

Lithium mining for rapidly growing markets

**Keliber - Innovation and Technology to Enhance
Sustainability**



Mines and Technology | Mines and Money
London, 2017



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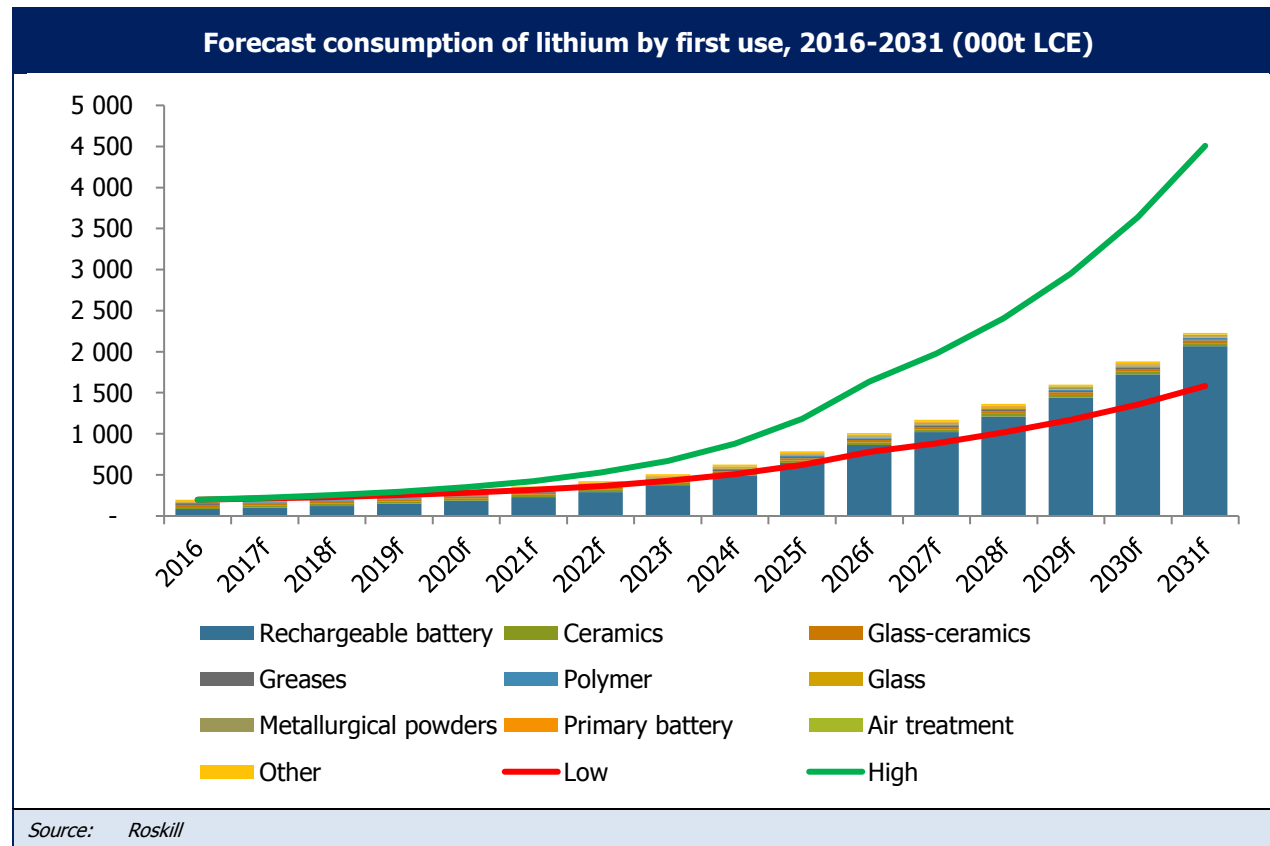
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Global demand and production of lithium

Increase in demand for lithium

Rechargeable battery sector driver for growth

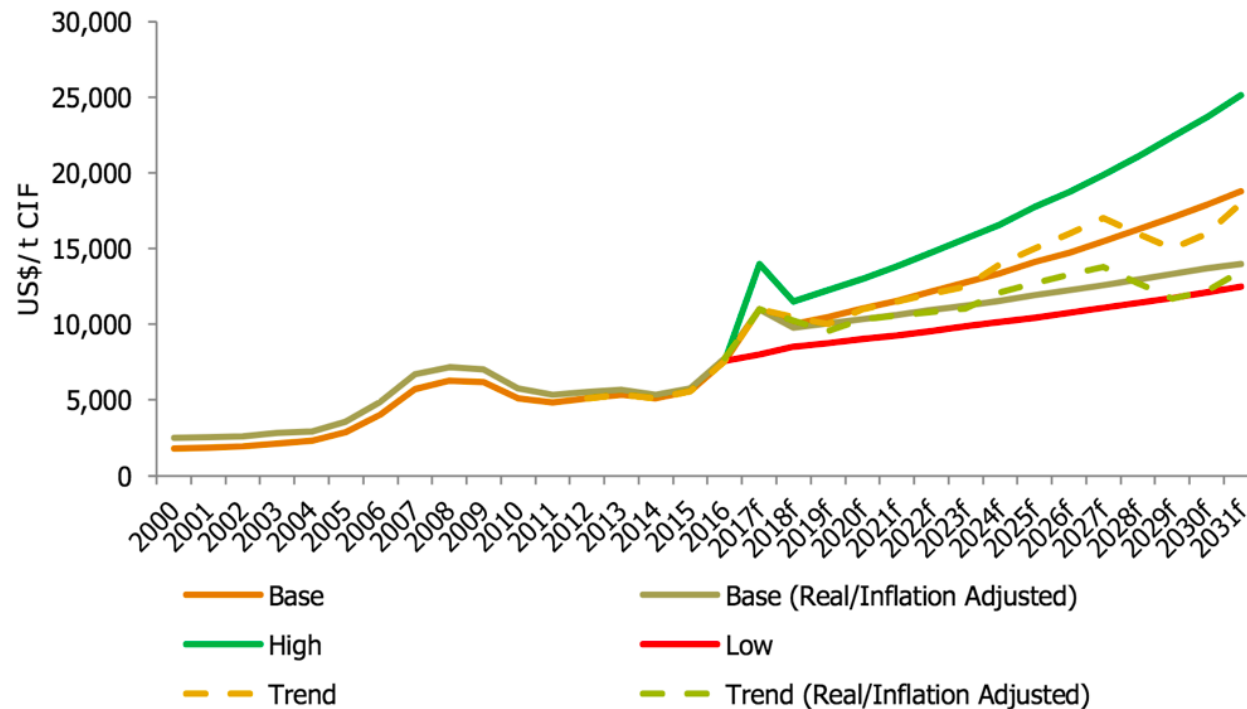


- Increasing global demand driven by the rechargeable battery sector, which is forecast to register 23.9 % pa growth through to 2031
- Other markets for lithium are also forecasted to provide areas of growth (ceramics and glass-ceramics, polymers, metallurgical powders)
- Annual global demand is forecasted to grow from 197,200 tons in 2016 to 1,008,900 tons in 2026 and 2,231,000 tons in 2031

Increase in demand for lithium

Price forecast for battery-grade lithium carbonate

Figure 35: Average annual price forecast for battery-grade lithium carbonate, 2000-2031 (US\$/t CIF Asia)



Source: Global Trade Atlas

Note: Real prices adjusted to constant US dollars using World GDP deflator data from the International Monetary Fund's World Economic Outlook Database

- Lithium carbonate prices started to rise in Chinese spot market in H2 2015
- Contract pricing started to rise in China and elsewhere in Asia in 2016 and have continued to rise world wide in 2017
- US\$10 000/t is expected to be the new floor in the base-case scenario for battery grade lithium carbonate

Increase in demand for lithium

Towards a more mobile and sustainable world

Increasing demand for lithium-ion batteries

- mobile electronics
- portable hand tools
- hybrid and electric vehicles
- stationary grid batteries
- stationary home batteries



Estimated lithium requirement in batteries

Mobile phone	1 – 3 g
Smartphone	2 – 3 g
Tablet	20 – 30 g
Laptop	30 – 40 g
Power tool	40 – 60 g
Hybrid vehicle – Plug-in hybrid vehicle	1.6 – 12 kg
Electric car	15 – 50 kg

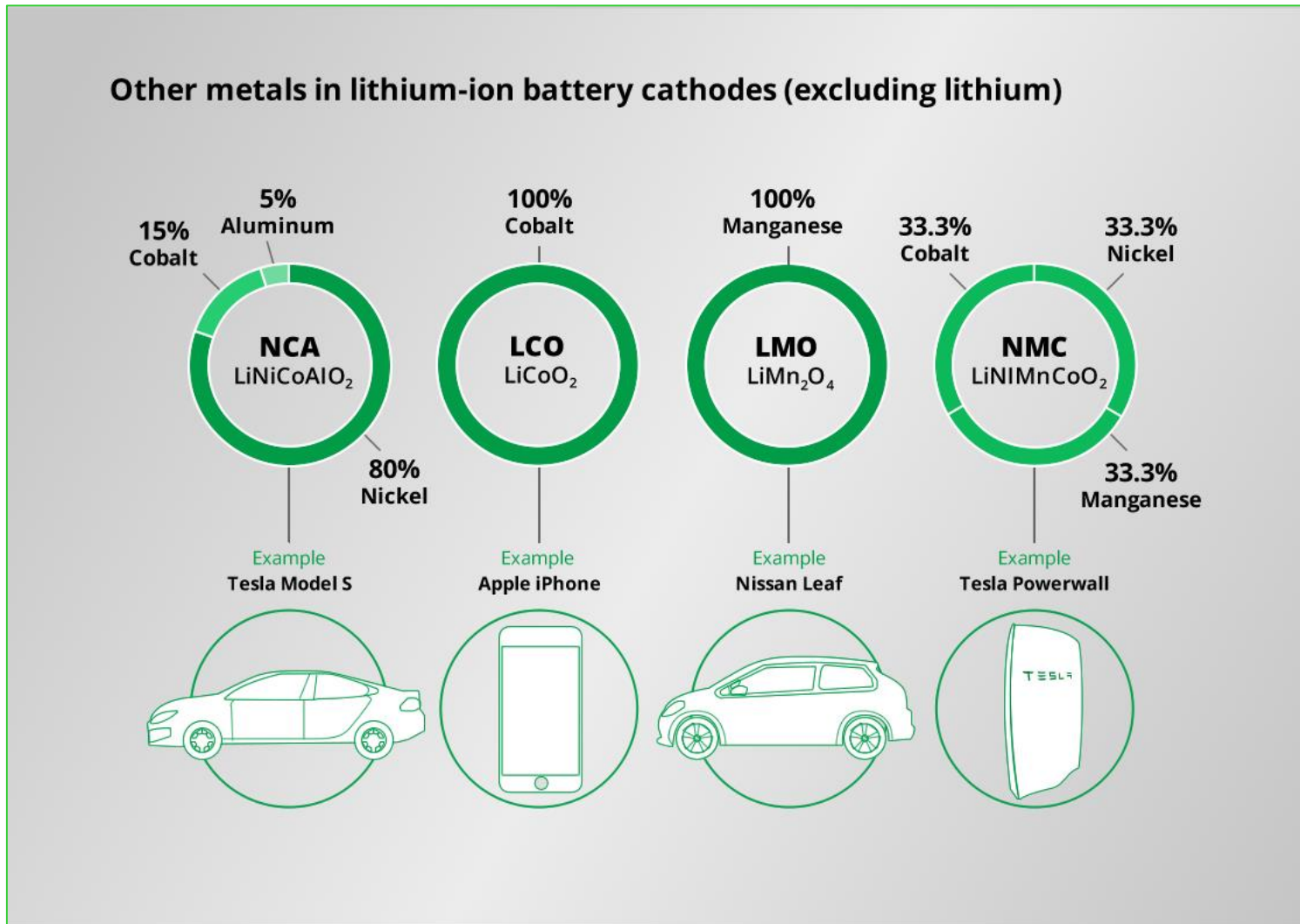
Source: IM Research, FMC Lithium

Global megatrend

Global electrification of transportation with continuing political and regulative support accelerate investment in the lithium value chain

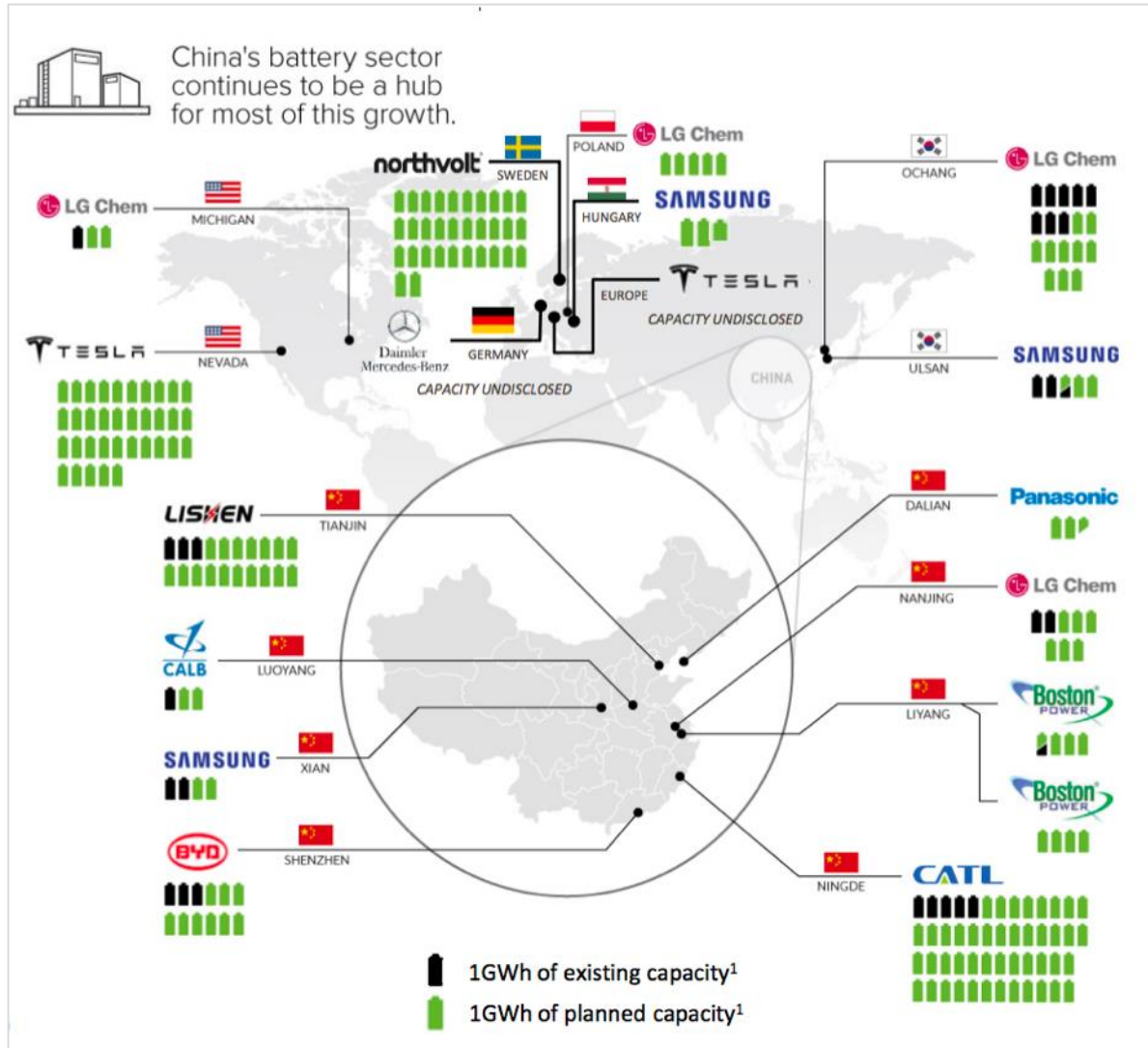
Increase in demand for lithium

Other metals in lithium-ion batteries



Global megatrend increases the demand also for other metals used in lithium-ion cathodes

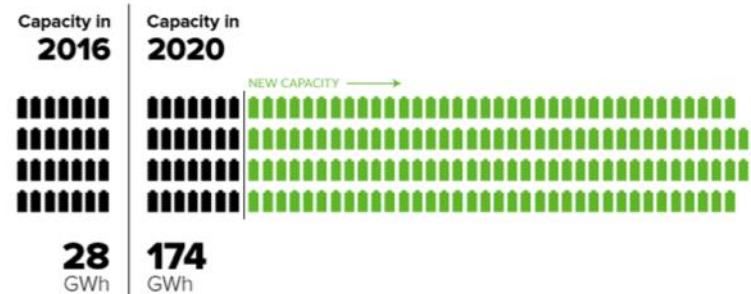
Lithium-ion megafactories



New lithium battery projects have been announced in Europe by SDI Samsung (Hungary), Daimler (Germany), Nissan (UK), Northvolt (Sweden), LG (Poland) and Tesla (location TBD)

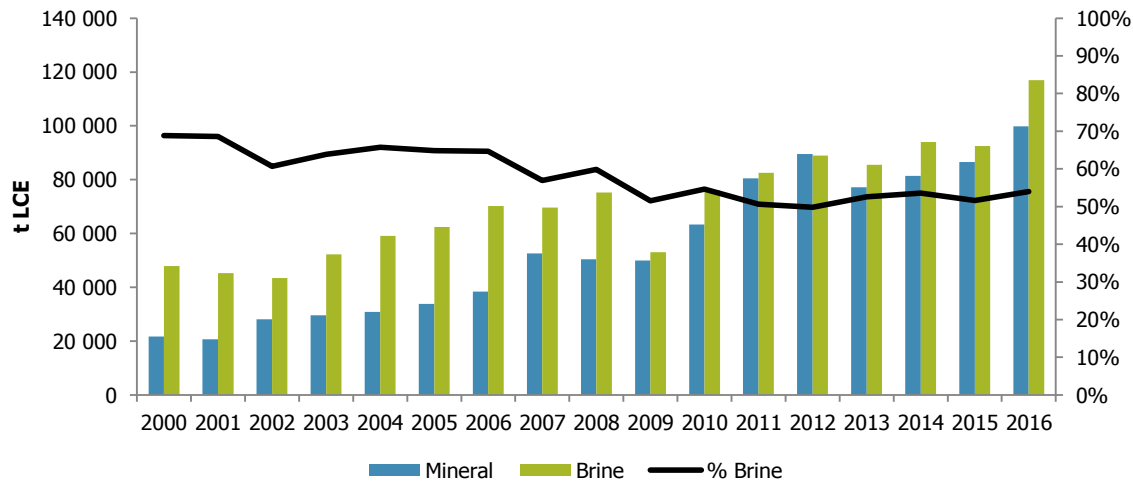


Global lithium-ion battery production capacity will increase by **521%** between 2016 and 2020.



Global mine production of lithium

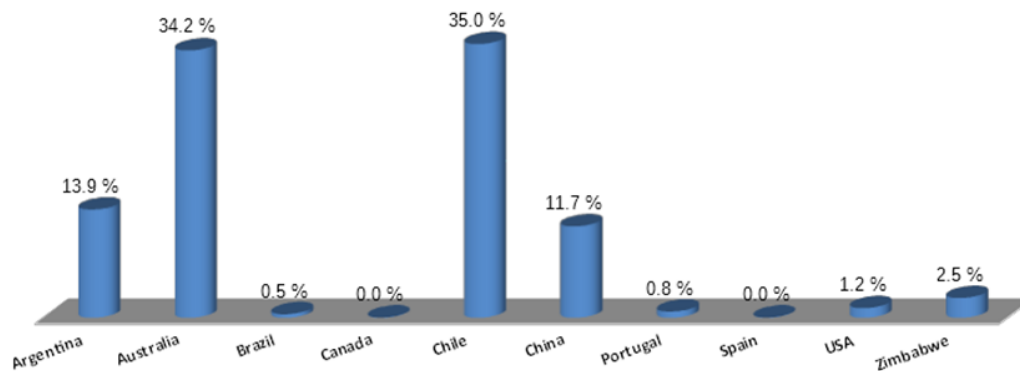
Figure 1: World: Mine production of lithium by type, 2000-2016 (t LCE and % brine)



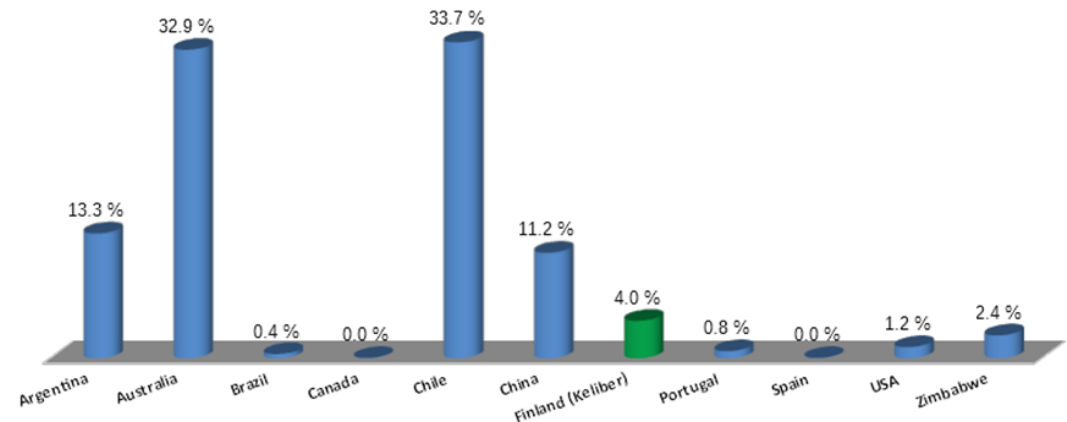
In 2016 mine production of lithium totalled 216 740 LCE tons

- 20 % increase in production compared to 2015
- Mine production of lithium from hard rock sources growing

Mine production of lithium by country in 2016 (t LCE)



Keliber's future production compared to mine production of lithium by country in 2016 (t LCE)



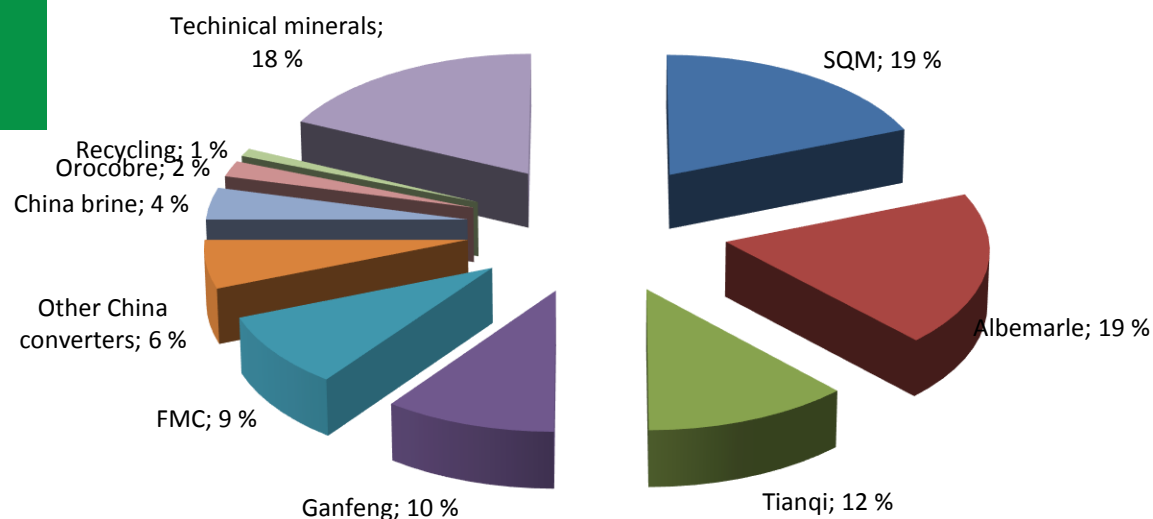
Global refined lithium production

Refined lithium output by producer 2016

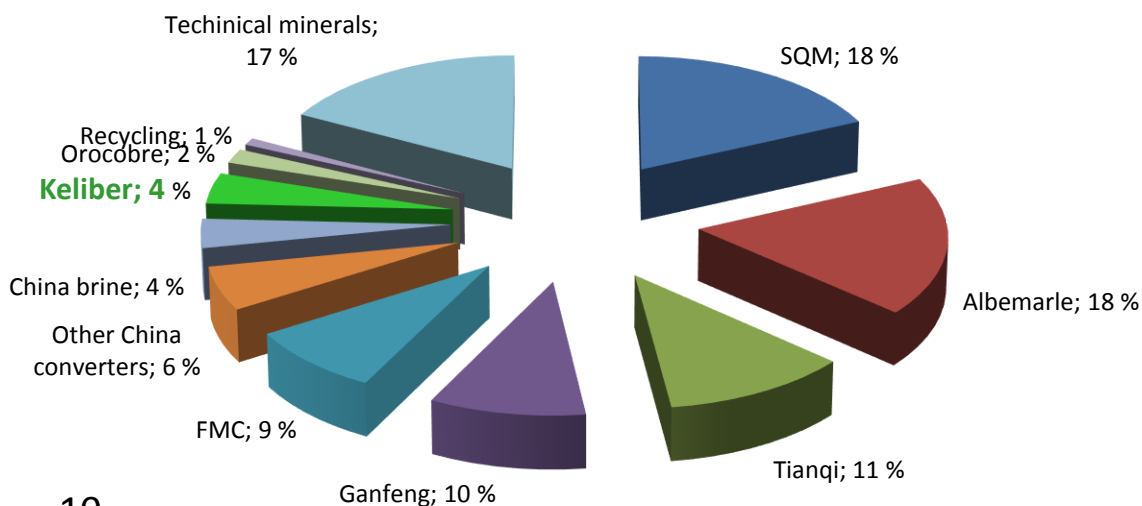
Total output of refined products in 2016 was just over 211,200t LCE

- Brine-based 55% of total supply
- Mineral conversion 26%
- Technical-grade minerals 18%
- Recycled material 1%

Refined lithium output by producer 2016 (%)



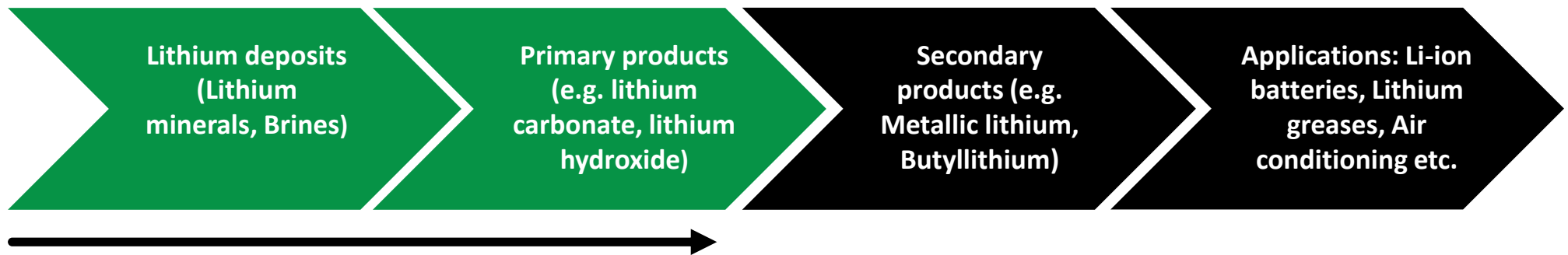
Keliber's future production compared to refined lithium output in 2016 (%)



Keliber as a European producer

Key strengths

- Definitive Feasibility Study on-going –project is in excellent development phase for the global, growing markets
- Geographical location offers stable regulatory environment and excellent infrastructure with a strong existing logistics chain
- Selected production process technology secures supply reliability, high-quality end-product and environmentally sound operations
- High potential for growing mineral resources and ore reserves in the future
- Chosen strategy enables optimization of production and gives a strong position in the lithium value chain



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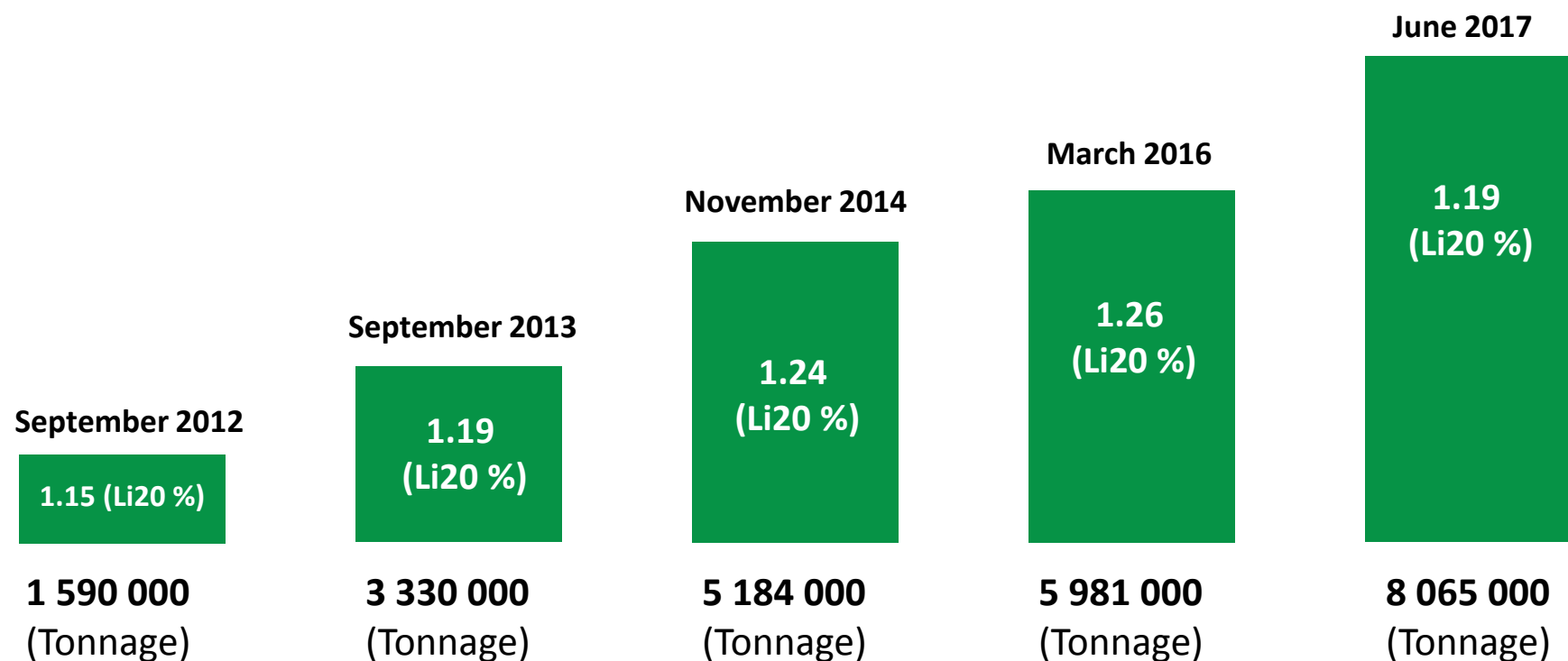
Growing resources and high exploration potential



Development of mineral resources

Sufficient for production of 9 000 tons of lithium carbonate per annum for +10 years

Mineral Resources (0.5 % Li₂O cut-off)

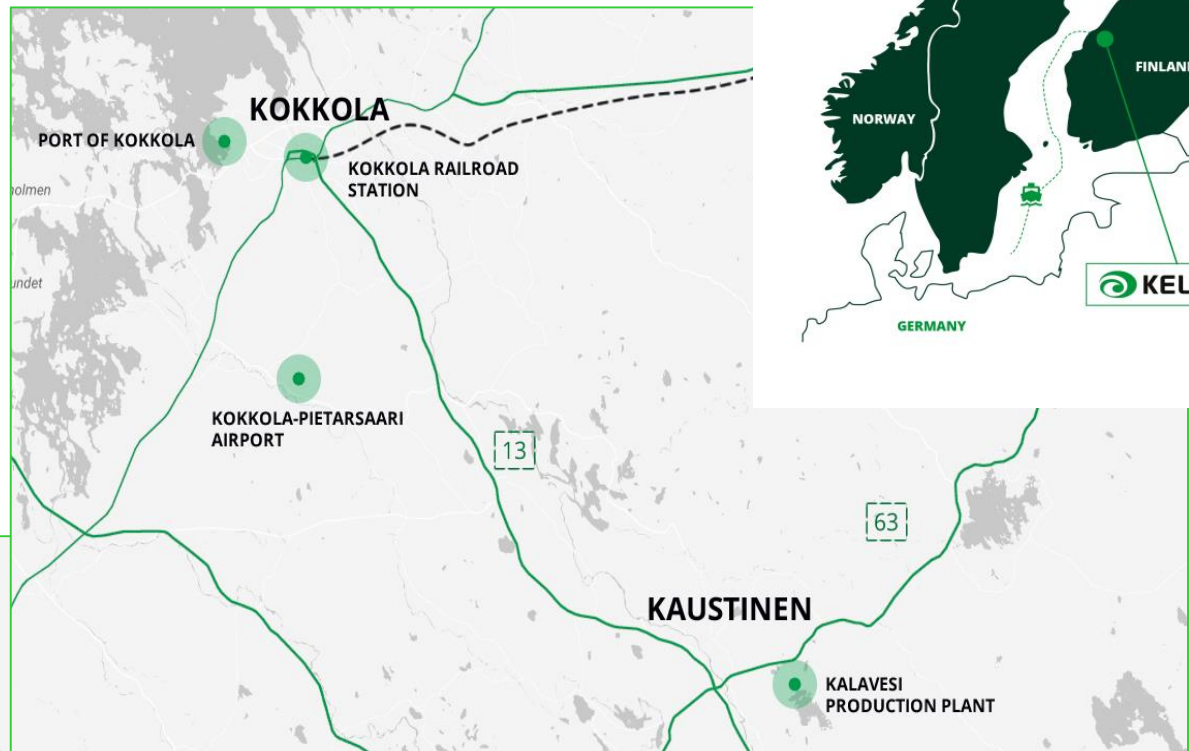


Estimates prepared by Competent Persons in accordance with 2012 JORC code

Excellent exploration potential

One of the most significant lithium-bearing areas in Europe

- The lithium-rich province of Central Ostrobothnia covers over 500 sq. km
- A number of unexplored areas and excellent potential for further discoveries



- More than 1 400 erratic boulders in the area

From ore reserves to high quality product



Growing reserves

Latest estimate of mineral resources and ore reserves (million metric tonnes)							
Mt	Länttä	Syväjärvi	Outovesi	Rapasaari	Leviäkangas	Emmes	Total
RESOURCES (June 2017)							
Measured	0.437	0.810	-	-	-	-	1.247
Indicated	0.910	1.160	0.283	3.456	0.190	0.820	6.818
Total	1.347	1.970	0.283	3.456	0.190	0.820	8.065
<i>Ore grade (Li20 %)</i>	<i>1.06</i>	<i>1.24</i>	<i>1.43</i>	<i>1.15</i>	<i>1.14</i>	<i>1.40</i>	<i>1.19</i>
<i>Inferred</i>	-	-	-	-	0.300	-	
RESERVES (March 2016)							
<i>Proven</i>	<i>0.470</i>	-	-	-	-	-	<i>0.470</i>
<i>Probable</i>	<i>0.540</i>	<i>1.480</i>	<i>0.250</i>	<i>1.750</i>	-	-	<i>4.020</i>
Total	1.010	1.480	0.250	1.750	-	-	4.490
<i>Ore grade (Li20 %)</i>	<i>0.94</i>	<i>1.19</i>	<i>1.20</i>	<i>1.09</i>	-	-	<i>1.10</i>

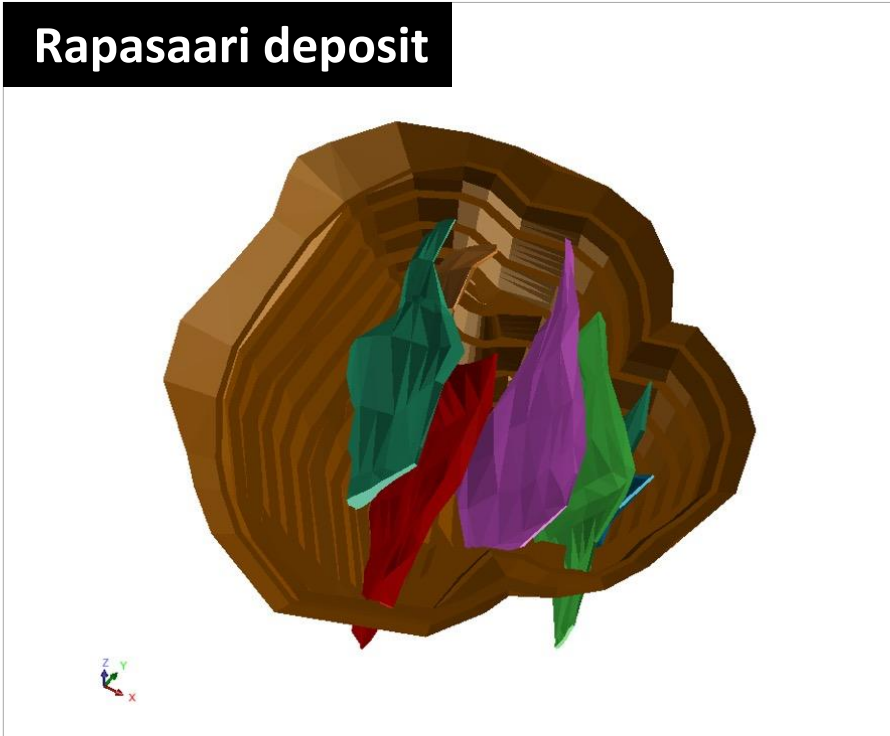
Ore reserves are included in the Mineral Resources

Estimates prepared by Competent Persons in accordance with 2012 JORC code

Sizeable deposits

Significant upside potential

Rapasaari deposit



Rapasaari deposit - consists of several pegmatite veins -thickness of the veins varies from a few meters to tens of meters

Syväjärvi deposit



Syväjärvi deposit -consists of a main vein, which is divided into two separate pegmatite veins in places - also parallel veins exists -the maximum thickness of the main vein is about 30 meters

Favourable mineralogy

- Host rock of lithium ore is spodumene pegmatite. Spodumene is comprising on average 18 weight % in modal abundance
- Spodumene is favorable mineral (high in lithium, no harmful elements, easy to concentrate)
- Main gangue minerals: Albite, Quartz, Potassium feldspar, Muscovite
- Only rarely negligible amount of sulphide minerals, e.g. sphalerite, chalcopyrite, pyrite, pyrrhotite, galena
- Low heavy metal contents, very low grades of minerals having acid generation potential





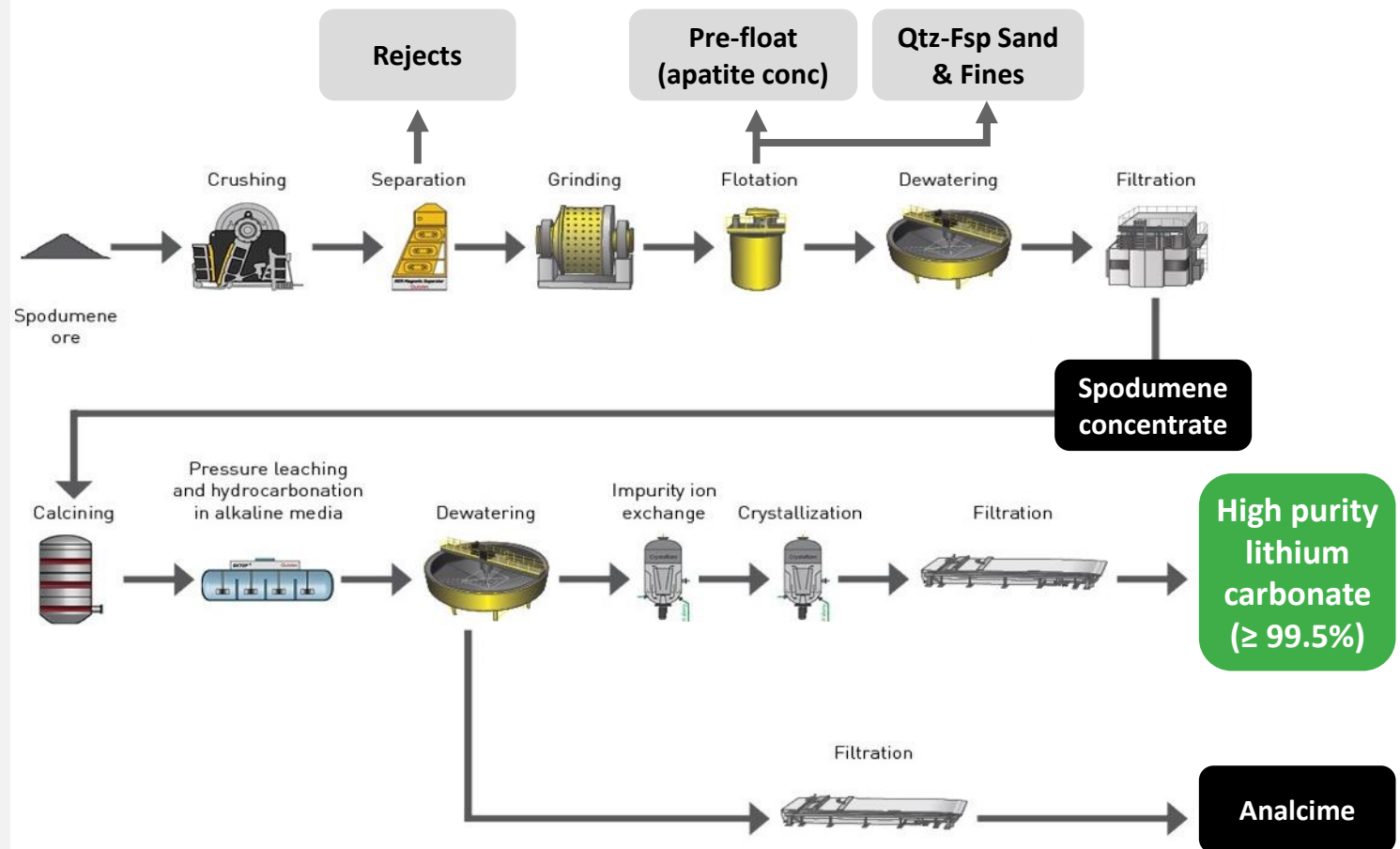
Role of Innovation and Technology

Clean tech process

Efficient and environmentally sound production of high purity lithium carbonate

Soda leaching process developed together with Outotec

- Optical sorting
- Valuable by-products: Analcime and quartz-feldspar sand
- Concentrate grade optimization
- Flexible and environment-friendly soda leaching
- Tailings with no heavy metals nor acid generating minerals



Extensive experimental testing

From Ore Sorting via Flotation and Calcination to Hydro Process

High Technology Partners

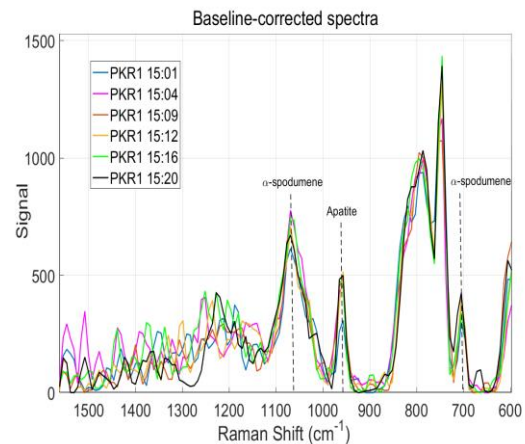
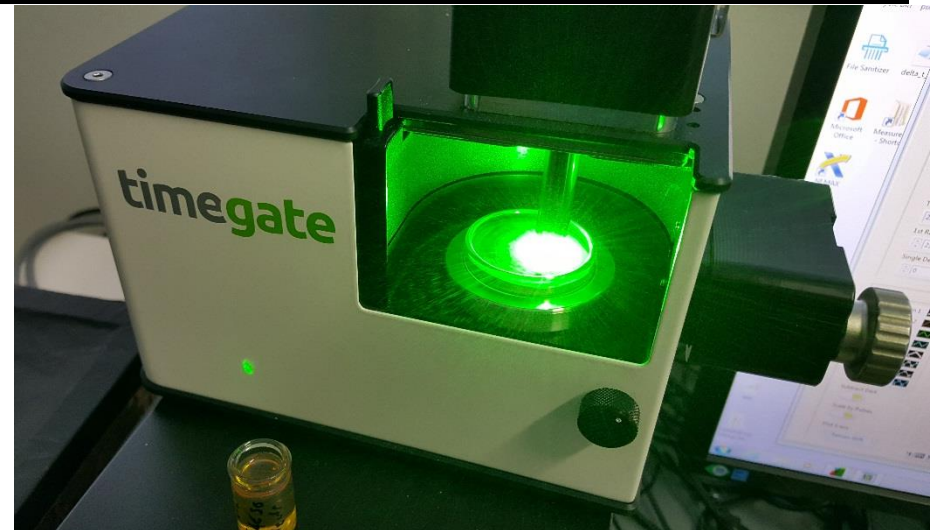


Novel On-Line Analysis Techniques

Ensuring efficient and sustainable production

Patented Timegated® Raman technology for On-line Mineral Analysis

- Inelastic light scattering, i.e. Raman scattering is very powerful optical technique for material identification and quantification
- Mineral specific information can be gathered through pulsed laser source, fast SPAD detector and 100 pico second time resolution
- Gives quantitative analysis of spodumene (alpha; beta), apatite etc.

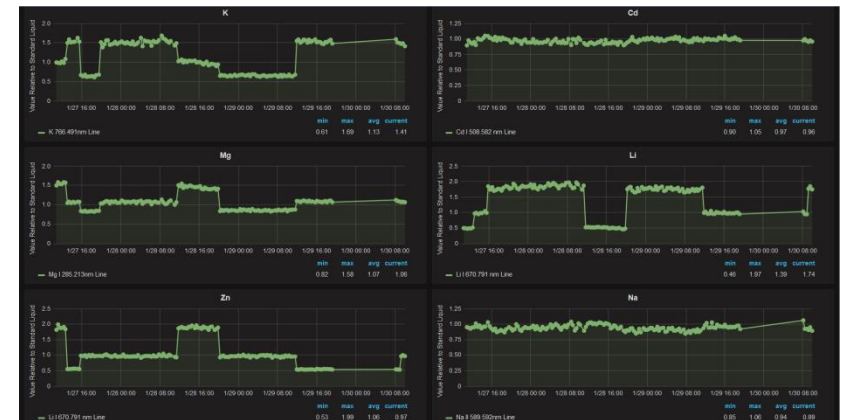
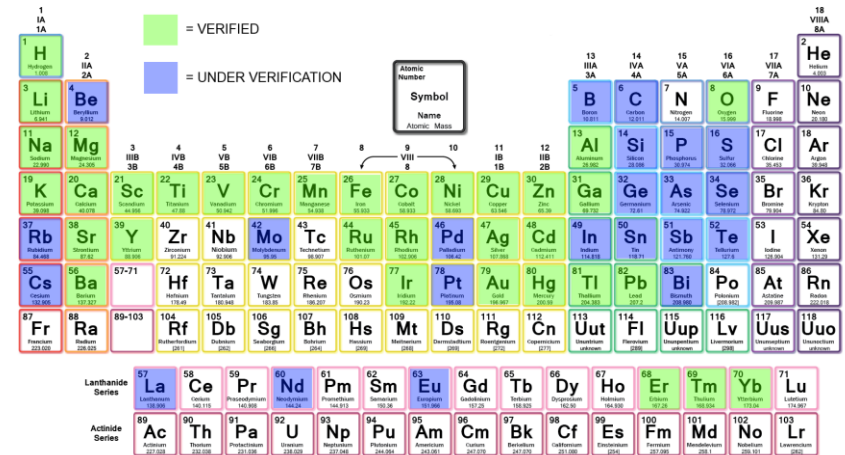


Novel On-Line Analysis Techniques

Ensuring efficient and sustainable production

Plasma-based technology for simultaneous real-time multi-element analytics of liquids

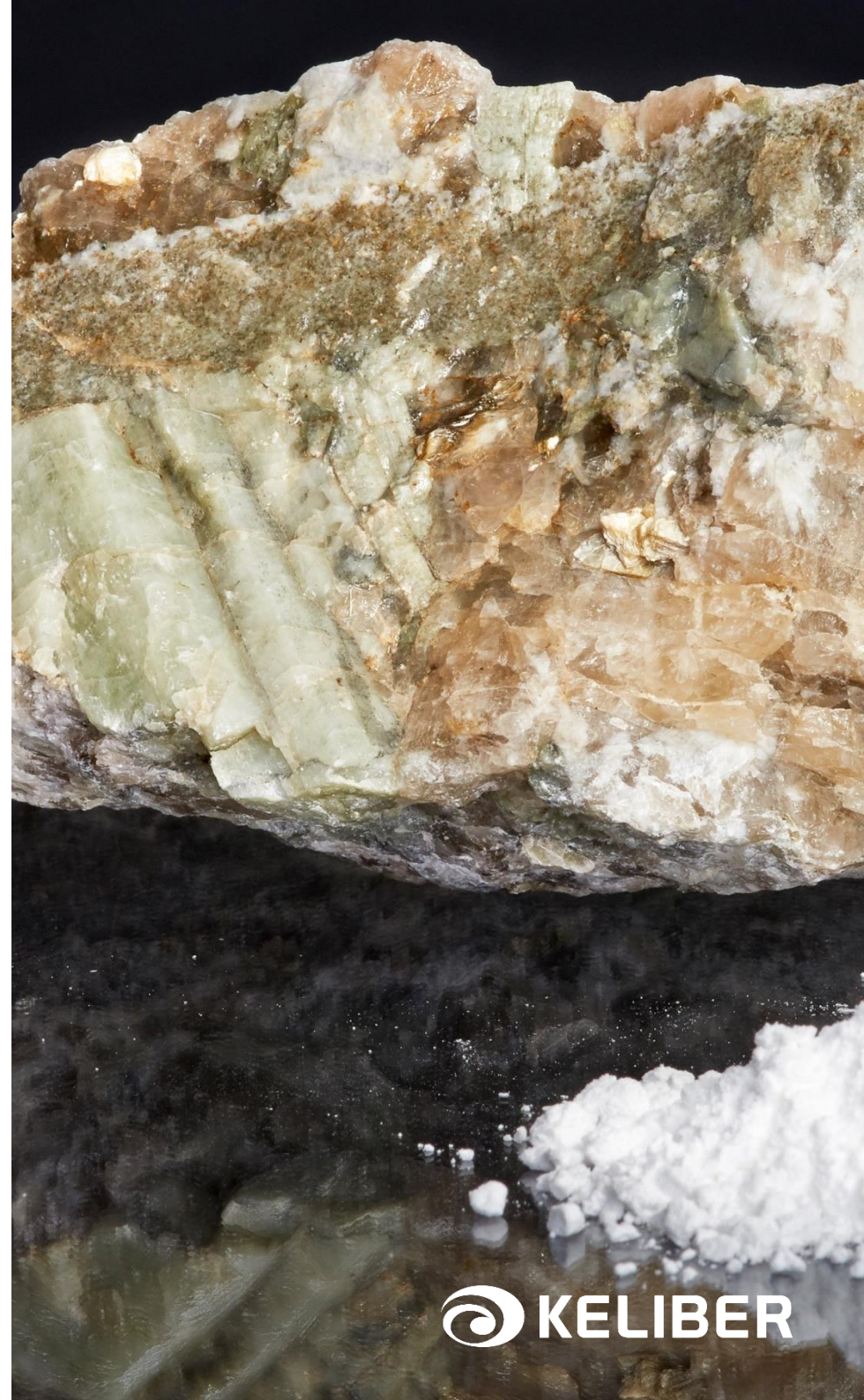
- Breakthrough measurement technology for real-time analysis of 20+ elements in process waters
- Robust, field-proven and requires no expensive consumables
- 24/7 real-time process optimisation



Battery-grade lithium carbonate

9 000 tonnes per year

- Battery grade lithium carbonate (Li_2CO_3 min. 99.5 %) can be used in the manufacturing of batteries intended for
 - portable electronics,
 - electric tools,
 - electric means of transport
- Lithium carbonate from Länttä spodumene pegmatite ore test program
 - 99,61- 99.91 % Li_2CO_3
- Lithium carbonate from Syväjärvi spodumene pegmatite ore test program
 - 99,5 % Li_2CO_3



Potential by-products

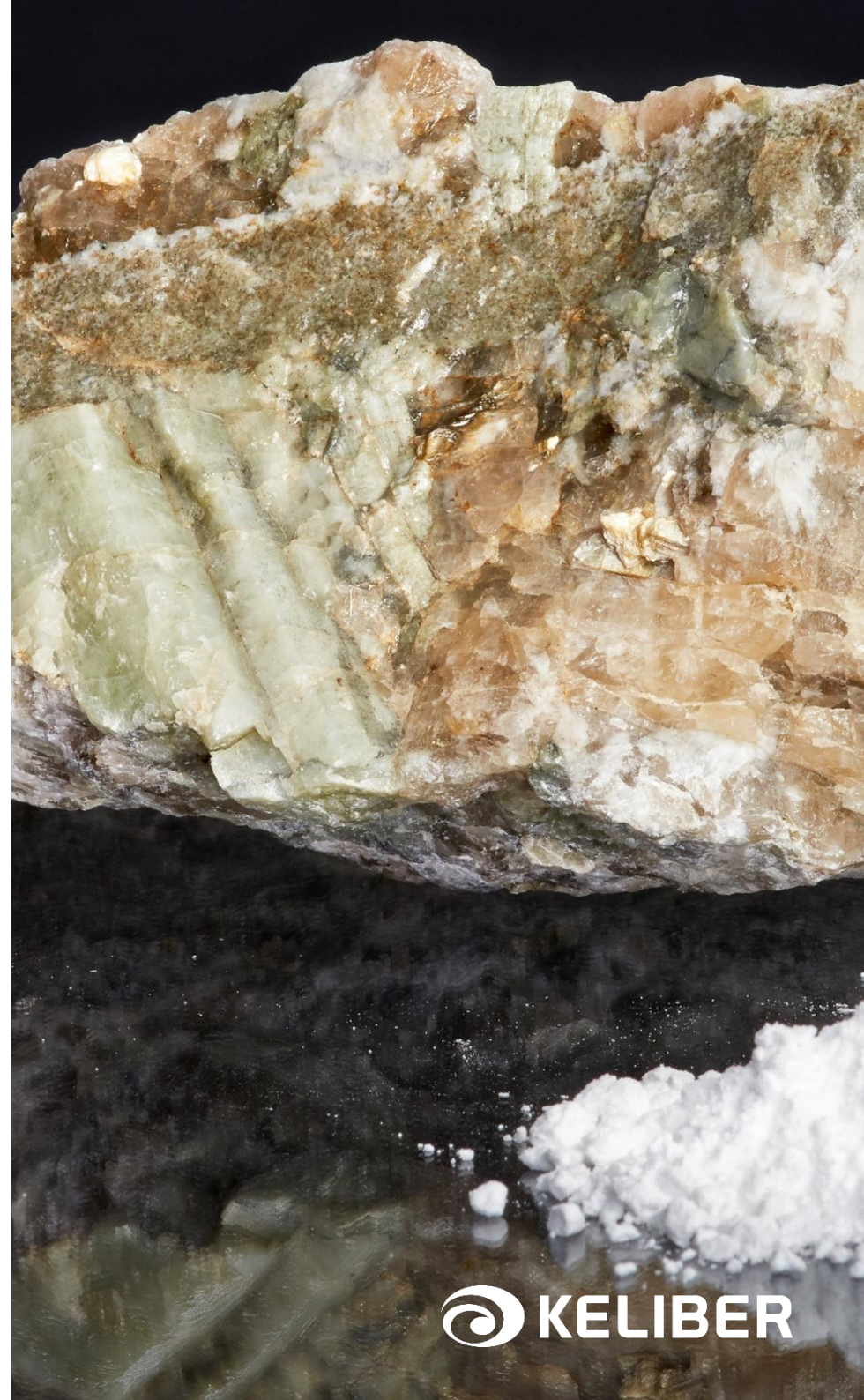
Analcime and Quartz-feldspar

Analcime is a porous zeolite with a number of potential industrial uses

- a molecular sieve
- an agent in the manufacture of cement, concrete, ceramic tiles and asphalt

Fine-grained quartz feldspar sand

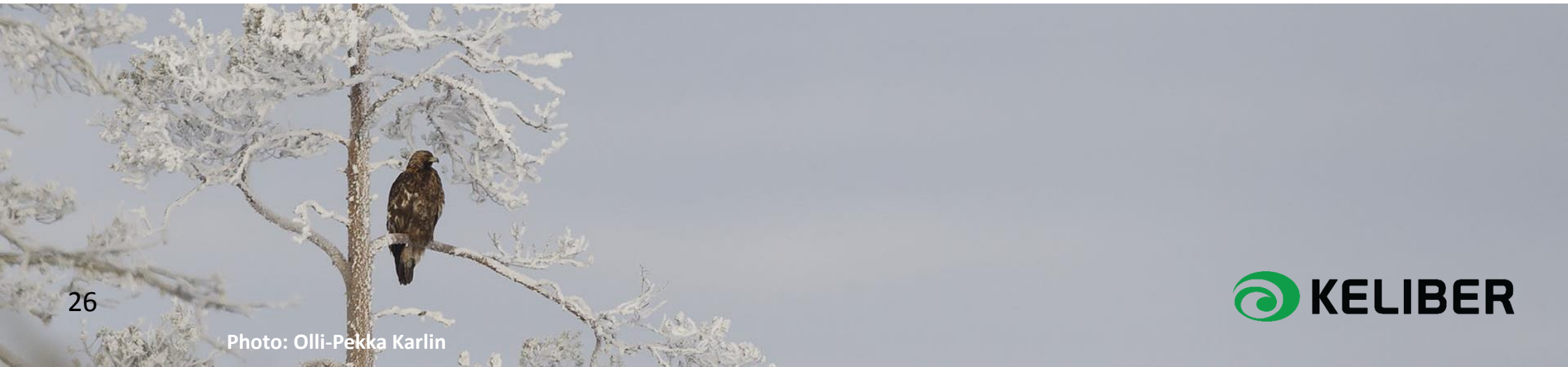
- various uses as a filler, in for instance, asphalt coatings



Strong commitment to sustainability

Sustainable production process and proactive environmental actions

- Production process designed to be efficient and environmentally friendly simultaneously enabling superior quality end-product
 - Optical sorting reduces the amount of waste rock going through the process
 - Hydrometallurgical leaching is conducted with soda -an environmentally neutral alternative to sulphuric acid typically used in hard rock lithium production
 - Production process designed to exploit the potential of the possible future by-products
- Proactive environmental actions e.g. protection of moor frogs and golden eagle
- Committed to transparent communication with surrounding community and society at large
- Keliber is a member of the Finnish Network for Sustainable Mining



An aerial photograph of a mining or construction site. The central area is a large, flat, gravel-covered processing zone. Several pieces of heavy machinery are visible, including a red truck, a yellow excavator, and a yellow loader. A long conveyor belt system runs across the site, transporting material from the processing area towards the right. The site is bordered by dense green forest on the top and bottom edges. The text "From a project to production" is overlaid in white on the left side of the image.

From a project to production

Way to production

Definitive feasibility study and preparation for production

Tentative timeline for the next stages	2017	2018	2019	2020
Permitting (environmental, mining and other)		October 2017 – April 2018		
Basic Engineering		October 2017 – April 2018		
Detailed Engineering		May 2018 – March 2019		
Main equipment purchases		June 2018 – September 2018		
Start of Earth works		September 2018		
Civil construction	September 2018 – 2019			
Main Equipment Installation		May 2019 – January 2018		
Commissioning and testing		January 2020 – May 2020		

Production estimated to start 2020

Committed and skillfull management

Management team

Pertti Lamberg



- CEO since 2016
- Chair of the management team

Jaakko Vilponen



- Chief Financial Officer since 2016

Manu Myllymäki



- Chief Production Officer since 2017

Pentti Grönholm



- Chief Geologist since 2017

Olle Sirén



- COO since 2016
- Member of the board since 2016

Kari Wiikinkoski



- Environmental Manager since 2012

Jarmo Finnilä



- Communication and Administration Manager since 2013

Finnish majority ownership

Largest shareholders

- The company is owned by Finnish investment companies, private investors and the Norwegian Nordic Mining ASA

	Total number of shares	Percentage
Nordic Mining ASA	239,044	22.1
Tesi Industrial Management Oy	190,662	17.6
Ab Mine Invest Oy	97,527	9.0
Keskinäinen Eläkevakuutusyhtiö Ilmarinen	70,929	6.6
Thominvest Oy	68,683	6.4
Jorma Takanen	63,123	5.8
Osuuskunta PPO	60,000	5.6
Case Invest Oy	59,547	5.5
Jussi Capital Oy	35,010	3.2
Eero Halonen	20,000	1.9

Current activity

- Additional process test work to reconfirm recent positive results in minerals processing tests
- Additional drilling to further increase of the resource base
- Trade-off study of location of the lithium carbonate plant between Kalavesi Kaustinen and Kokkola Industrial Park (KIP)
- Preparation of the Environmental Impact Assessments (EIA)
- Preparations for the environmental and other permits
- Negotiations with potential clients to obtain end-product supply agreements
- Preparations related to the investment phase financing
- Finalizing the DFS report



Project in a nutshell

Lithium carbonate production with high value creation potential

1 Innovative clean tech process

- Efficient and environmentally sound production
- Potential for recovery of valuable by-products

2 Production of high purity lithium carbonate

- 9 000 tonnes of lithium carbonate per annum for +10 years
- Attractive market driven by Electric Vehicle industry

3 Position in the lithium value chain

- Production strategy enables competitive advantage in the lithium value chain

4 Growing resources

- Deposits located in one of the most significant lithium-bearing areas in Europe
- Significant upside potential

KELIBER – Lithium Mining for fast Growing Markets

