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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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

Source: Roskill Consulting Group Ltd, 2017
Increase in demand for lithium
Price forecast for battery-grade lithium carbonate

- 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 worldwide in 2017
- US$10 000/t is expected to be the new floor in the base-case scenario for battery grade lithium carbonate

Source: Roskill Consulting Group Ltd, 2017

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

<table>
<thead>
<tr>
<th>Product</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile phone</td>
<td>1 – 3 g</td>
</tr>
<tr>
<td>Smartphone</td>
<td>2 – 3 g</td>
</tr>
<tr>
<td>Tablet</td>
<td>20 – 30 g</td>
</tr>
<tr>
<td>Laptop</td>
<td>30 – 40 g</td>
</tr>
<tr>
<td>Power tool</td>
<td>40 – 60 g</td>
</tr>
<tr>
<td>Hybrid vehicle – Plug-in</td>
<td>1.6 – 12 kg</td>
</tr>
<tr>
<td>Electric vehicle</td>
<td>15 – 50 kg</td>
</tr>
</tbody>
</table>

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

Source: https://electrek.co/2016/11/01/breakdown-raw-materials-tesla-batteries-possible-bottleneck/
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).

Source: Benchmark Mineral Intelligence, 2017
Global mine production of lithium

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

Source: Roskill Consulting Group Ltd, 2017
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%

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

Refined lithium output by producer 2016 (%)

Source: Roskill Consulting Group Ltd 2017
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

**Lithium deposits** (Lithium minerals, Brines)  
**Primary products** (e.g. lithium carbonate, lithium hydroxide)  
**Secondary products** (e.g. Metallic lithium, Butyllithium)  
**Applications**: Li-ion batteries, Lithium greases, Air conditioning etc.
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)

<table>
<thead>
<tr>
<th>Date</th>
<th>Tonnage (T)</th>
<th>Li2O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2012</td>
<td>1,590,000</td>
<td>1.15</td>
</tr>
<tr>
<td>September 2013</td>
<td>3,330,000</td>
<td>1.19</td>
</tr>
<tr>
<td>November 2014</td>
<td>5,184,000</td>
<td>1.24</td>
</tr>
<tr>
<td>March 2016</td>
<td>5,981,000</td>
<td>1.26</td>
</tr>
<tr>
<td>June 2017</td>
<td>8,065,000</td>
<td>1.19</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Mt</th>
<th>Länttä</th>
<th>Syväjärvi</th>
<th>Outovesi</th>
<th>Rapasaari</th>
<th>Leviäkangas</th>
<th>Emmes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESOURCES (June 2017)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured</td>
<td>0.437</td>
<td>0.810</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.247</td>
</tr>
<tr>
<td>Indicated</td>
<td>0.910</td>
<td>1.160</td>
<td>0.283</td>
<td>3.456</td>
<td>0.190</td>
<td>0.820</td>
<td>6.818</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1.347</td>
<td>1.970</td>
<td>0.283</td>
<td>3.456</td>
<td>0.190</td>
<td>0.820</td>
<td>8.065</td>
</tr>
<tr>
<td><strong>Ore grade (Li20 %)</strong></td>
<td>1.06</td>
<td>1.24</td>
<td>1.43</td>
<td>1.15</td>
<td>1.14</td>
<td>1.40</td>
<td>1.19</td>
</tr>
<tr>
<td><strong>Inferred</strong></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.300</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>RESERVES (March 2016)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proven</td>
<td>0.470</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.470</td>
</tr>
<tr>
<td>Probable</td>
<td>0.540</td>
<td>1.480</td>
<td>0.250</td>
<td>1.750</td>
<td>-</td>
<td>-</td>
<td>4.020</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1.010</td>
<td>1.480</td>
<td>0.250</td>
<td>1.750</td>
<td>-</td>
<td>-</td>
<td>4.490</td>
</tr>
<tr>
<td><strong>Ore grade (Li20 %)</strong></td>
<td>0.94</td>
<td>1.19</td>
<td>1.20</td>
<td>1.09</td>
<td>-</td>
<td>-</td>
<td>1.10</td>
</tr>
</tbody>
</table>

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

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

17 Note: Different colors in models used to distinguish separate spodumene pegmatite veins
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

High purity lithium carbonate (≥ 99.5%)
Extensive experimental testing
From Ore Sorting via Flotation and Calcination to Hydro Process

High Technology Partners

[Images of industrial equipment and personnel]
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.

www.timegate.com
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

www.sensmet.com
Battery-grade lithium carbonate

9 000 tonnes per year

- Battery grade lithium carbonate ($\text{Li}_2\text{CO}_3$ 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 % Li2CO3
- Lithium carbonate from Syväjärvi spodumene pegmatite ore test program
  - 99,5 % Li2CO3
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
From a project to production
# Way to production

Definitive feasibility study and preparation for production

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

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

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