Lithium

Lithium: Boom or bubble? Projected demand sends prices skyrocketing

by Chee Theng, Technical Editor

Figure 1

700

600

600

400

300

100

Production (Nons LCE)

200

Electric cars have been stirring up a storm for lithium. Prices of the mineral, which is an essential component of the lithium-ion batteries that power electric cars like Teslas, have been rising to stratopheric heights since October 2015 amid the prospect of widespread mass production of fully electric cars, each requiring some 21.4 kg (47 lb) of lithium carbonate equivalent in their batteries. Is the price boom

Lithium supply growth forecast, 2017-2020: Orange bars denote brines, blue bars

denote hard-rock deposits. (Courtesy of SRK Consulting)

Cortegoso pointed out that the total number of lithium projects and operations worldwide was around 450 — and growing — on the morning of his talk on "Lithium supply and market: Past, present and future" at the American Exploration & Mining Association (AEMA) Annual Meeting in Sparks, NV, on Dec. 7, 2017. Only 3.5 percent of these are actually operating, he said, with 2.7 percent in construction, 8.6 percent in feasibility

> study, 35.8 percent in exploration and 49.4 percent at the grassroots stage (Fig. 2).

"There are many projects trying to make it happen, and only a few will become reality," said Cortegoso. He sees a lithium rush with many project owners and developers focusing solely on demand while ignoring the supply side of the equation and the existence of an expanding supply side without substantial barriers to entry. A key determinant of who will make it and who will not would be how the lithium is extracted and how much is the operating cost. Technological innovations exist that could potentially halve costs and boost the reserve base. "It's a matter of

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sustainable, or is it a bubble? The answer may be a bit of both.

"Lithium is not rare — it is abundant, it's out there," said Pablo Cortegoso, consultant for lithium projects development at SRK Consulting. "There is a pricing bubble — hang tight. Oversupply may happen in the short term, but future demand will balance the lithium market. It will even out, just be patient."

Cortegoso noted that supply, currently standing at around 200 kt/a (220,000 stpy) of lithium carbonate equivalent, mainly from brines and hard rock, is growing steadily, with many projects coming online, and SRK forecasts total production capacity could reach between 500 and 650 kt/a (551,000 and 716,500 stpy) in 2020 (Fig. 1). He assessed that there can be a small dip, but prices will continue to rise again as supply and demand adjust, with the market balancing out within the next five to 10 years.

Lithium rush

In response to the steep climb in prices, lithium projects have been proliferating.

who can get the right process and be out the door first," he said. "Lithium demand is growing, and we'll need it right now."

Executive order signed

600-660

2020 Supply

The urgency is being stepped up a notch. As one of the 23 critical minerals covered by the U.S. Geological Survey (USGS) in its 2017 report on "Critical mineral resources of the United States — Economic and environmental geology and prospects for future supply," lithium will fall under an executive order signed by President Donald Trump on Dec. 20, 2017, containing a directive for a report that includes (1) a strategy to reduce the country's reliance on critical minerals, (2) a plan to improve the topographic, geologic and geophysical mapping of the United States and make the resulting data and metadata electronically accessible to support private-sector mineral exploration of critical minerals and (3) recommendations to streamline permitting and review processes related to developing leases, enhancing access to critical mineral resources and increasing the



Figure 2

Lithium projects and operations, categorized according to operating and development stages. (Courtesy of SRK Consulting)

discovery, production and domestic refining of critical minerals.

Uses, recycling and production of lithium

Although rechargeable batteries for cars have taken the spotlight recently, it was only in 2016 that the lithium market share of lithiumion batteries exceeded that of ceramics/glass, at 39 percent and 24 percent, respectively, said Catherine Hickson, director and chief operating officer of Dajin Resources Corp. Lubricants accounted for 12 percent, medical for 5 percent, polymers and refrigeration for 4 percent each, metallurgy for 3 percent and other applications for 9 percent. Lithium's applications include lithium aluminum alloys, which are lightweight materials used in the aerospace industry and vehicles like the Ford F-150, and grease and drilling muds.

Car batteries are now turbocharging the demand for lithium, with as many as 14 mega and gigafactories reported as being constructed in China, Hickson said, and the worldwide capacity of lithium cells and batteries is expected to triple by 2020.

Lithium is extracted from brines pumped from beneath arid sedimentary basins and from granitic pegmatite ores. According to the USGS, Chile is the lead country for brine production and Australia the lead country for pegmatite production. Clays, geothermal brines, oilfield brines and zeolites are other potential sources. Recycling is a promising additional supply source — with lithium having the advantage of being able to be recycled indefinitely, unlike oil, which can only be used once — but it is not economic as yet. Hickson noted that lithium recycling is projected to account for only 9 percent of demand by 2025, and the lithium-ion batteries in electric vehicles can last from five to 20 years.

The world's four main producers are SQM, Albemarle Corp., FMC Lithium and Talisom Lithium. SQM's production from brines in Chile has the lowest operating cost at \$3,000/t (\$2,720/st), followed closely by Albemarle's production from brines, also in Chile, at slightly above SQM's. "Brines are historically cheaper to produce from than hard-rock sources," said Hickson. Typically, the cost of lithium extraction from brines, which traditionally uses evaporation ponds, is about half that of hard-rock mining.

New technologies are coming online that can create high-purity results in a few days, eliminate the use of evaporation ponds, reinject the spent brine and are more environmentally friendly overall, Hickson said. As an example, she pointed to Enirgi Group's Direct Xtraction Technology process (DXP),



Operating Construction = Feasibility Deploration Grassroots

which produces lithium carbonate directly from raw, unconcentrated brine in less than 24 hours without requiring a network of solar evaporation ponds. Dajin, which holds two key U.S. exploration projects in Teels Marsh valley and Alkali Lake valley in Nevada, has been reviewing various technological processes that use a range of techniques to extract and purify the lithium. "So far, it seems that Enirgi's DXP process is the only one with a demonstration size plant directly scalable to a large-scale commercial production facility," Hickson said.

Types and locations of lithium deposits

According to the USGS, present and potential sources of lithium in the world can be broken down into closed-basin brines, 58 percent; pegmatites, including lithium-enriched granites, 26 percent; lithium-clays, or hectorite, 7 percent; and oilfield brines, geothermal brines and lithium-zeolites, or jadarite, 3 percent each (Figs. 3 and 4).

Figure 3

World map showing locations of selected lithium-cesium-tantalum (LCT) pegmatites and lithium granites. (Source: U.S. Geological Survey)



Lithium

Figure 4

World map showing locations of selected closed-basin lithium-brine, lithium-enriched oilfield brine, geothermal brine, lithium-clay and lithium-zeolite deposits. (Source: U.S. Geological Survey)



Role of Nevada

Nevada is the only source of domestic lithium production, with value totaling to \$23 million in 2016, according to the Nevada Bureau of Mines and Geology. The bureau reported that placer claims for lithium accounted for 46 percent of the 19,039 new claims staked in 2016 in the state, mostly near Clayton Valley in the southwestern sector, and that several projects were drilled in the past two years by junior companies.

"Only one operating lithium brine mine exists in the United States, and it is in Nevada," said Hickson. Developed in 1966 by Foote Mineral Co., the Rockwood Silver Peak lithium brine mine in Clayton Valley is now owned by Albemarle and has formed a nucleus for exploration efforts.

Hickson delved into the question "Do

Figure 5

Plots of lithium grade and tonnage for selected world deposits. (Source: U.S. Geological Survey)



geothermal systems play a role in lithium brine enrichment in Nevada playas?" at the AEMA meeting. She said that, in general, lithium brine deposits have the prerequisites of (1) a source of lithium, (2) an extraction mechanism, (3) a transport mechanism, (4) a trap such as a closed basin, (5) a suitable solar evaporation rate and (6) scale in terms of mass flux of lithium and limited dissolved salt competition. "The basins of western Nevada have many of these prerequisites but are dominated by clastic sediments and have relatively high subsidence and sedimentation rates. For these reasons, it is likely that lithiumenriched brines are deeper than in the mature basins of South America," she said.

Lithium clay deposits

Tom Benson, who spoke at the AEMA meeting on "Li enrichment in intracontinental rhyolite magmas leads to large Li clay deposits in caldera basins," said lake sediments preserved within intracontinental rhyolitic calderas formed on the eruption and weathering of lithiumenriched magmas have the potential to host large lithium clay deposits.

As a researcher in the Department of Geological Sciences in Stanford University, he and his coworkers compared lithium concentrations of magmas formed in various tectonic settings using in situ trace-element measurements of quartz-hosted melt inclusions to demonstrate that moderate to extreme lithium enrichment occurs in magmas that incorporate felsic continental crust.

"Cenozoic calderas in western North America and in other intracontinental settings that generated such magmas are promising new targets for lithium exploration because lithium leached from the eruptive products by meteoric and hydrothermal fluids becomes concentrated in

> clays within caldera lake sediments to potentially economically extractable levels," said Benson.

Reserves and resources

The USGS reported that global lithium resources now total more than 39 Mt (43 million st), which is nearly 3,000 times current annual production. The plots of grade versus tonnage shown in Fig. 5 give an indication of the sizes of deposits that might remain to be found. With the potentially huge lithium battery market for hybrid and electric vehicles, more exploration is taking place, and new deposits will likely be discovered, the agency said. ■