LITHIUM MINERALS

By Special Contributors

Lithium minerals constitute approximately 25% of the total consumption of lithium worldwide, and the manufactured product, lithium carbonate, the remainder. Lithium minerals are used mainly as raw materials to the glass, ceramic and metallurgical industries. Some new uses have been developed over the past few years for lithium minerals in ceramics, for which there was little or no use previous use for carbonate. The total consumption of lithium minerals is forecast to continue growing as the new applications enjoy more widespread use.

Consumption

In 2003, the consumption of lithium minerals grew by 9.5%. The worldwide estimated consumption for 2003 was 214,000 t.

The growth came mainly from the growing economies of China and other Asian countries. Demand in North America and Europe remained flat and the outlook is for only modest growth.

Lithium Pegmatites

Lithium minerals most commonly occur in pegmatites associated with granitic intrusions, although they are also present in some sedimentary deposits where lithium may occur in brines associated with them. The most important lithium minerals are spodumene, petalite and lepidolite, owing to their availability and ease of mining. Spodumene is the most important because of its high lithium content, substantial good-quality reserves and ease of processing into suitable grades of mineral concentrates. Spodumene was the principal source of lithium for the production of lithium chemicals until the mid-1990s when the north American deposits were exhausted. Since that time, large-scale production of lithium from lithium chloride brines in South American salars have became more prevalent because they provide a cheaper route for the production of lithium carbonate.

The lithium silicate mineral spodumene is a monoclinic pyroxene with a prismatic crystal structure. It undergoes an irreversible phase transformation at about 1,080ºC to tetragonal beta phase and exhibits a very low thermal expansion coefficient. Accompanying this change is an increase in its volume by 30% and thereby a drop in its relative density from 3.2 to 2.4.

The other main lithium silicate mineral, petalite, is also monoclinic and when heated, it converts irreversibly to beta spodumene quartz in the solid solution phase. Lepidolite is a complex lithium mica, a phyllosilicate and monoclinic. Depending on availability, product requirements, price and environmental concerns, petalite and lepidolite can both be used in glass, ceramic and metallurgical applications. Lepidolite was originally the most commonly-used lithium mineral. However, lepidolite and some lithium feldspars contain significant amounts of fluorine. Their usage is gradually declining due to the strict environmental regulations on fluorine emissions being enforced in many countries.

Petalite and spodumene are traditionally used in thermal shock resistant (heat-proof) cookware, glass ceramics (corningware) etc.

Main suppliers

Over the past decade, the three major producers of lithium minerals, Sons of Gwalia Ltd in Australia, Tanco in Canada and Bikita Minerals in Zimbabwe (Figure 1) have supplied more than 85% of worldwide demand for minerals.

Sons of Gwalia owns the largest operating high-grade deposit of lithium ore (spodumene) at Greenbushes in Western Australia. Bikita operates the largest known high-grade deposit of petalite. The nominal total installed lithium minerals production capacity is 342,000 t/y.

Potential suppliers

There are several other known deposits of lithium minerals, in China, the CIS, Brazil and Canada but these are often of low-grade and are either currently uneconomic or are awaiting development funding. With existing installed capacity exceeding demand, the entry of new producers of high-grade lithium mineral concentrates is not likely to be an economic proposition in the short term. For example, in Portugal, Sociedada Mineira de Pegmatites has been mining lepidolite for more than a decade and mainly supplying unprocessed ore to local ceramic and glass industries as a low- price flux. The target application is the same as that of the cheaper feldspar and other fluxing minerals. The price is very low and this material cannot be used in other major applications of lithium minerals. Consequently the Portuguese lepidolite has a very limited demand.

High freight costs, logistics, quality and consistency preclude its use in other countries.

Thus, potential new mineral producers like Avalon Ventures or Emerald Fields in Canada may face serious difficulties with the mining and development of a lithium feldspar product. To date, neither of these projects has progressed to commercial production.

In China there have been similar developments involving low lithia-containing feldspar as a by-product, although the high fluorine content (thought to be from lepidolite) could preclude the use of the Chinese by-product in several important applications.

Uses

The most common applications of lithium minerals include:

- heatproof cookware (freezer to oven use)
- glass ceramics
- glass containers
- pharmaceutical glass
- flaconnage
- fibreglass
- ceramic frits and glazes
- enamels
- sanitaryware
- porcelain tiles.

(Lithium was used in black and white television tubes but production of such tubes has now practically ceased.)

During 2003, Sons of Gwalia developed and introduced a new grade of spodumene concentrate which they named SC6.4 (Gresflux). This product is designed to meet the needs of porcelain tile manufacturers who require an economic lithium mineral that is suitable for use in high-quality tiles (including superwhite porcelain tiles) to flux or vitrify the high percentage of refractory minerals like zircon and alumina in the composition.

Lithium minerals, when combined with other traditional fluxes such as feldspars and nepheline syenite, develop an eutectic mixture that increases the fluxing powers of the traditional flux batches, to improve product quality and plant efficiency. Some of the benefits are detailed below:

- Lithium minerals in glass – increased melting rates result from the lowering of its viscosity (giving reduced reject rate, higher output), lower melting temperature (giving energy savings), lower seed (bubble) count, lower thermal expansion coefficient and higher chemical durability. Another increasingly important benefit is the total or partial replacement of fluorine and other refining agents thus enabling reduction of increasingly regulated toxic emissions.

- Lithium minerals in ceramics – lower firing temperature (giving energy savings), shorter firing-cycle times (giving higher output), lower thermal expansion coefficient, lower pyroplastic deformation (less rejects) and more brilliant body and glaze colours. The last-mentioned attribute can be used to develop much higher grades of products with more intense colours. However, it can also be used to maintain certain colour intensity while reducing the use of more costly colourants.

Lithium carbonate
Until about 1995, the major feedstock for specialty lithium chemicals was spodumene ore converted to lithium carbonate. However, most lithium carbonate is now sourced from salars in North and South America. These salars are considered by many to be a lower-cost source for producing lithium carbonate when they are of suitable grade. However, this is also subject to some debate. Brine deposits in China have long been under investigations for

development. However, they have significant technical, infrastructure and economic problems to overcome.

As in the lithium-minerals sector, the technical-grade, lithium-carbonate sector is also serviced by only a handful of major producers:

- SQM Chemicals recovers lithium carbonate from brines in Chile. It has a estimated capacity of 28,000 t/y of lithium carbonate equivalent (LCE) and is now the world's largest producer and supplier of lithium carbonate;

- Chemetall Foote Corp's SCL-owned brine operations in Chile have a capacity of 16,000 t/y of LCE and its operations in Nevada have a capacity of 9,000 t/y of LCE. (It was previously owned by Cyprus Foote Minerals before the latter's take-over by Chemetall.);

- FMC of the US has ceased lithium carbonate production at its brine operations in Argentina but is believed to continue to market lithium carbonate supplied by SQM under contract. However, FMC continues to produce lithium chloride and other lithium derivatives from its brine deposits at several locations worldwide.

Other smaller producers of lithium carbonate operate in China and Brazil.

The major applications for technical-grade lithium carbonate are as an additive in the aluminium smelting industry and as a feedstock for the manufacture of downstream lithium chemicals and lithium metal.

Competition between minerals and carbonate

Lithium minerals were generally only used as the raw material for lithium carbonate or as the low thermal expansion mineral in glass ceramics prior to the mid-1980s. However, the strategy adopted to market spodumene from the Greenbushes mine resulted in several new uses for lithium being commercialised. The market for minerals grew from that time until the present and generally without significant replacement of lithium carbonate. Lithium carbonate now constitutes about 75% of the total lithium market worldwide. Lithium minerals occupy the other 25% once chemical feed use has been discounted. There are very few applications in which both the lithium minerals and lithium carbonate can be considered for use, either due to technical or economic reasons.

For example, in high-grade optical glasses, special glasses and applications where discolouration from Fe_2O_3 is an issue in the finished product, lithium carbonate is generally preferred to lithium minerals. In other applications like ceramic tile bodies, enhanced fluxing of the mineral and ease of use in the ceramic slurry is preferred to the chemical. Lithium carbonate is rarely used in applications that normally use lithium minerals unless it is available at the special discounted prices of the late 1990s. However, even then, lithium minerals are the preferred choice because they generally offer superior technical and melting performance for these applications. With the rising price of lithium carbonate over the past three years, the carbonate is being replaced by lithium minerals in a small number of applications eg, ceramic frits and cosmetic glass.

The consumption and pricing of lithium minerals has not been significantly affected by the turmoil in the lithium carbonate industry. The market for lithium minerals has continued to increase in combination with the focus on new applications and the economic development in East Asia and the Middle East. Consequently, the economic case to use lithium minerals will continue to strengthen in common applications for minerals.

The focus for growth in demand for carbonate is more likely to be as a feedstock in the manufacture of lithium chemicals, such as for use in the production of lithium ion and lithium polymer batteries. This is potentially the largest growth sector in the lithium industry.

Pricing

A price comparison of lithium minerals and lithium carbonate is shown in Table 2. The trend of the previous two years continued during 2003 when the major producers increased the price of lithium carbonate by another 5 – 10%. It is thought that higher production costs due to transport and energy price increases have made increases in the carbonate price more pressing. Lithium carbonate prices may continue to rise into the US$2,500/t range. Mineral prices, by comparison, have remained relatively stable for the past five years. Marginal increases due to higher fuel, energy and freight costs may arise.

The dramatic increase in demand for shipping services to cater for iron ore shipments to China is having quite a significant impact on the cost and availability of shipping for most producers and users in the lithium market.

Conclusion

Overall, the market for lithium minerals is expected to remain stable and to experience moderate growth. The growth will be the result of the commercialisation of new applications and the more widespread recognition of the benefits of lithium minerals by numerous producers in the glass, ceramics and metallurgical industries.

It is generally recognised that the combined fluxing properties of the lithium minerals are superior to that of lithium carbonate in glass and ceramic batches. The added alumina and silica present in the mineral composition enhance batch cost savings, melting properties and production efficiency.

Tables and graphs following pages:

Table 1 Typical lithia content of lithium minerals

Mineral	Formula	Li_2O Content Theoretical (%)	Typical (%)
Eucryptite	$Li_2O\ Al_2O_3\ 2SiO_2$	11.9	5
Spodumene	$Li_2O\ Al_2O_3\ 4SiO_2$	8	1.5 – 7.6
Petalite	$Li_2O\ Al_2O_3\ 8SiO_2$	4.9	3.0 – 4.5
Lepidolite	$K_2\ (Li, Al)_{5-6}\ [Si_{6-7}, Al_{2-1}\ O_{20}]\ (OH, F)$	3.3 – 7.8	3 – 4
Montebrasite	$Li\ Al\ (PO_4)\ (F, OH)$	10.1	8 – 9
Amblygonite	$(Li\ Na)\ Al\ (PO_4)\ (F, OH)$	7.4	3 – 4
Zinnwaldite	$K\ (Li, Al, Fe)_3\ (Al, Si)_4\ O_{10}\ (F, OH)_2$	5.6	2 - 5

Table 2 Market prices in 2003

Material	Li_2O (%)	Price (Approx)	Price (US$ / kg Li_2O)
Lithium Carbonate	40.4	US$2,000 - 2,600 / Mt bag or drum	4.95 - 6.53
Spodumene	6.9 - 7.5	US$365 – 395 / Mt ex seller’s warehouse	4.84 - 5.27
Spodumene	4.8 - 5.0	US$215 - 230 / Mt ex seller’s warehouse	4.48 - 4.60

*Depends on packaging and particle size.

Figures 1 & 2: 2003 Production and sales of lithium minerals

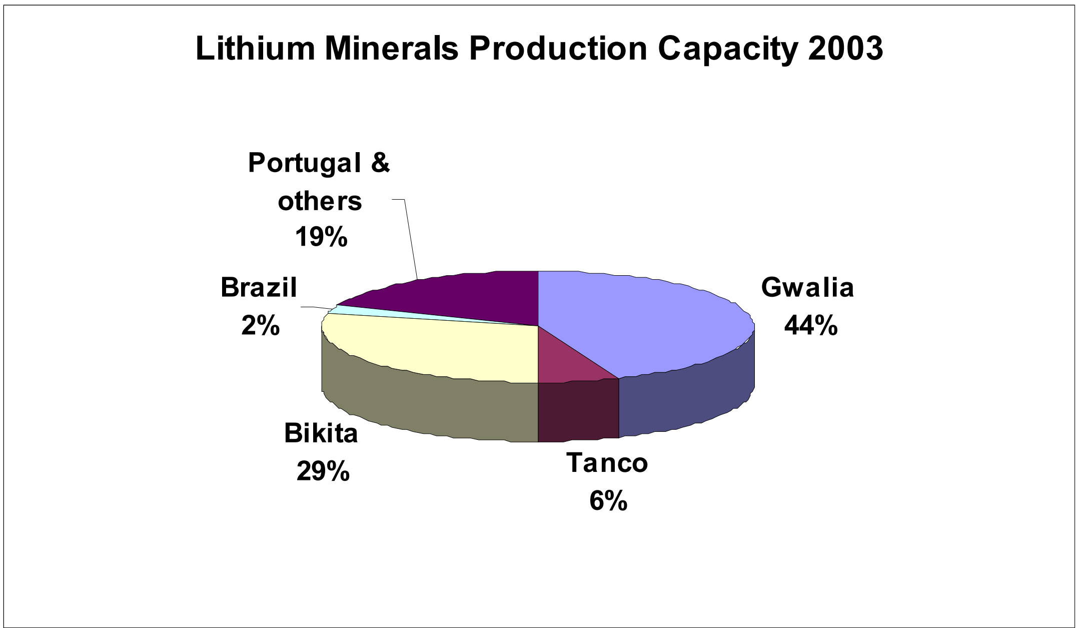
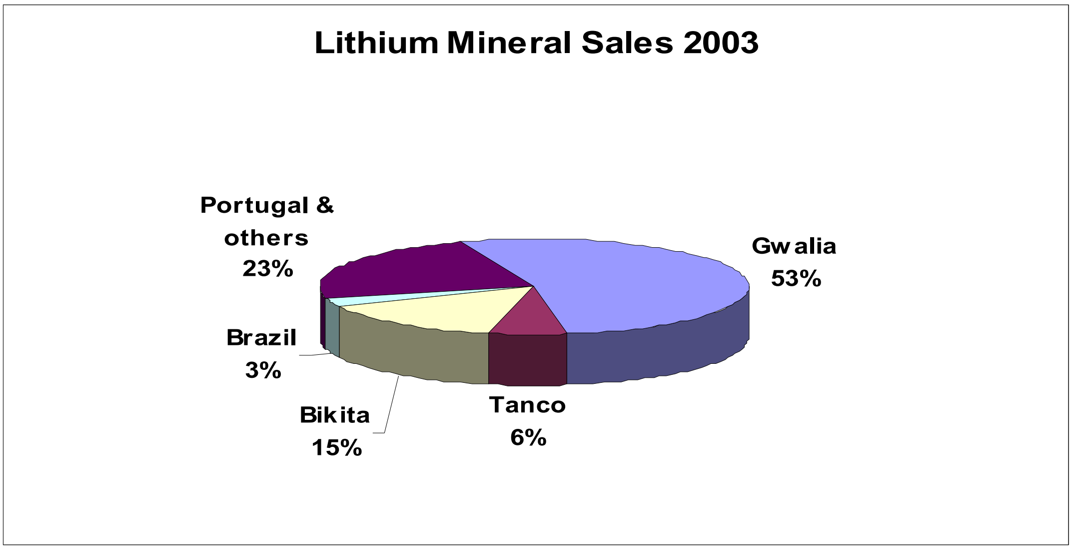


Figure 2


Lithium Mineral Sales 2003
Portugal & others 23%
Gwalia 53%
Brazil 3%
Bikita 15%
Tanco 6%

From containers
to flaconage,
Spodumene delivers:

Reduced melting
temperatures

Increased furnace capacity

Improved
chemical resistance

Combined with our free
technical advisory service,
Gwalia can also
improve your profitability

GWALIA

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