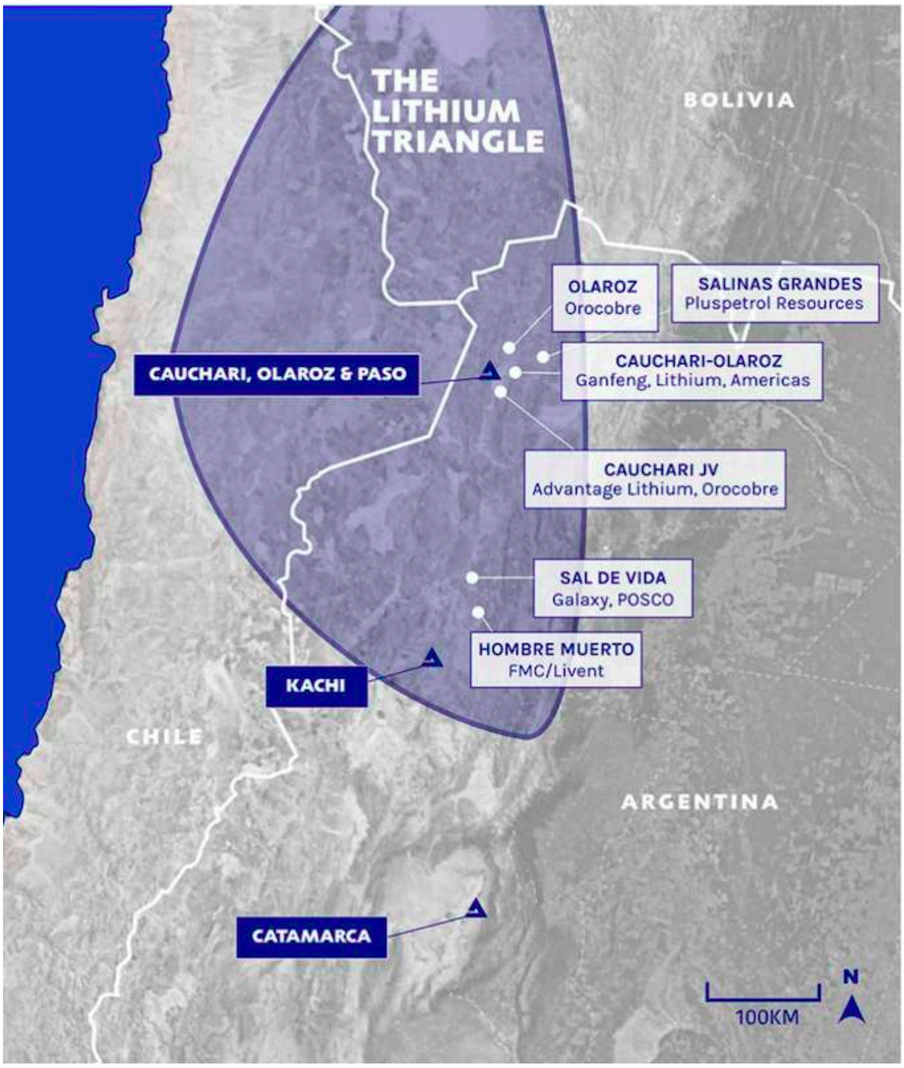
Lake Resources is developing five lithium projects in Argentina. Four of these are lithium brines projects, and one is a pegmatite project. The company has the largest lithium lease holding in Argentina, amounting to more than 2,000 km^2, all of which it owns 100%.

Figure 28: Lake Resources lithium projects, Argentina

Project	Area, km^2	Province
Brine		
Kachi	705	Catamarca
Cauchari	37	Jujuy
Olaroz	142	Jujuy
Paso	296	Jujuy
Pegmatite		
Catamarca	904	Catamarca
Total	**2,084**	

Source: Lake Resources

Figure 29: Lake Resources lithium projects



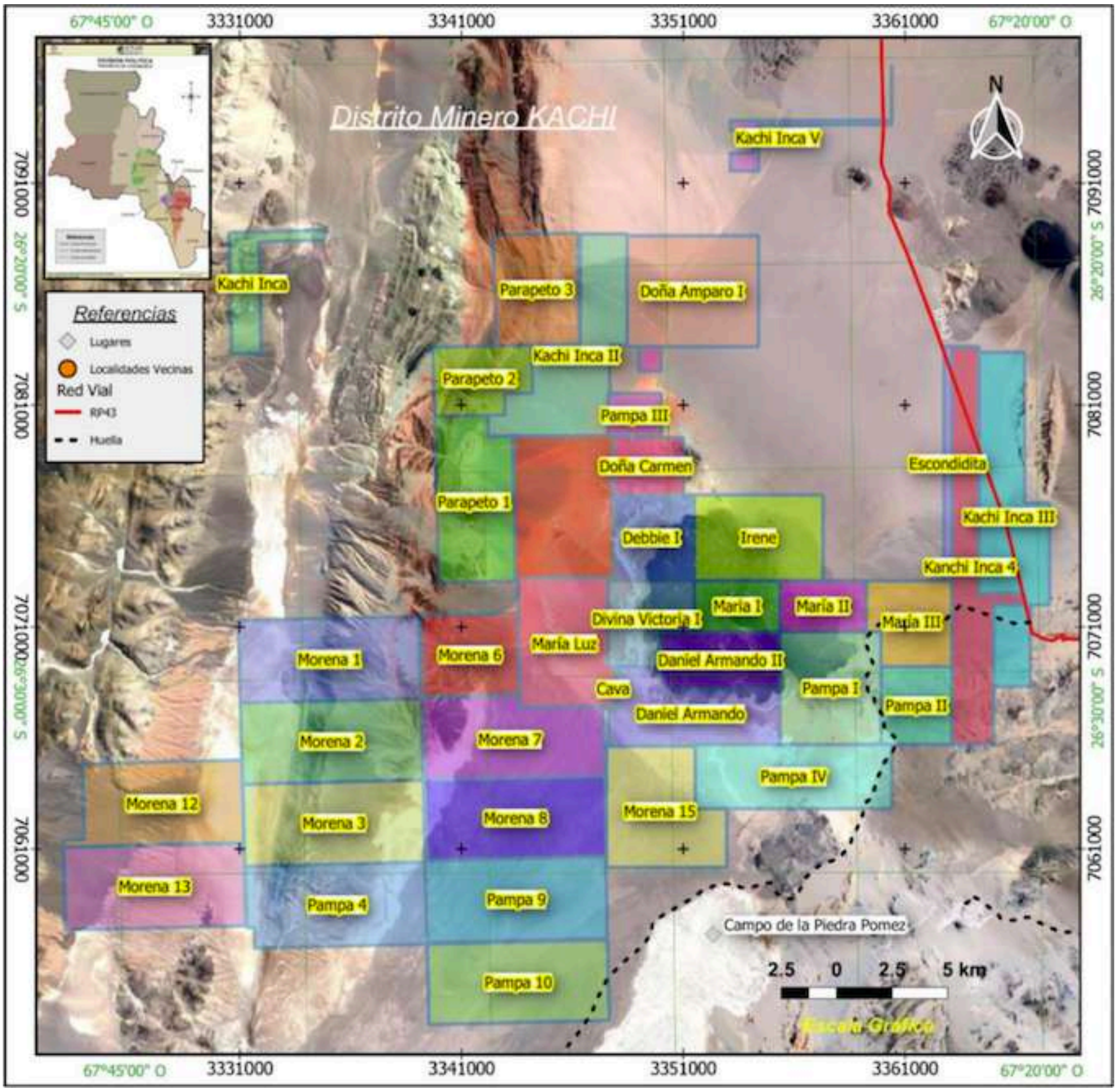
Source: Lake Resources

Kachi

Kachi is most advanced of Lake Resources' projects. The company released a maiden resource at Kachi of 4.4 million tonnes lithium carbonate equivalent (LCE) in November 2018. The PFS, discussed herein, was released in April 2020.

The project is held under 37 mineral concessions covering 70,462 hectares that are 100% owned by Lake Resources through its wholly owned Argentine subsidiary, Morena del Valle Minerals S.A. In Argentina, mineral rights are awarded by provincial governments as ether exploration or mining licenses. All tenements at Kachi are held under mining licenses. The mineral licenses have no expiry date provided (small) annual fees are paid, and all obligations are met under the national mining code.

Figure 30: Kachi map of mineral licences



Source: Lake Resources

Figure 31: Kachi mining concessions

Name	Role No.	Area, Ha	Status
Kachi Inca	13-M-2016	858	Granted
Kachi Inca I	16-M-2016	2,881	Granted
Kachi Inca II	17-M-2016	2,823	Granted
Kachi Inca III	47-M-2016	3,354	Granted
Kachi Inca 4	107-M-2017	2,723	In Process
Kachi Inca V	45-M-2016	305	Granted
Kachi Inca VI	44-M-2016	110	Granted
Dona Amparo I	22-M-2016	3,000	Granted
Dona Carmen	24-M-2016	874	Granted
Debbie I	21-M-2016	1,501	Granted
Divina Victoria I	25-M-2016	1,266	Granted
Daniel Armando	23-M-2016	2,116	Granted
Daniel Armando II	97-M-2016	1,388	Granted
Escondidita	131-M-2018	373	In Process
Irene	28-M-2018	2,250	In Process
Maria Luz	34-M-2017	2,425	Granted
Maria I	140-M-2018	889	In Process
Maria II	14-M-2016	888	Granted
Maria III	15-M-2016	1,396	Granted
Morena 1	72-M-2016	3,025	Granted
Morena 2	73-M-2016	2,989	Granted
Morena 3	74-M-2016	3,007	Granted
Morena 5	97-M-2017	1,415	Granted
Morena 6	75-M-2016	1,606	Granted
Morena 7	76-M-2016	2,805	Granted
Morena 8	77-M-2016	2,961	Granted
Morena 12	78-M-2016	2,704	Granted
Morena 13	79-M-2016	3,024	Granted
Morena 15	162-M-2017	2,559	Granted
Pampa I	129-S-2013	2,312	Granted
Pampa II	128-M-2013	1,119	Granted
Pampa III	130-M-2013	477	Granted
Pampa IV	78-M-2017	2,569	In Process
Morena 11	201-M-2018	815	In Process
Parapeto 1	133-M-2018	2,504	In Process
Parapeto 2	134-M-2018	1,259	In Process
Parapeto 3	132-M-2018	1,892	In Process
37 Mining leases	**Total**	**70,462**	

Source: Lake Resources

The resource at Kachi is based on 15 drill holes totalling 3,150m, with depths of up to ~400m. Drilling revealed thick permeable sand dominated sediments that are believed to continue below the drilled levels, and beyond the surface dimensions of the salt lake.

The brine resource, begins at a depth of 50m from the surface and continues to 400m depth; it is assumed to be a constant 350m thick throughout the resource area. The seismic geophysical survey shows the host sediments extend well beyond 400m depth in the west of the basin.

The total Mineral Resource comprises a brine volume of 3.8 km^3, with an average drainable porosity of 8% and mean lithium grade of 211 mg/L, for a total lithium content of 826,000 tonnes, or 4.4m tonnes LCE. Of this, the Indicated Resource comprises 1.01m tonnes LCE at an average grade of 289 mg/L lithium. A diluted head grade of 250 mg/L is used in the study.

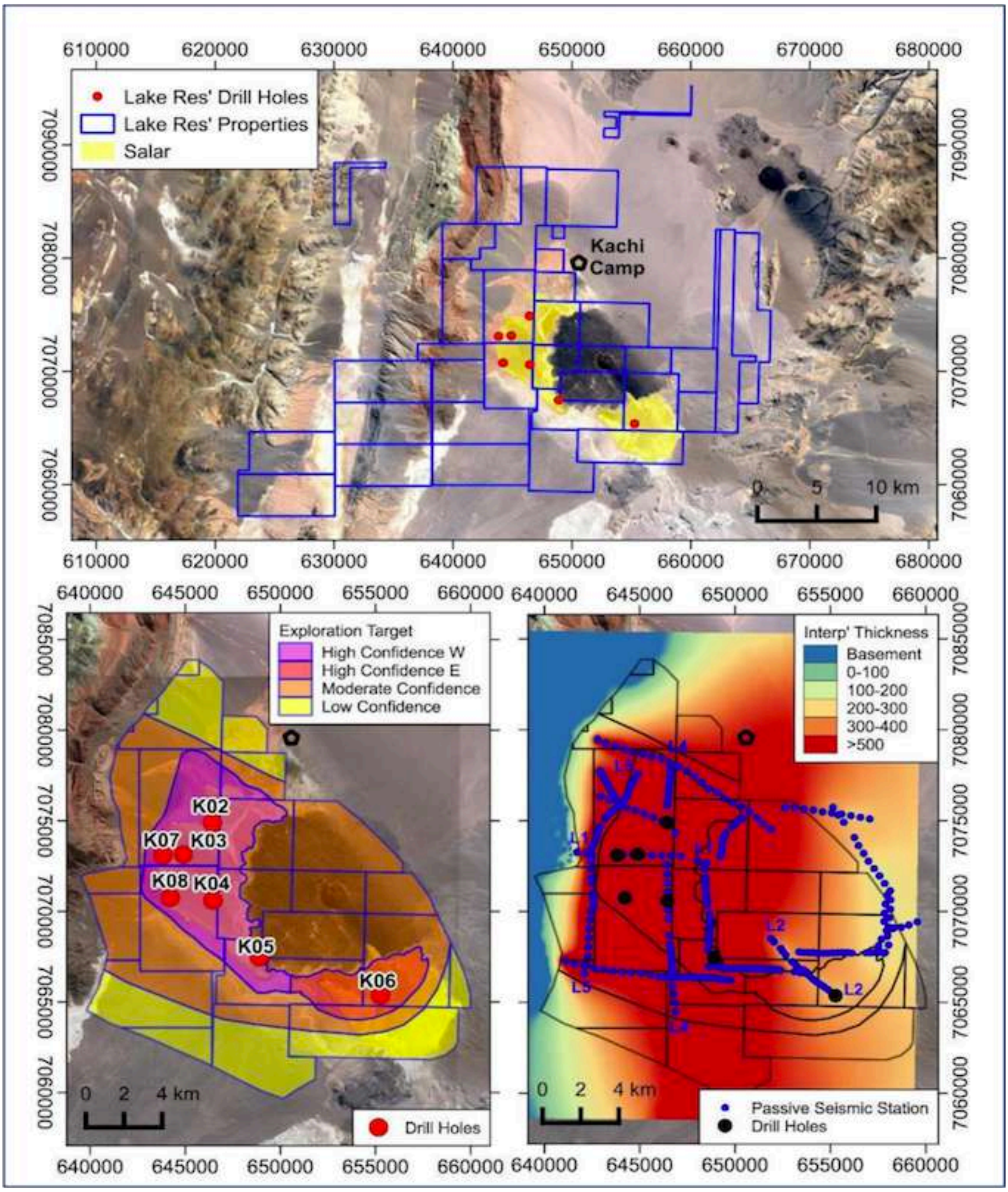
Figure 32: Kachi drilling results

Drill hole	Type	Total Depth m	Interval From m	To m	Lithium mg/L	Magnesium mg/L	Potassium mg/L
Northern Area							
K07D01	Diamond	76	10	34	157	-	3,330
K03D02	Diamond	151	74	92	180	1,740	4,435
K03R03	Rotary	242	213	237	306	1,307	5,998
K03R12	Rotary	400	358	400	267	1,180	5,180
K02D13	Diamond	404	60	60	217	3,557	4,438
			64	108	182	2,884	3,620
			269	298	204	2,163	4,100
			313	343	252	1,411	4,987
Southern Area							
K06D04	Diamond	168	95	113	203	766	3,321
K06R05	Rotary	87	68	85	167	1,000	3,160
K06R06	Rotary	180	not	sampled			
K06R07	Rotary	189	159	179	191	1,009	961
K06D08	Diamond	405	69	70	194	958	3,171
			120	121	191	873	3,199
			165	166	170	880	3,650
			206	206	164	894	3,590
			258	259	164	888	3,560
			354	405	170	877	3,670
K05D09	Diamond	139	62	62	83	1,229	965
			108	108	222	1,325	4,360
K05D11	Diamond	391	157	157	95	1,460	1,926
			188	188	215	919	3,596
			224	248	175	876	3,065
			289	289	143	1,088	2,251
			301	301	116	1,035	1,782
			291	334	234	3,199	4,980
			349	391	185	1,955	3,892
K08R14	Rotary	364	301	361	326	1,232	6,038
K04R15	Rotary	350	290	350	265	1,154	4,993

Note: Intervals shown as being 1m are point samples at that depth, taken with a downhole spear

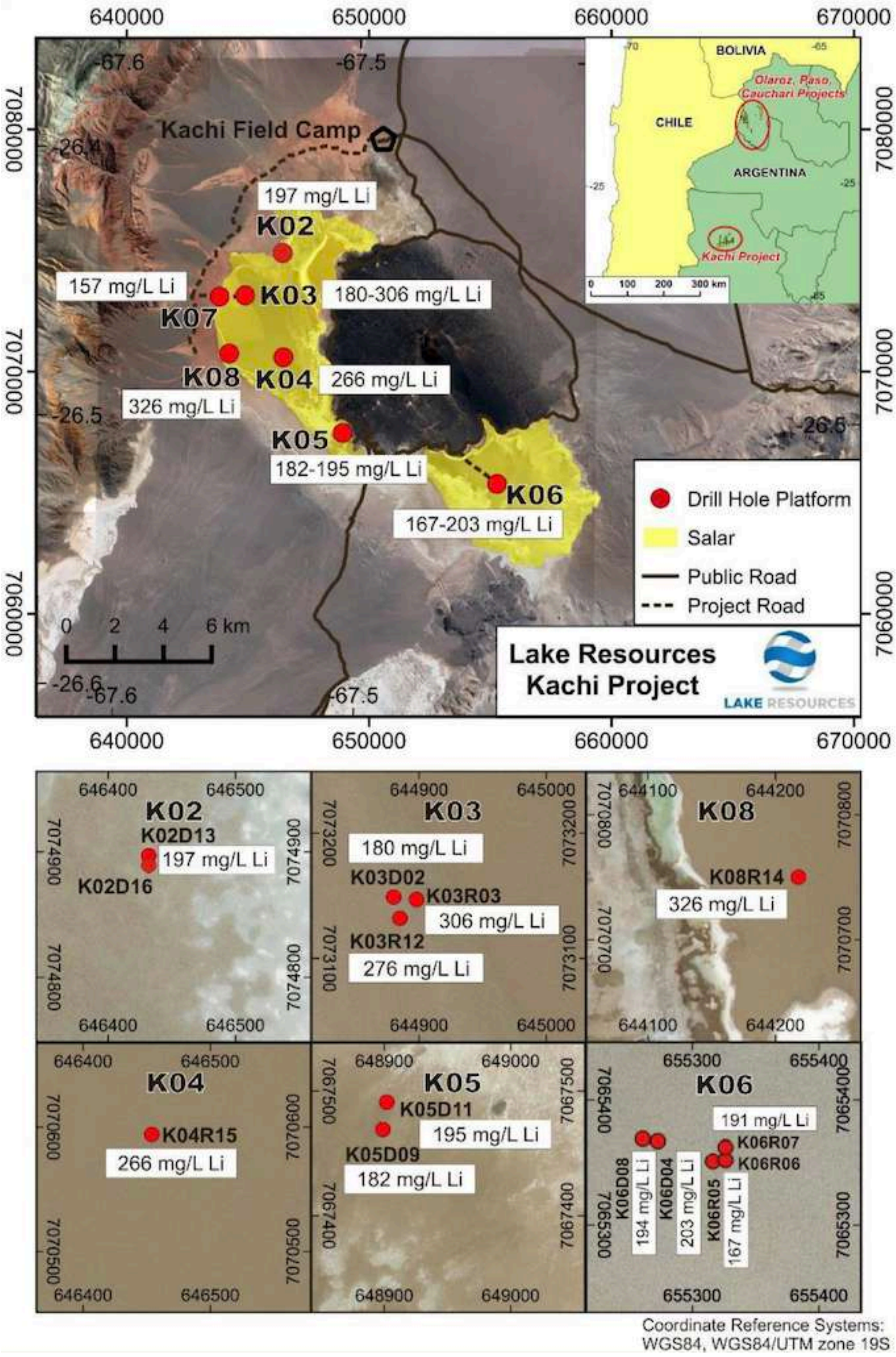
Source: Lake Resources

Figure 33: Kachi: drill holes and seismic lines used in exploration



Source: Lake Resources

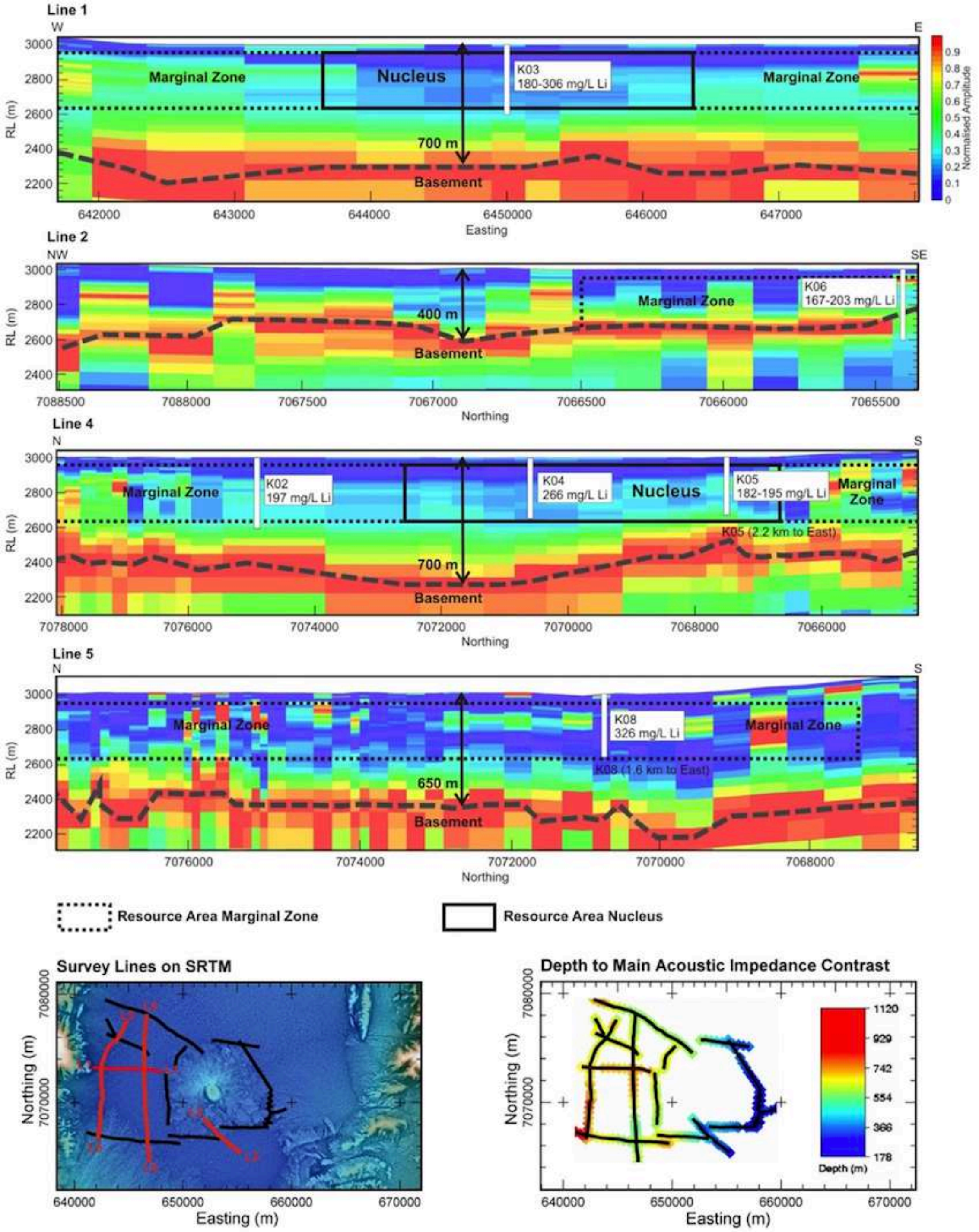
Figure 34: Drilling locations and average lithium concentrations



Source: Lake Resources

A passive seismic survey of the basin was undertaken to better understand the basin stratigraphy, geometry, and thickness of the sediments hosting the brine. This helped identify drill hole sites. The seismic information suggests the basin is 700-800 m deep in the western area. Interpretation of the seismic survey indicates that much of the basaltic volcanic material visible at surface forms a thin veneer overlying lake sediments, extending the bounds of the salar beyond the visible salt crust. This has led to the initial brine target area being expanded to the north, west and south of the observed salar with lake sediments evident in seismic lines to significant depths below alluvial fans and relatively thin ignimbrites. Based on this geological and geophysical interpretation the area of 295 km^2 has been applied to the exploration target. There is a significant volume of lake sediments below the 400m depth of drilling, which is used as a cut off depth for the exploration target estimate and the base of the sedimentary basin over a large proportion of the project area.

Figure 35: Seismic Profiles showing location and depth to basement together with the depths used in the mineral resource estimate and exploration target calculation (thick dashed black line is the basement reflector)



Source: Lake Resources

Adjacent properties

There a number of other lithium producers and developers in northwest Argentina. Two of these projects are in production. In 2018, Livent produced 17,238 tonnes of lithium carbonate and 5,000 tonnes of lithium chloride at its Salar de Hombre Muerto. Orocobre and Toyota Tsushu produced 11,837 tonnes of lithium carbonate at Salar de Olaroz in 2018.

Ganfeng and Lithium America's Cauchari-Olaroz project is under construction. The project was initially expected to have capacity of 25,000 tpa LCE, but this has been expanded to 40,000 tpa LCE. There is also the Eramet project, which was recently postponed.

In addition to these projects, management has identified a further 12 projects at the feasibility stage (PEA, PFS, DFS) that combined would have a capacity of 386,000 tpa LCE by 2025 if they all come to fruition. Of these only four plan to use direct extraction. That is Lake Resources, Livent, Eramet (project on hold), and Rincon. According to Rincon's February 2020 presentation, the company is owned by funds managed by Sentient Equity Partners.

Figure 36: Principal lithium brine projects in Argentina

Source: Lake Resources

Cauchari

The Cauchari project covers some 37 km^2 in Jujuy province. The licences are contiguous to brine deposits owned by Ganfeng/Lithium Americas, and Orocobre (having acquired Advantage Lithium). **Lake Resources drilled one hole at Cauchari in 2019, which returned compelling results, confirming a major discovery.** Lithium brines were intersected over 506m from a depth of 102m to the end of the hole at 608m. The results include 493 mg/L over a wide 343m intersection from 117m depth with a magnesium to lithium ratio of 2.9.

The results are similar to those at the neighbouring Ganfeng/Lithium Americas Cauchari project which has total resources of 24.6m tonnes LCE at 592 mg/L. Management is confident of advancing the project with further drilling.

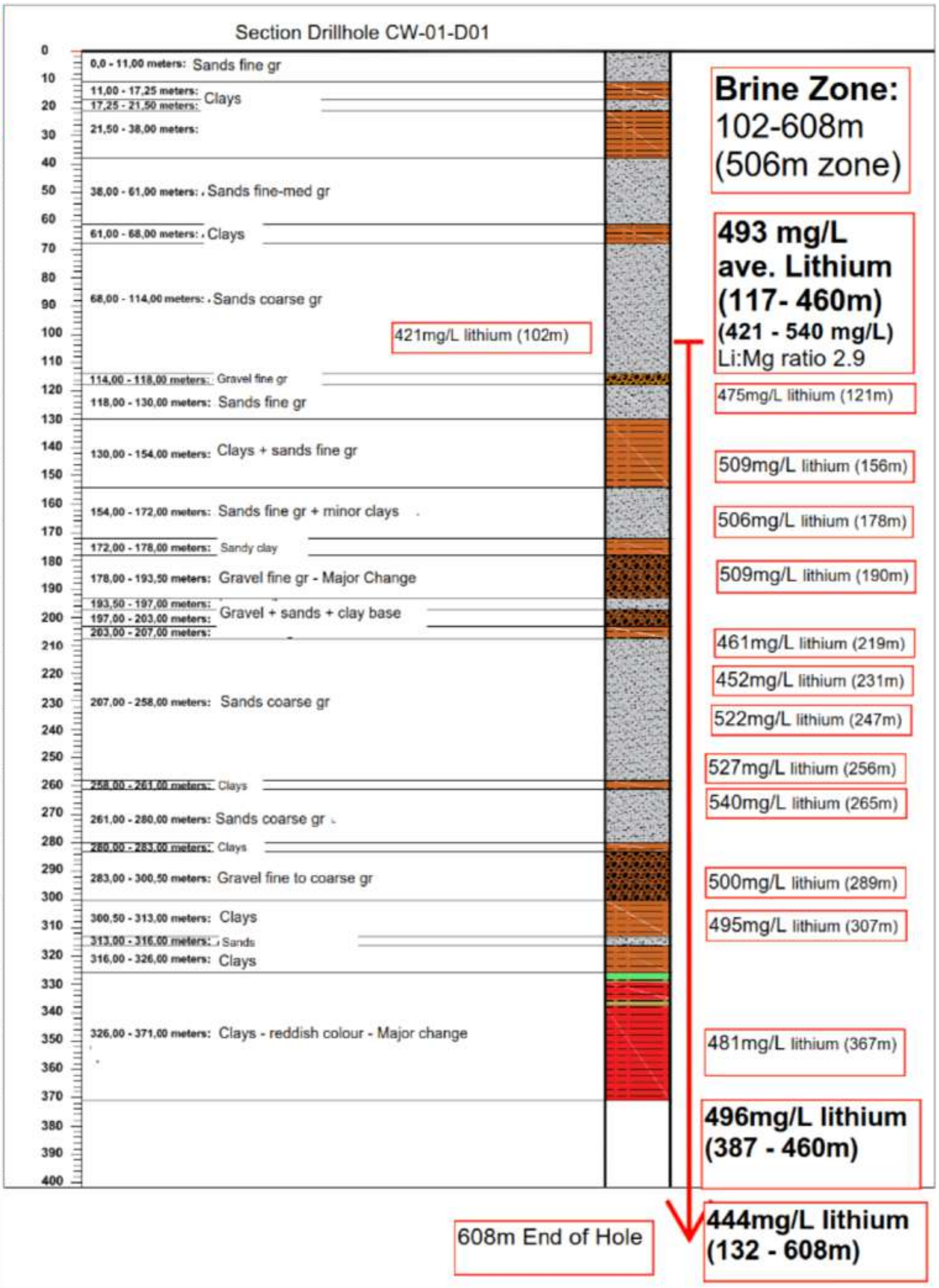
The discovery vindicated a new exploration model designed by Lake Resources in 2016 to explore on the margins of lithium bearing basins under thin alluvial cover to locate similar brines as in the centre of brine bearing basins.

Figure 37: Lake Resources drilling at Cauchari, 2019, indicative boundaries to neighbouring projects

Source: Lake Resources

Figure 38: Results from Cauchari drill hole CW-01-D01

Assay Interval (m)	Lithium (mg/L) 1st Packer
PACKER SAMPLES	
102m	421
121m	475
132m	422
156m	509
178m	506
190m	509
219m	461
231m	452
247m	522
256m	527
265m	540
289m	500
307m	495
367m	481
387m-460m	496
132m-608m	444



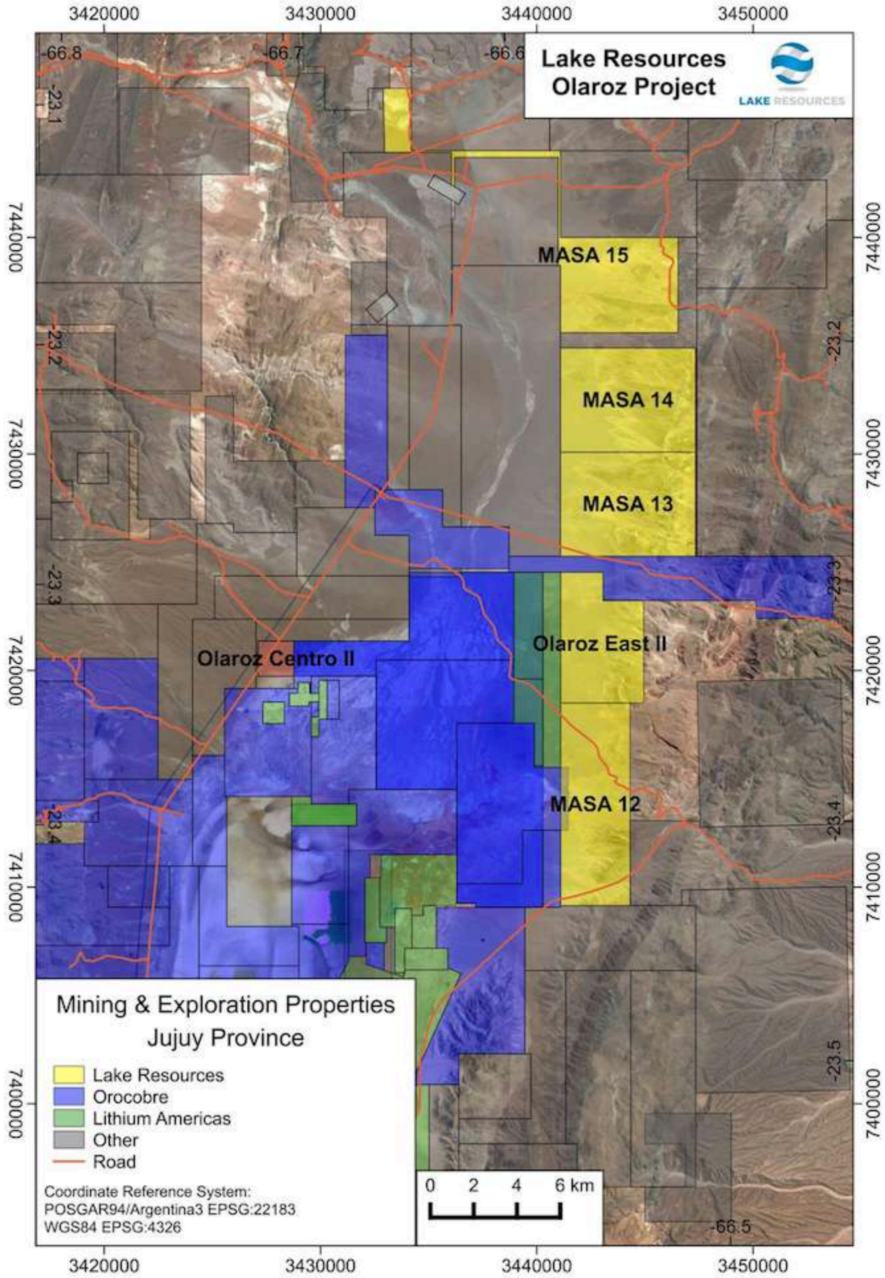
Source: Lake Resources

Other projects

Olaroz

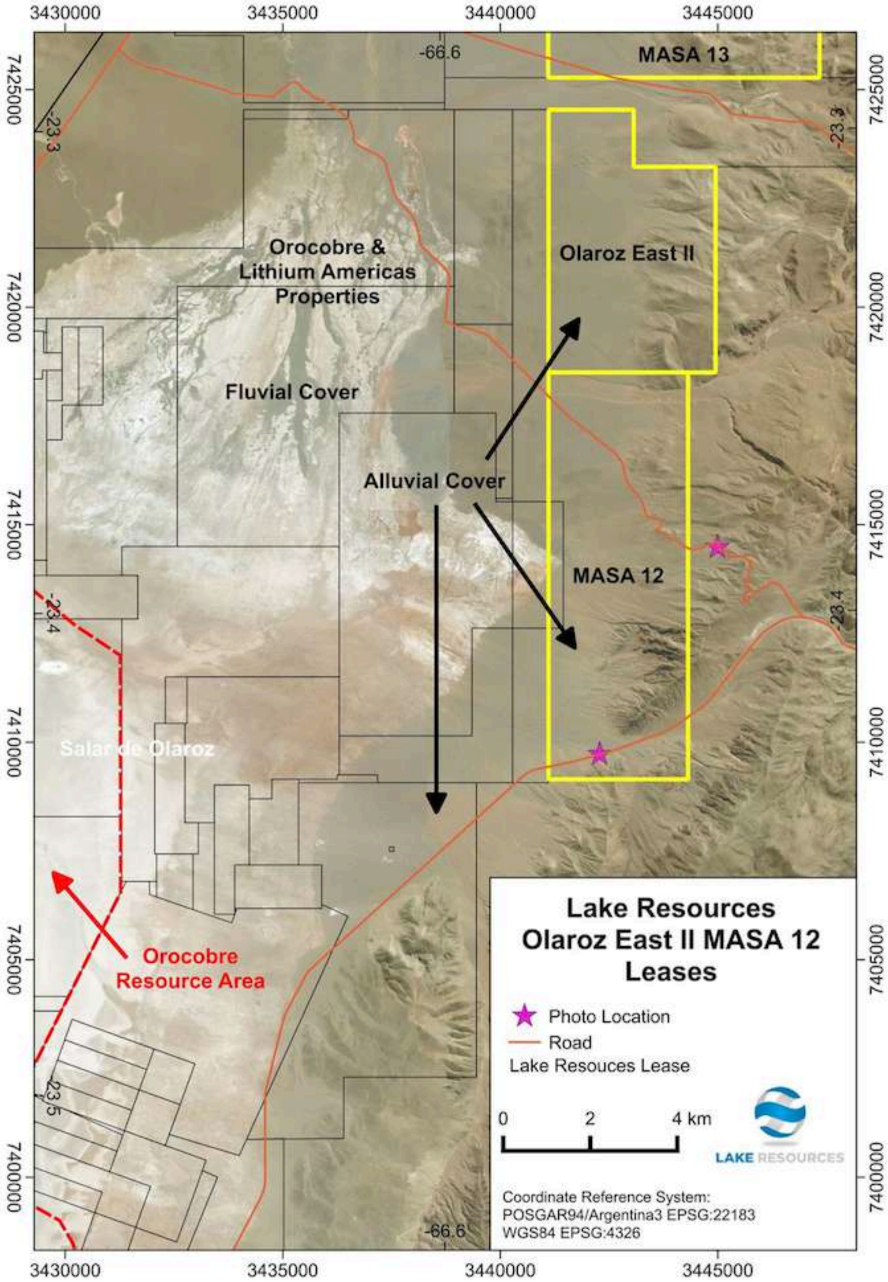
The Olaroz project, covering some 142 km^2, is also situated in Jujuy province in close proximity to Ganfeng/Lithium Americas' Cauchari project, and adjoining Orocobre's Olaroz production area. Lake Resources plans to drill at the project, but it is unclear at this stage when drilling activities will be approved. Management believes, based on the success of drilling on the basin margins under cover at Cauchari and Kachi, that similar brines will extend into Lake's Olaroz property. The leases extend along the eastern margin of Orocobre's producing resource, for over 30km north-south, which is a similar length to Ganfeng/Lithium Americas resource area.

Figure 39: Lake Resources' Olaroz project and neighbouring leases



Source: Lake Resources

Figure 40: Lake Resources' Olaroz project showing alluvial cover



Source: Lake Resources

Paso

The Paso project covers some 296 km^2 in Jujuy province. It lies west of Orocobre's Cauchari-Olaroz lease area. Salt lakes in the area have shown elevated lithium results at surface. The concession area lies at an elevation of 4,050m. Direct extraction has not been tested at this altitude. Management has been focused advancing Olaroz and Cauchari before turning its attention to Paso.

Catamarca

The project is Located at the southern end of Catamarca province, south of the 'lithium triangle' in the Ancasti Ranges. The project covers some 904 km^2. The area is known for small-scale production from lithium bearing spodumene pegmatites, mainly from the 1950s to 1990s. Lake Resources exercised its option to acquire the project in September 2018.

According to management, a combination of literature reviews, satellite imagery, and field work helped to identify a series of pegmatite swarms over a belt of 150 km. Outcropping pegmatites with coarse grained spodumene crystals measuring 30cm to 70 cm were identified in a number of locations. **The Catamarca project represents an enormous target, with compelling geology, and historical production in the area.** Opportunities exist to locate new lithium bearing spodumene deposits among pegmatite swarms by using modern exploration technologies.

Latin Resources holds adjoining leases. Latin Resources announced, 14 June 2016, the results of 4 samples taken from spodumene exposures in old mine workings, with grades ranging from 4.9% Li_2O to 7.1% Li_2O. In April 2017, the company announced the results of a drill program in which four holes intercepted the down dip extension of outcropping pegmatite that was subject to historical drilling. Results included 3m at 2.98% Li_2O including 1m at 4.61% Li_2O from drill hole LCRC004, 4m at 2.03% Li_2O from drill hole LCRC002, and 6m at 1.62% Li_2O from drill hole LCRC001.

Figure 41: Outcropping pegmatites, Catamarca

Source: Lake Resources, 2018

Latin Resources, ASX announcements June 2016 and April 2017

https://www.asx.com.au/asxpdf/20160614/pdf/437wn4ljbfjvqb.pdf

https://www.asx.com.au/asxpdf/20170426/pdf/43hqzwdv84lws4.pdf

Appendix 2: Lithium basics

Continental brines deposit model

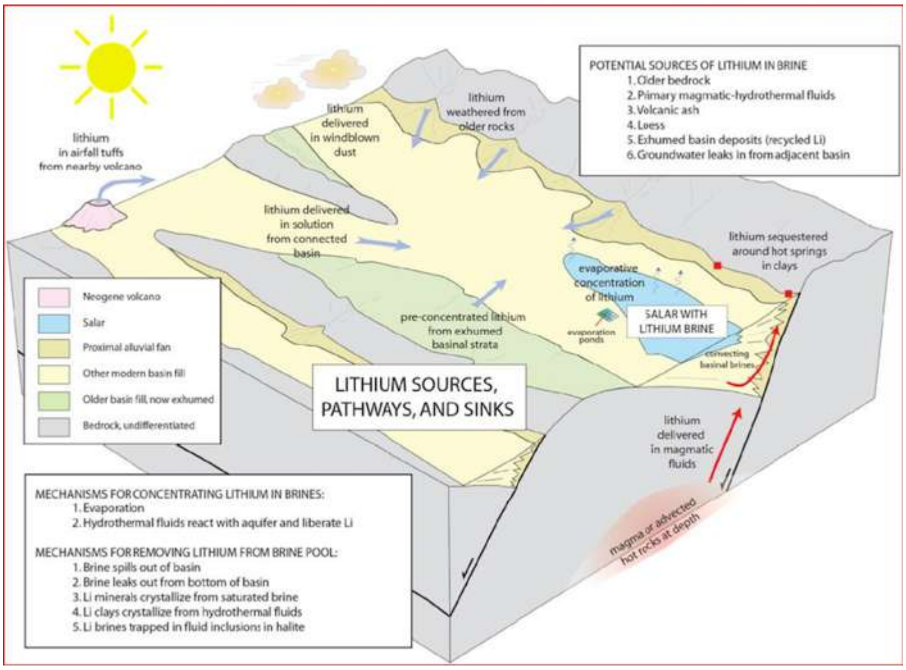
There are three main types of lithium deposit; pegmatites, continental brines, and sedimentary deposits (also called ‘hydrothermally altered clays’). Whereas historically, lithium production was dominated by continental brines, in 2019, Australia produced 54% of global lithium output from pegmatites. Lithium-bearing clays such as hectorite or micas such as lepidolite are difficult to process and are not used commercially, though a number of companies are in advanced stages of testing the development of lepidolite deposits in Australia and sedimentary deposits in the US.

Lithium brine deposits are essentially accumulations of saline groundwater enriched in dissolved lithium (Bradley et al, 2013). Brines in these deposits typically carry lithium concentrations of 200 to 1,400 mg/L. They have a number of common characteristics including:

- Arid climate
- Closed basin containing a salt lake
- Associated igneous/geothermal activity
- Tectonically driven subsidence
- Suitable source of lithium
- Sufficient time to concentrate brine

Important factors in determining whether a basin can accumulate lithium include whether or not the basin is closed, which is a function of tectonics, and whether evaporation exceeds precipitation, increasing salinity.

Figure 42: Deposit model for lithium brines



Source: Bradley et al (2013).

World lithium resources and reserves

Although battery grade lithium chemicals are expected to be in short supply over the next few years, lithium resources are abundant. USGS (2020) estimates global resources at 80m tonnes of contained lithium. Reserves are estimated at 17m tonnes contained lithium which compares to production in 2019 of 77,000 tonnes according to USGS. World resources and world reserves are dominated by Argentina, Chile, Australia, and China, which together have 46% of resources, and 85% of reserves.

Figure 43: World lithium resources and reserves

World resources	79,579,000	100%	World reserves	16,585,000	100%
Argentina	17,000,000	21%	Argentina	1,700,000	10%
Chile	9,000,000	11%	Chile	8,600,000	52%
Australia	6,300,000	8%	Australia	2,800,000	17%
China	4,500,000	6%	China	1,000,000	6%
Other	42,779,000	54%	Other	2,485,000	15%
- Includes Bolivia	21,000,000				

Source: USGS, 2020

Global production is also dominated by these four countries. The production shares of Argentina, China, Australia and China has risen from 82-82% in the early 2000s to 94-97% in 2016-2019.

There has been a notable increase in primary lithium production from Australia, from 3,770 tonnes in 2005 to a peak of 58,800 tonnes in 2018. This has resulted from a substantial increase in the mining of hard rock pegmatites. According to data from USGS, Australia's share of lithium production grew from 33% of global production in 2010, to 54% in 2019, peaking at 62% in 2018.

The raw lithium product being produced in Australia is spodumene. Spodumene is not an end-product in the lithium chemical market, meaning that Australia's production has to be further refined to convert it to lithium hydroxide. This is usually done in integrated plants such as owned by Tianqi, or by third party toll operations, mostly in China. As a result, Australian spodumene production has become largely dependent upon third party Chinese converters which has restricted production.

Although Chile has good quality brines, and an ideal climate for evaporation ponds, the lithium industry has faced challenges. Chile requires companies to partner with the state (as SQM and Albemarle have done) or to obtain special permits. Water usage remains a key concern. As a result, while Chilean production grew by more than 70% from 2010 to 2019, Chile's share of global output declined in the same period from 37% to 23%.

Chemical formulae:

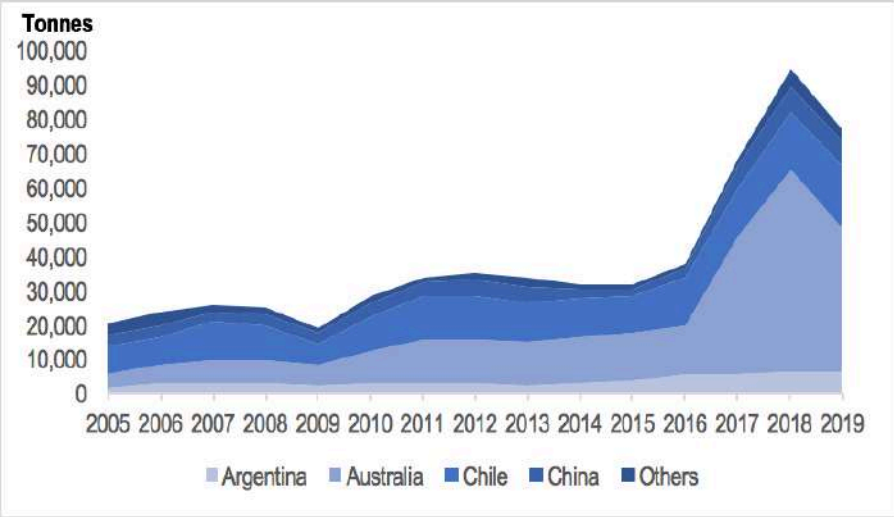
Spodumene $LiAlSi_2O_6$, Hectorite $Na_{0.3}(Mg,Li)_3Si_4O_{10}(OH)_2$, Lepidolite $K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$

Munk L.A., Hynek S.A., Bradley D.C., Boutt D., Labay K., and Jochens H. (2016) Lithium brines: A global perspective. Reviews in Economic Geology v18, p 339-366. http://blogs.umass.edu/dboutt/files/2017/07/Munketal2016.pdf

Bradley D., Munk L., Jochens H, Hynek S., and Labay Keith (2013). A preliminary model for lithium brines. USGS Open-File Report 2013-1006. United States Geological Survey.

https://pubs.usgs.gov/of/2013/1006/OF13-1006.pdf

Figure 44: Global primary lithium production

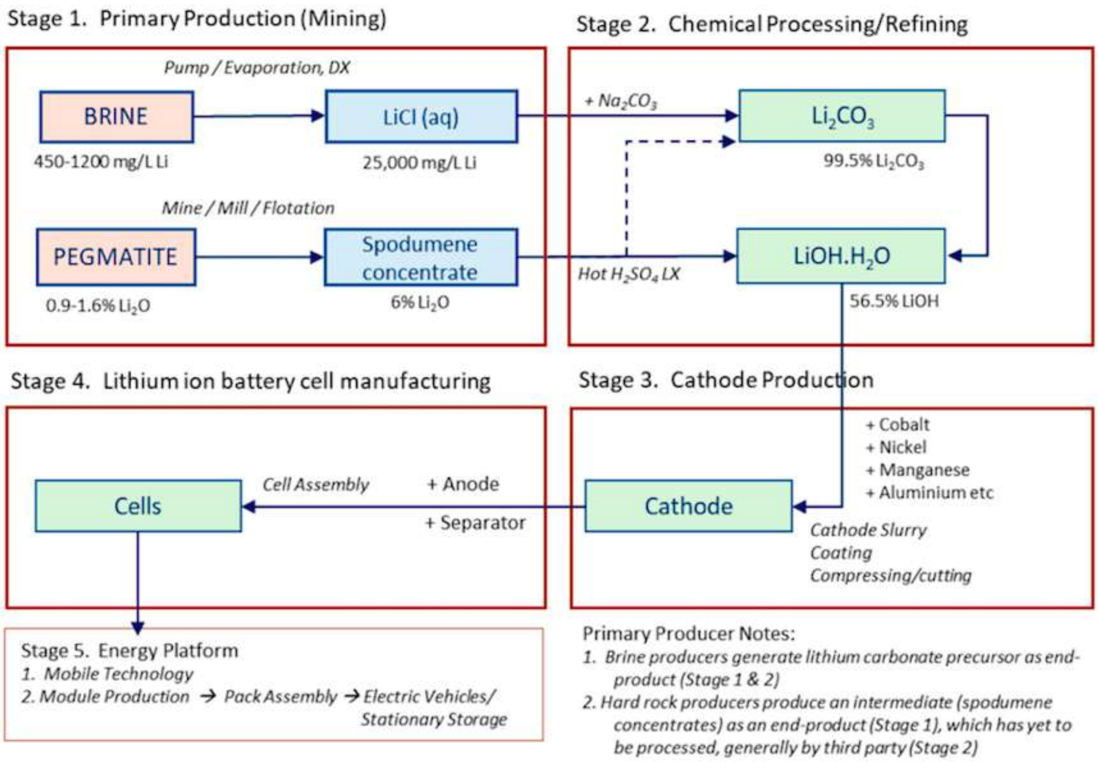


Source: USGS

Overview of supply chain

The chemical precursors to lithium-ion cathodes used in batteries are either lithium carbonate which are usually sourced from brines, and lithium hydroxide sourced mostly from spodumene (pegmatites). Lithium carbonates are often upgraded to lithium hydroxide. In 2018, some 52% of the primary lithium feedstock was sourced from brines, with the remaining 48% sourced from pegmatites.

Figure 45: Lithium supply chain from primary source to EV batteries



Source: Lake Resources

Lithium chemistry

Lithium brines occur mainly in salt lakes in the Andes of Chile and Argentina, and in Qinghai, China. Brines are pumped to the surface and left to evaporate, producing a concentrated lithium chloride solution, which is then reacted with sodium carbonate to produce lithium carbonate:

$$LiCl + Na_2CO_3 \rightarrow Li_2CO_3 + NaCl$$

Most spodumene concentrates are produced in Australia from hard rock mines, where lithium-enriched pegmatites (0.9% to 1.6% Li_2O) are mined, and then concentrated by floatation. This results in spodumene concentrate (~6% Li_2O) which is further processed to produce lithium hydroxide, usually by a third-party toll-treatment spodumene converter:

$$\text{alpha-}LiAlSi_2O_6 \rightarrow \text{beta-}LiAlSi_2O_6\text{, roasting at >950}^{o}C$$

$$2\text{beta-}LiAlSi_2O_6 + H_2SO_4 \rightarrow Li_2SO_4 + 2HAlSi_2O_6$$

$$Li_2SO_4 + NaOH \rightarrow LiOH + Na_2SO_4$$

$$Li_2CO_3 + Ca(OH)_2 \rightarrow 2LiOH + CaCO_3$$

There is a small market for intermediate products including lithium chloride and lithium sulphate. Lithium chloride is the precursor chemical for butyllithium and lithium metal. Lithium metal production will become more important as the battery sector moves towards lithium sold state batteries where lithium is used in the anode, complementing a lithium oxide based cathode, and a solid-state lithium electrolyte. Lithium sulphate from brines is seen as a direct route for lithium hydroxide.

Figure 46: Lithium conversion rates

Chemical	Formula	Lithium content	To Li	To Li_2O	To Li_2CO_3
Lithium	Li	100%	1.000	2.153	5.323
Lithium oxide	Li_2O	6.4%	0.464	1.000	2.473
Lithium bromide	LiBr	8.0%	0.008	0.172	0.425
Lithium carbonate	Li_2CO_3	18.8%	0.188	0.404	1.000
Lithium hydroxide monohydrate	$LiOH.H_2O$	16.5%	0.165	0.356	0.880
Lithium chloride	LiCl	16.3%	0.163	0.362	0.871
Lithium fluoride	LiF	26.8%	0.268	0.576	1.420
Lithium hypochlorite	LiOCl	11.89%	0.119	0.256	0.633
Butyllithium	C_4H_9Li	10.83%	0.108	0.233	0.576

Source: aboutlithium.blogspot.com

Product specifications and uses

There are essentially two broad classifications of lithium, called 'technical grade' and 'battery grade'. Technical grade product is used in the manufacture of glass, ceramics, lubricants and butyl-lithium, and disposable battery materials. Battery grade is used in rechargeable batteries. Product specification has become more stringent as regards impurities over time. This trend is expected to continue, benefitting producers using direct extraction technologies. The Lilac process produces very high grade product, with low impurities.

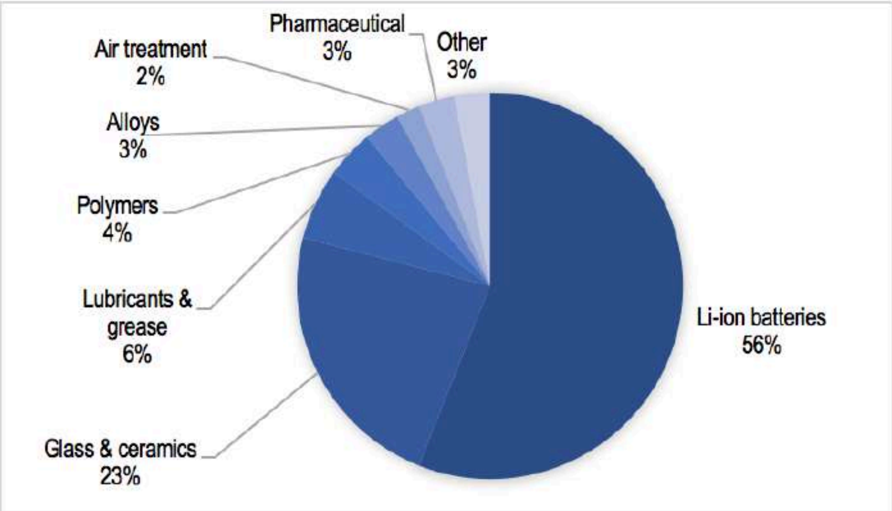
Figure 47: Product specifications used in lithium pricing

Product	Content	Size	Common impurity tolerances
Lithium Carbonate			
Technical grade	Li_2CO_3, min. 99.0%	<40 µm	Na <0.15%, SO_4 <0.35%, Ca <0.04%, Cl <0.02%
Battery grade	Li_2CO_3, min. 99.5%	<15 µm	Na<0.025%, Mg<0.008%, Ca<0.005%, Fe<0.001%, Si<0.003%
Lithium hydroxide			
Technical grade	LiOH, min. 55.0%	<40 µm	CO_2 <0.35%, SO_4 <0.01%, Cl <0.002%
Battery grade	LiOH, min. 56.5%	<40 µm	CO_2 <0.35%, SO_4 <0.01%, Cl <0.002%
Spodumene	Li_2O, 5-6%	<0.495	Fe_2O_3 <2.5%, MnO <0.25%, MgO <0.2%

Source: Lake Resources

Lithium has a wide range of uses including in glass, ceramics, alloys, pharmaceuticals, lubricants, polymers, batteries and others. In glass, lithium fluoride is used as a flux, and lithium carbonate in glazes in ceramics. In alloys, lithium aluminium compounds are used in aircraft frames, high speed trains and high-performance bicycles Lithium magnesium alloys are used in armour plating. Also, lithium fluoride is used as a flux in aluminium smelting. Lithium stearate is used to thicken oils, and as a lubricant in high temperature applications.

Figure 48: Lithium uses, 2018



Source: Lake Resources

Lithium-ion batteries have high energy densities, are rechargeable, and have long battery lives compared to previous alternatives. There is a wide variety of lithium-ion battery types in the market.

Figure 49: Common cathodes types used in lithium–ion batteries

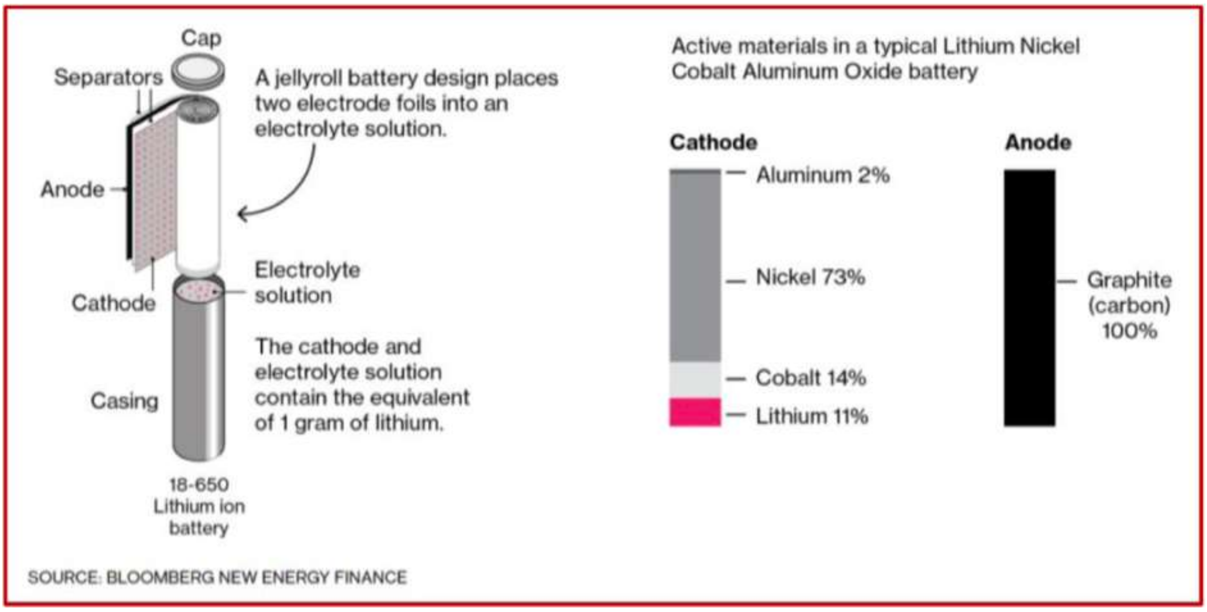
Battery type	Reaction and comments
LCO Lithium Cobalt Oxide $LiCoO_2$ Energy density 150-2,000 kWh/kg	Positive electrode half-cell: CoO_2 + Li+ + e- Full reaction: LiC_6 + CoO_2 Most common lithium-ion battery Has the highest energy density and lowest discharge rate Used in handheld electronics Has safety issues related to overheating
LFP Lithium Iron Phosphate LiFePO4 Energy density 90-120 kWh/kg	Positive electrode half-cell: $FePO_4$ + Li+ + e- Lower energy density but high current Lower overheating and fire risk (good thermal stability) Can cope with higher temperatures Used in power tools, medical equipment and e-buses Longer life and inherently safe The dominant Li-ion battery in public transportation
LTO Lithium Titanate, $Li2TiO_3$ Energy density 50-110 kWh/kg	Replaces graphite at the anode, with cathode being LMO or NMC Lower energy density Can operate at very low temperatures (-40^{o}C) Has rapid charge-discharge rates Low inherent voltage (2.4V)
LMO Lithium Manganese Oxide $LiMn_2O_4$ Energy density 110-150 kWh/kg	Cathode made from lithium manganese spinel (LiMnIIIMnIVO4), which gives it good thermal stability Low cost, safe, high discharge rate, shorter life, lower energy density
NCA Lithium nickel cobalt aluminium oxide $LiNiCoAlO_2$ Energy density 220-260 kWh/kg	Well established High discharge and short life Applications in medical equipment, industrial and electric vehicles
NMC Lithium Nickel Manganese Cobalt Oxide $LiNiMnCoO_2$ Energy density 200-250 kWh/kg	Cathode made from lithium manganese spinel, with nickel and cobalt in the structure for thermal stability, high conductivity, and high recharge rate Longer life, and inherently safe Dominant lithium-ion battery used in EVs, also power tools Combined with LMO to provide energy bursts, NMC providing range

Source: Wikipedia

In a lithium-ion battery, the cathode (positive electrode) is composed of a lithium-based oxide structure, and the anode (negative electrode) is usually made from graphite (carbon). The two are separated by an electrolyte which is often a liquid or gel of lithium salt in an organic solvent like dimethyl carbonate or diethyl carbonate.

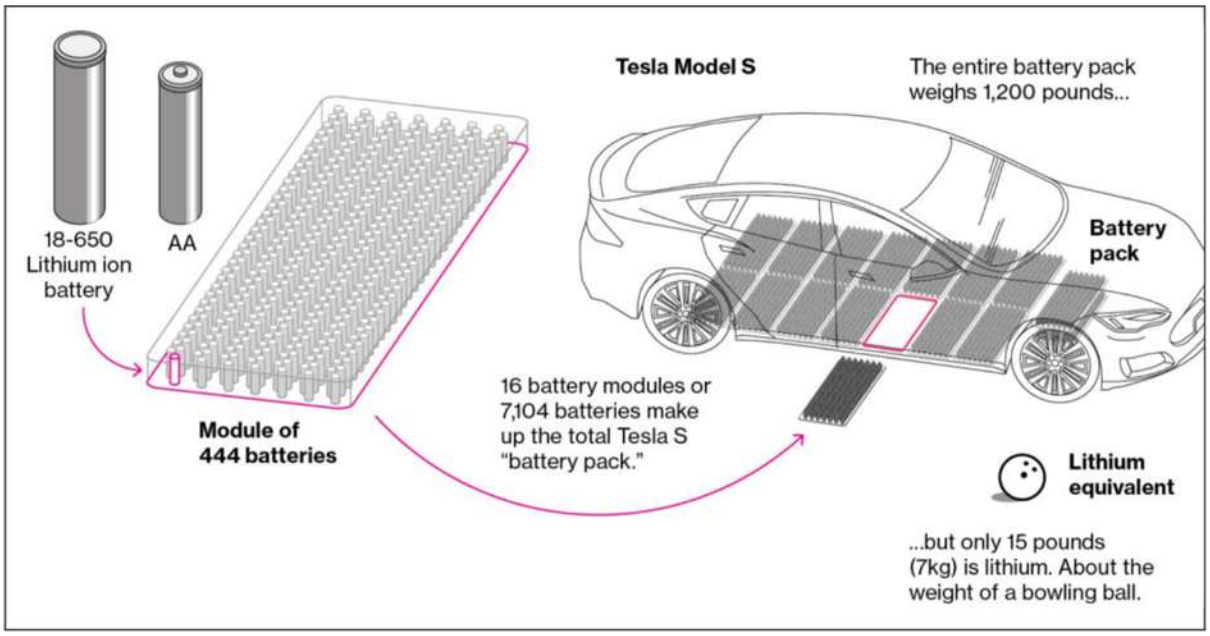
Battery makers aim to reduce the cobalt component in batteries by increasing the nickel content. This improves energy density, but at the expense of lower thermal stability. This is resolved by doping with lithium hydroxide, improving thermal stability in the cathode chemistry.

Figure 50: Lithium-ion battery composition



Source: We're going to need more lithium, Bloomberg Businessweek, 7 September 2017

Figure 51: Application of lithium-ion batteries in a Tesla S battery pack



Source: We're going to need more lithium, Bloomberg Businessweek, 7 September 2017

Appendix 3: Companies mentioned

Figure 52: Companies mentioned in this report

Company	Stock code
Lake Resources	LKE.AX
Advantage Lithium	AAL.V, now acquired
Albemarle	ALB
Anson Resources	ASN.AX
BMW	BMW.F
BYD Company	1211.HK
Chongqing Changan Auto	000625.SZ
Dongfeng Motor Co	0489.HK
E3 Metals	ETMC.V
Eramet SA	ERA.PA
Ford	F
Galaxy Resources	GXY.AX
Ganfeng Lithium	1772.HK
Geely Autos	0175.HK
General Motors	GM
Honda	7267.T
Lanxess AG	LXS.F
LG Chem	051910.KS
Lithium Americas	LAC
Lithium Power International	LPI.AX
Livent	LTHM
LSC Lithium	LSC.V, now delisted
Mahindra & Mahindra	M&M.BO
Mazda	7261.T
Millennial Lithium	ML.V
Neo Lithium	NLC.V
Orocobre	ORE.AX
Panasonic Corp	6752.T
Samsung SDI	006400.KS
SK Innovation	096770.KS
SQM	SQM
Standard Lithium	SLL.V
Tesla	TSLA

Source: Company data

The author

Simon Francis is a UK qualified chartered accountant with significant experience in the natural resources and minerals sector. Simon led research in the sector in various roles at major financial institutions including Macquarie, Samsung and HSBC, in a career spanning more than 20 years. He has been involved in approximately US$4bn of capital raising, for a number of natural resources companies. Simon has been engaged in the financing of early stage companies using production agreements, and has privately funded exploration companies in various metals and jurisdictions. Simon seeks to deploy capital in undervalued mining and resources opportunities that have been missed by the market.