How big is the lithium market in Brazil?

Coordination for Mineral Processing, Centre for Mineral Technology (CETEM), Rio de Janeiro-RJ, Brazil

ABSTRACT

Lithium is the lightest of the metals, with high reactivity and great electrochemical potential. It has a low thermal expansion coefficient and high caloric value, and it forms very light and resistant aluminium alloys. These properties make lithium an attractive element for use in battery manufacture and glass and ceramics production, in addition to its applications in the aeronautic industry.

Today, two sources of raw material are economically viable for lithium production: pegmatite rocks and brine. The world production, in 2012, was approximately 150,000 tons of LCE (lithium carbonate equivalent), almost triple the production in 2000. The forecasted consumption for the current year, 2013, was approximately 162,000 tons of LCE, and for 2020, it could be as much as 280,000 tons of LCE, stimulated essentially by the growth of world production of electric (EV), hybrid (HEV) and hybrid plug-in vehicles (PHEV), the batteries of which are based on Li-ions.

With the growth of world demand and increasing prices, lithium minerals such as spodumene, petalite and amblygonite, once considered uneconomical for the production of lithium carbonate, are regaining their economic value. New projects to produce lithium compounds based on mineral sources are being developed in many countries, aiming to produce battery-grade lithium carbonate (99.95% Li₂CO₃).

Although Brazil has large lithium pegmatite reserves, the domestic production of lithium carbonate and hydroxide is very low, at approximately 600 tons of LCE, which represents 0.4% of the world production. The application of these products is mostly in the grease and ceramic industries. The national lithium market is under government protection due to its potential use for nuclear purposes. Thus, the industrialization activities and import and export of ores and lithium minerals, as well as organic and inorganic products, such as metallic lithium and lithium alloys, are controlled by the National Commission for Nuclear Energy (Comissão Nacional de Energia Nuclear - CNEN).

The objectives of this work to quantify the real lithium demand in the Brazilian market, considering that a large amount of lithium is indirectly imported in the form of the Li-ion batteries used in equipment such as mobile phones, cameras, tablets, notebooks and e-bikes, and to compare this demand with the current national production of LCE. Finally, some technological alternatives will be discussed, with the aim of increasing the competitiveness of the lithium industry in Brazil.
INTRODUCTION

Lithium does not occur as a pure element in nature, but it is found in minerals (pegmatites), salts (evaporites), clay deposits (hectorites) and seawater. Its concentration in the earth’s crust is low (0.004%), and few lithium resources can be economically exploited.

Although lithium is rare in nature, its physico-chemical properties, such as its low thermal expansion coefficient, high electro-chemical potential, low density and high caloric power, make it difficult to substitute.

The world’s demand for lithium has continued to grow, despite the global economic crisis, the high indebtedness of many European countries and the slowing of Chinese domestic production in recent years. Rechargeable (secondary) lithium batteries are the main drivers of this above-average growth, a result of the widespread use of lithium batteries in portable electronic products and the increases in the capacity and durability of these batteries.

Lithium’s unique properties are also stimulating the growth of other market segments, for example, grease and lubricants, glass and ceramics, primary batteries and the post-metallurgy sector.

Lithium consumption has already surpassed 2008 levels and had exceeded 150,000 t of LCE (lithium carbonate equivalent) in 2012. Demand is expected to continue to grow at approximately 8% p.a. under the current conditions, with electric vehicles (EVs) representing a dominant share of the market by the end of the decade. Global lithium consumption is predicted to reach approximately 300,000 t of LCE by 2020 (Roskill, 2013).

In light of these developments, in 2010, the Brazilian government created the Interministerial Work Group on Strategic Minerals, consisting of the Ministry of Science, Technology and Innovation (MCTI – Ministério da Ciência Tecnologia e Inovação) and the Ministry of Mines and Energy (MME – Ministério das Minas e Energia), to develop proposals for the integration, coordination and improvement of policies, directives and actions pertaining to ores and minerals containing rare earth minerals, lithium, agrominerals and other minerals that are seen as vital for eventual use by National Power and that are required for most advanced technologies.

The CETEM, a research unit within the MCTI, has conducted studies of technologies that can be used to exploit national lithium resources and the market dynamics of lithium-based products, especially in the lithium-ion-based battery and accumulator segments, seeking to increase the competitiveness and visibility of the national market.

METHODOLOGY

Data on national and international production were obtained from documentary research in publications that specialize in the subject, with the aid of companies and Brazilian government Websites, particularly those of the MCTI and MME.

Data on lithium-ion battery imports were obtained from COMTRADE sites (United Nations Commodity) and from the Alice System of the MDIC, Brazil.

Assessments of the distribution of lithium compounds in the industrial sector were based on
information from the Brazilian Industrial Chemistry Association's Annual Report (Anuário da ABIQUIM - Associação Brasileira da Indústria Química).

The USGS (United States Geological Survey) Website was used to obtain data on global lithium resources and reserves.

RESULTS AND DISCUSSION

Global lithium overview

Resources and reserves

Although lithium is not among the 14 raw materials considered critical by the European Commission for Enterprise and Industry of the European Union, it is mentioned on the list of strategic critical materials of the United States Department of Energy. The USGS reports that total lithium resources amount to 40 Mt, of which 13 Mt are considered reserves.

Lithium resources are found in mineral brines (62%), pegmatite minerals (23%), geothermal brines (3%), the pre-salt layer (3%), jadarite minerals (3%) and lithium-rich hectorite clay (3%) (Smith, 2011).

South America has almost 60% of the world’s lithium resources and reserves. Among sites rich in lithium, the region of the Puna Plateau, located along the triple border of Chile, Argentina and Bolivia, stands out (U.S. Geological Survey, 2010/2013).

Global production structure

Germany was the first country to produce lithium minerals from ore extracted in Bohemia and Saxony. In 1886, France began amblygonite production (Montebras). In 1925, the German Metallgesellschaft began commercial production of metallic lithium from zinnwaldite. Starting in 1930, the United States began producing and commercializing lithium derivates in North Carolina (Foote Mineral Co.), using the alkaline process to produce lithium carbonate from spodumene; Lithcoa developed the acidic process, which is a more efficient process that is applicable to the same ore.

In the 1980s, there was a technological shift in the production of lithium salts, with lithium carbonate now being produced in Chile (Cyprus Foote/Chemettal) and Argentina (FMC/Lithium Division) from high-grade evaporites. This shift caused the facilities used to produce lithium carbonate and hydroxide from spodumene ore in the United States to be shut down, due to the high processing costs compared with those for processing evaporites (Braga & França, 2011).

Currently, global lithium production is concentrated in several companies that operate in Chile (SQM and Chemettal), Argentina (FMC Lithium), Australia (Talison and Galaxy), the United States (Chemettal) and China (Tianqi and Ganfeng). Australia is the world’s largest producer of lithium mineral concentrates; Brazil, Canada, Portugal and Zimbabwe also produce small quantities of
lithium (mineral concentrates and chemical products). Global production in 2012 was approximately 150,000 t of LCE, as shown in Figure 1 (Roskill, 2013).

![Figure 1](image1.png)

**Figure 1** Global lithium production by source (Roskill, 2013)

Technological innovation is leading to increasing demand from China, Japan and South Korea, linked primarily to equipment portability and mobility (lithium-polymer batteries for telephones and communication) and to power tools, in addition to the development of Li-ion batteries for electric vehicles and large-scale accumulators (grid storage) (Mining Journal, 2012).

**New lithium projects**

The increasing use of lithium in batteries has led to a worldwide boom in research and projects related to lithium resources. Currently, hundreds of such projects are in preparation and/or under economic assessment, and some are already being implemented. Table 1 lists some of the new lithium projects currently being implemented or undergoing economic assessment (Signum Box, 2010 and Mining Journal, 2012).

**Table 1** New lithium projects being implemented or undergoing economic assessment

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Lithium source</th>
<th>LCE capacity (t/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>Lítio One</td>
<td>Brine</td>
<td>25,000</td>
</tr>
<tr>
<td>Argentina</td>
<td>Rincon Lítio</td>
<td>Brine</td>
<td>16,000</td>
</tr>
<tr>
<td>Argentina</td>
<td>Orocobre</td>
<td>Brine</td>
<td>15,000</td>
</tr>
<tr>
<td>Canada</td>
<td>Canada Lithium</td>
<td>Ore</td>
<td>19,300</td>
</tr>
<tr>
<td>United States</td>
<td>Western Lithium</td>
<td>Hectorite</td>
<td>13,500</td>
</tr>
<tr>
<td>Australia</td>
<td>Reed Resources</td>
<td>Ore</td>
<td>25,000</td>
</tr>
</tbody>
</table>
Uses and applications

Lithium hydroxide and carbonate, the main lithium products used for industrial purposes, are obtained from lithium-rich minerals and brine. Other lithium compounds are usually obtained by reacting these raw materials with acids to produce the desired lithium salts. Therefore, through adequate treatment, lithium hydroxide and carbonate provide the base materials used to prepare other compounds and metals (Braga & Sampaio, 2008).

Currently, the main applications of lithium in its metal, carbonate, hydroxide, bromide and more complex compound forms are in: ceramics-glass and glass-ceramics processes for the manufacture of frits and enamel; production of primary aluminum; production of synthetic rubber and plastic; pharmaceutical products; as a reducing agent in the synthesis of organic compounds; manufacture of special greases; production of primary and secondary batteries; and air conditioning and dehumidification systems (Ebensperger, Maxwell & Moscoso, 2005). Figure 2 shows the global distribution of lithium products by industrial consumption sector in 2011, highlighting applications for portable batteries, glass and ceramics and the grease and lubricant industries (Baylis, 2012).

![Figure 2: Global distribution of the lithium market by industry segment](image)

National lithium overview

Some pegmatites have been known in Brazil since 1924, but it was only in 1942 that the research and mining of lithium minerals began. Commercial exploitation started in 1966, after the discovery of pegmatite bodies (spodumene) in Aracuá, Minas Gerais (Afgouni & Silva Sá, 1977). By the 1970s, Brazil already used petalite, lepidolite and spodumene in the manufacturing of ceramics, enamels and special glasses. Amblygonite was used by Nuclemon for the production of lithium salts.

Lithium deposits in Brazil are associated with pegmatitic rock located in the states of Minas Gerais, Ceará, Rio Grande do Norte and Paraíba. The main pegmatitic minerals are amblygonite, spodumene, petalite and lepidolite.
History of lithium production

Brazil’s lithium industry started in the 1970s when the company Nuclemon, known as Santo Amaro Plant (USAM - Usina Santo Amaro), started producing lithium salts (Nogueira et al., 2009). The unit that produced lithium salts processed amblygonite ore (LiAl(PO₄)(F,OH)), which contains between 3.5% and 4.2% Li₂O, and the ore was either supplied by small companies or obtained through hand sorting in the states of Minas Gerais and Ceará. The plant, which had a processing capacity of 120 t of amblygonite/month, usually operated at 60% capacity. The main products were lithium carbonate, hydroxide, chloride and fluoride, sodium sulfate (Glauber’s Salt), sodium aluminate and trisodium phosphate.

Figure 3 shows the apparent consumption (production + imports) of lithium products in the period from 1974 to 1995 (Sumário Mineral, 1975-1996). It is clear that, in the 1970s, Nuclemon produced approximately 100 t/year and that Brazil imported approximately 250 t/year of lithium compounds. In the 1980s, national production decreased to 30 t/year, while imports exceeded 500 t/year. In 1987, Nuclemon halted the production of lithium salts, due to operational difficulties in guaranteeing the supply of amblygonite ore (small and irregular), depreciation and environmental problems at its plant in São Paulo.

Nowadays, the Brazilian Lithium Company (CBL – Companhia Brasileira de Lítio) is the only domestic company that produces lithium compounds. The CBL extracts lithium by underground mining of pegmatites in the municipalities of Araçuaí and Itinga-MG. Subsequently, the spodumene concentrate, produced by concentration in a dense medium, is transferred to a chemical plant in Divisa Alegre, MG, where it is transformed into industrial grade lithium carbonate and hydroxide, the specifications of which are presented in Table 2. The lithium compounds produced in Brazil do not meet the specifications for battery-grade products.
Table 2 National lithium carbonate and hydroxide specifications

<table>
<thead>
<tr>
<th>Products</th>
<th>Domestic</th>
<th>Battery grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium carbonate - Li$_2$CO$_3$ (%)</td>
<td>98.8</td>
<td>99.5</td>
</tr>
<tr>
<td>Lithium hydroxide - LiOH.H$_2$O (%)</td>
<td>54.8</td>
<td>56.5</td>
</tr>
</tbody>
</table>

The main form in which lithium is used in Brazil is lithium hydroxide, which is used in the production of grease and lubricants. Lithium carbonate, used in the production of primary aluminum, is currently not in demand in Brazil, due to the closing of Valesul smelter. Figure 4 shows the national production of lithium carbonate and hydroxide plus total production in terms of LCE (Sumário Mineral, 2000-2012).

Figure 4 National production of lithium compounds and total lithium production in terms of LCE

LCE consumption by sector in the Brazilian market for the year 2011 is shown in Figure 5, based on information contained in the Brazilian Chemical Industry’s Annual Report (Abiquim, 2012).

Figure 5 Lithium distribution in the Brazilian market by industrial segment
Braga & França (2013), in a study of the international lithium market, emphasized the absence of battery-manufacturing applications for lithium compounds in the national market, in marked contrast to the 25% share of such applications for lithium compounds worldwide, as shown previously in Figure 1.

**Lithium and portable equipment – a secondary market in Brazil**

Lithium, whether in carbonate or hydroxide form, is widely employed to manufacture the materials and compounds used in (secondary) rechargeable batteries. A Li-ion rechargeable battery consists of a cathode (+), an anode (-) and electrolytes. The cathodes of current Li-ion batteries are made of LiCoO$_2$, LiMn$_2$O$_4$ and LiFePO$_4$; the anodes are made of graphite; and the electrolytes are solutions of lithium salts (LiClO$_4$) in organic solvents. In the case of non-rechargeable (i.e., primary) batteries, lithium is used in its metallic form.

These secondary batteries are used in portable products, such as notebooks and netbooks, smartphones, digital cameras, mobile phones, tablets and power tools, which are all devices that normally operate without being connected to a power grid and that will become increasingly popular in the coming years. It is estimated that approximately 80% of the lithium consumed in batteries is used in portable products, and it is expected that, in the short and medium terms, the Li-ion batteries used in portable equipment will become increasingly efficient. For this efficiency to occur, an increase in lithium consumption will be needed to provide greater energy autonomy. The use of polymer-based portable batteries, which take the form of portable equipment, has sparked a revolution in this market, with new products appearing every year (SQM, 2013).

The large global markets for lithium carbonate and/or hydroxide are related to the manufacturing of portable electronic equipment, e-bikes, grid storage solutions and electric and hybrid vehicles. To estimate the real national demand for this raw material, one must know both the size of the market and the amount of LCE indirectly traded in lithium batteries. Table 3 shows the relationship between power (Wh) and the LCE content (g) of Li-ion batteries (Perez, 2012).

<table>
<thead>
<tr>
<th>Battery</th>
<th>Power (Wh)</th>
<th>LCE content (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile phone</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Smartphone</td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Tablet</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>Notebook</td>
<td>50</td>
<td>37</td>
</tr>
<tr>
<td>E-bike</td>
<td>400</td>
<td>300</td>
</tr>
</tbody>
</table>

Due to the possibility that lithium could be used in nuclear technology, lithium minerals and ore imports, exports and industrialization activities, as well as those of its organic and inorganic compounds, lithium metal and alloys, are all under the supervision of the National Nuclear Energy Commission. However, Brazil continues to import and produce large amounts of electrical and electronic equipment that uses imported Li-ion batteries.
Table 4, which indicates the amount of LCE (contained in Li-ion batteries) that Brazil imports without CNEN supervision (previous consent regimen), was generated from the data contained in Table 4. It is evident that there is a secondary lithium market in Brazil on the order of 3,624 t of LCE, which, combined with the national production of 598 t of LCE (Figure 3), indicates an apparent consumption level of 4,264 t/year of LCE.

<table>
<thead>
<tr>
<th>Product</th>
<th>Power (Wh)</th>
<th>LCE (g)</th>
<th>Import (units)</th>
<th>Total LCE (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li-ion batteries (300 cm³ max. volume)</td>
<td>1.6</td>
<td>2.1</td>
<td>37,464,516</td>
<td>78.68</td>
</tr>
<tr>
<td>Other Li-ion batteries</td>
<td>25</td>
<td>19</td>
<td>17,390,252</td>
<td>330.41</td>
</tr>
<tr>
<td>Li-ion electrical accumulators</td>
<td>50</td>
<td>37</td>
<td>85,269,400</td>
<td>1,515.97</td>
</tr>
<tr>
<td>E-bikes and similar products</td>
<td>400</td>
<td>300</td>
<td>33,404</td>
<td>10.02</td>
</tr>
<tr>
<td>Mobiles and smartphones</td>
<td>1.6</td>
<td>2.1</td>
<td>10,207,927</td>
<td>21.44</td>
</tr>
<tr>
<td>Digital cameras</td>
<td>1.6</td>
<td>2.1</td>
<td>2,946,830</td>
<td>6.19</td>
</tr>
<tr>
<td>Notebooks and netbooks</td>
<td>50</td>
<td>37</td>
<td>281,985</td>
<td>10.43</td>
</tr>
<tr>
<td>Tablets</td>
<td>25</td>
<td>19</td>
<td>638,815</td>
<td>12.14</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>3,624.28</td>
</tr>
</tbody>
</table>

This secondary lithium market, which is apparently outside government control, is approximately six times larger than national LCE production.

**CONCLUSIONS**

The production of lithium from pegmatites, which had been abandoned, has resumed in the face of rising prices and demand in the global market due to the intensification of Li-ion battery usage. New initiatives for the production of lithium from ore were described by Clarke (2013), who cited projects in Canada, the United States and Australia, generating a total output of 72,000 t of LCE.

Although Brazil may have significant lithium resources and reserves, the national production of lithium compounds was only 598 t of LCE in 2012. However, it must be noted that, due to its characteristics as a developing country, whereby it consumes and produces large amounts of electrical and electronic equipment, Brazil also contains a secondary lithium market associated with Li-ion batteries (3,600 t/year LCE), which is six times as large as the current national LCE production.

The production of Li-ion batteries for electronic equipment and electric vehicles (EV, HEV and PHEV) requires high-purity lithium carbonate (>99.50% Li₂CO₃), which cannot currently be obtained by the national industry, the compounds of which are of a lower technical grade (98.8% Li₂CO₃).
REFERENCES


U.S. Geological Survey (2010-2013), Lithium, Mineral Commodity Summaries, Virginia, USA.