LITHIUM

By Joyce A. Ober

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Regina R. Coleman, international data coordinator.

Introduction

In 2001, Chile was once again the world's leading producer of lithium carbonate with production at its two lithium brine operations on the Salar de Atacama in the Andes Mountains and two lithium carbonate plants in Antofagasta. In the United States, production continued at the lithium brine operation and lithium carbonate plant in Nevada. There was one lithium carbonate plant in Argentina on the Salar del Hombre Muerto, but it operated at a level far below its capacity; and production of lithium chloride continued. Chinese and Russian lithium carbonate production continued. Australia, Canada, and Zimbabwe were important sources of lithium ore concentrates. A large percentage of the material produced in South America was exported to the United States as feed material for the production of downstream lithium compounds and for consumption in industrial applications.

Because lithium is electrochemically reactive and has other unique properties, many commercial lithium products are available. Producers sell lithium as brine, chemical, metal, or mineral concentrate depending on the end use. Most lithium compounds and minerals are consumed in the production of ceramics, glass, and primary aluminum, although the use of organic lithium compounds as industrial catalysts and the consumption of various lithium compounds in lithium batteries are the most rapidly expanding markets.

Production

The U.S. Geological Survey collects domestic production data for lithium from a voluntary survey of U.S. operations. The single U.S. lithium carbonate producer responded to the survey, representing 100% of total production. Production and stock data were withheld from publication to avoid disclosing company proprietary data (table 1).

Chemetall Foote Corp. (a subsidiary of the German company Chemetall GmbH) produced lithium carbonate from brines near Silver Peak, NV. The company's other lithium operations included a lithium hydroxide plant in Silver Peak; a butyllithium plant in New Johnsonville, TN; and facilities for producing downstream lithium compounds in Kings Mountain, NC.

FMC Corp., Lithium Division, produced a full range of downstream compounds, including lithium metal and organic lithium compounds, at its facilities in Bessemer City, NC, and Bayport, TX. FMC operated a lithium carbonate plant and spodumene mine in North Carolina until 1998. Since 1999, the company has met its lithium carbonate requirements through a long-term agreement with Chilean producer Sociedad Quimica y Minera de Chile S.A. (SQM) to supply FMC with lithium carbonate produced at SQM's brine operation. FMC determined that the supply agreement with SQM would be more economical than continuing to produce lithium carbonate from its own operation in Argentina that began production in 1997 (FMC Corp., 2001a, p. 25). FMC produced lithium chloride and minor quantities of lithium carbonate in Argentina in 2001.

LithChem International (a subsidiary of ToxCo, Inc.) of Anaheim, CA, produced lithium carbonate and lithium hydroxide at its plant in Baltimore, OH. LithChem produces these compounds from lithium compounds that are products of ToxCo's lithium battery recycling operation in Trail, British Columbia, Canada. In 2000, LithChem acquired Ozark-Mahoning Co.'s inorganic fluorine compounds facility in Tulsa, OK, from ATOFINA Chemicals Inc. and renamed it Ozark Fluorine Specialties Inc. LithChem used some of the hydrofluoric acid produced at Ozark's facility to make lithium hexafluorophosphate, high-purity lithium fluoride, and other electrolytes used in lithium batteries (Hunter, 2000).

Lithium carbonate is the most important lithium compound produced from brine and ore deposits. In most cases, other lithium compounds require lithium carbonate as a feedstock for further processing. Domestic production of lithium carbonate from brine is limited to Chemetall Foote's operation in Nevada. Nevada brines enriched in lithium chloride, which averaged about 300 parts per million (ppm) when Foote Mineral Co. (the original owner of the deposit) began operations in 1966, are pumped from the ground and progress through a series of evaporation ponds (Engineering and Mining Journal, 1970). Over the course of 12 to 18 months, the concentration of the brine increases through solar evaporation to 6,000 ppm lithium. When the lithium chloride reaches optimum concentration, the liquid is pumped to a recovery plant and treated with soda ash, precipitating lithium carbonate. The carbonate is then removed through filtration, dried, and shipped. A similar process is used to recover lithium from the Chilean brines, with slight adjustments to account for their different chemistries. The brine operation in Argentina uses a different, proprietary technology that allows for the lithium recovery as either carbonate or chloride (FMC Corp., 1998, p. 23, 25).

Until the last domestic mine closed in 1998, spodumene had been the major raw material used for the production of lithium carbonate in North Carolina, and small amounts of spodumene concentrate were produced for sale. Spodumene is the most common lithium ore, but petalite and lepidolite are other types that are mined in different parts of the world. These three ores are beneficiated to produce lithium ore concentrates that can be used directly in certain applications.

Extracting lithium from spodumene entails an energy-intensive chemical recovery process, which is more costly than that used for brines. Because of the high cost of producing lithium carbonate from spodumene, most lithium carbonate production has shifted to brine deposits. After mining, spodumene is crushed and undergoes a flotation beneficiation process to produce concentrate. The concentrate is heated to 1,075° C to 1,100° C, changing the crystal structure of the mineral and making it more reactive to sulfuric acid. A mixture of finely ground converted spodumene and sulfuric acid is heated to 250° C, forming lithium sulfate. Water is added to the mixture to dissolve the lithium sulfate. Insoluble portions are then removed by filtration. The purified lithium sulfate solution is treated with soda ash, forming insoluble lithium carbonate that precipitates from solution. The carbonate is separated and dried for sale or use by the producer as feedstock in the production of other lithium compounds.

Consumption

The aluminum, ceramics and glass, lubricating grease, and synthetic rubber industries used most of the lithium minerals and compounds sold in 2001. Estimated domestic consumption was stable from 1997 through 2000, but in 2001, consumption plummeted to only 50% of what it was in the 4 previous years. A major reason for this dramatic decrease was that primary aluminum production was 28% lower in 2001 than in 2000 as a result of increased energy costs and reduced energy supplies in the Pacific Northwest (Plunkert, 2002). This resulted in reduced lithium demand for that sector. Lithium consumption in other end uses, including ceramics and glass, lubricants, batteries, synthetic rubber, and pharmaceuticals, was negatively affected by a slow domestic economy (Schmitt, 2001).

The largest use of lithium in the United States was in ceramics and glass manufacturing processes. Addition of lithium can be made as lithium carbonate or ore concentrates to the glass melt, lowering process melting points, reducing the coefficient of thermal expansion and the viscosity, and eliminating the use of more toxic compounds. The production of ceramics and glass was the only use for lithium ore concentrates. The domestic manufacture of thermal shock-resistant cookware (pyroceramics) consumed the majority of lithium used in the ceramics and glass industry. Low-iron spodumene and petalite were sources of the lithium used to improve the physical properties of container and bottle glass, as well as sources of alumina, another important component of glass. Glass manufacturers used lithium in container and bottle glass, enabling them to produce lighter weight, thinner walled products. Until 1997, lithium ore concentrates had been the only lithium products that were acceptable for most ceramics and glass applications because of their low cost in comparison with lithium carbonate. Applications sensitive to other elements and impurities that came with ore concentrates or to the price of lithium carbonate were unable to take advantage of the benefits of lithium in their production processes. When the lithium carbonate price was cut to about one-half of its previous level, these specialty glass producers were economically able to change their glass formulations to take advantage of the improved properties made possible by lithium additions (Sheets and Rios, 1999).

Although significantly reduced in 2001, the second largest lithium use was in primary aluminum production. Adding lithium carbonate to aluminum potlines lowers the melting point of the cryolite bath, allows a lower operating temperature for the cells, increases the electrical conductivity, and decreases viscosity of the bath. These factors contribute to increased production or reduced power consumption. Perhaps more important are the environmental benefits of lithium consumption at aluminum smelters—reducing fluorine emissions by 20% to 30% (Chemetall GmbH, 2001§[1]).

Domestically, the third largest and the fastest growing end use for lithium compounds was as catalysts in the production of synthetic rubbers, plastics, and pharmaceuticals. N-butyllithium is used to initiate the reactions between styrene and butadiene that form abrasion-resistant synthetic rubbers that require no vulcanization. Other organic lithium compounds were catalysts for the production of plastics, such as polyethylene. Lithium metal and compounds were catalysts in the production of an analgesic, anticholesterol agents, antihistamines, contraceptives, sleep inducers, some steroids, tranquilizers, vitamin A, and other products. Lithium catalysts were used in the production of protease inhibitors, important drugs in the treatment of human immunodeficiency virus type 1/acquired immunodeficiency syndrome (HIV-AIDS) (Schmitt, 2001). Pharmaceutical-grade lithium carbonate was used in the treatment of manic-depressive psychosis. This was the only treatment approved by the U.S. Food and Drug Administration in which lithium was consumed by the patient.

The multipurpose grease industry was another of the important markets for lithium in 2001. Lithium hydroxide monohydrate was the compound used for the production of lithium lubricants. Lithium-based greases were favored for their retention of lubricating properties over a wide temperature range; good resistance to water, oxidation, and hardening; and formation of a stable grease on cooling after melting. These greases continued to be used in aircraft, automotive, industrial, marine, and military applications.

Almost all major battery manufacturers marketed some type of lithium battery. Research and development continued, and innovative rechargeable battery configurations continued to be developed to meet the changing requirements for electronic equipment, such as portable telephones, portable computers, and video cameras. Lithium-ion batteries were of particular interest for these applications because they take advantage of the large power capacity available from lithium batteries with fewer safety problems than are encountered when batteries contain lithium metal, a very reactive and volatile material when exposed to air and moisture. Electric vehicles (EVs) have been considered a large potential market for lithium batteries, but general acceptance of these vehicles has been slower than expected. Hybrid vehicles and vehicles powered by fuel cells may find greater popularity than pure EVs.

Nonrechargeable (primary) lithium batteries offer improved performance over alkaline batteries at a slightly higher cost and have been commercially available for more than 10 years. They are used in cameras, electronic games, microcomputers, small appliances, toys, and watches. The military purchased large and small lithium batteries for a variety of military applications. For example, in 2000, two lithium oxyhalide reserve batteries were

[1]References that include a section twist (§) are found in the Internet References Cited section.

qualified for use in different missile programs, the High Altitude Area Defense and the Boeing Ground Based programs. These reserve batteries, which are stored in an inactive form until needed for short-term use, provide high current for short times from small packages (McHale, 2000).

Aircraft manufacturers in several countries have considered using aluminum-lithium alloys for wing and fuselage skin or for structural members in different types of aircraft. Use of these alloys could reduce the weight of the aircraft by more than 10%, allowing significant fuel savings during the life of the aircraft. The alloys, which are 2% to 3% lithium by weight, were attractive to the aircraft and aerospace industries because of their reduced density and superior corrosion resistance compared with conventional aluminum alloys. These alloys, however, have not been as widely used in aircraft manufacture as was hoped at the initial introduction of the alloys. In airplane construction, these alloys faced direct competition from composite materials consisting of aramid, boron, or graphite fibers embedded in polymers. McCook Metals LLC produced an aluminum-lithium alloy that is being used for a fatigue-critical aft bulkhead replacement and other parts on the F-16 fighter plane built by Lockheed Martin Corp. The alloy was produced at the McCook, IL, plant formerly owned by Reynolds Metals Co. (Light Metal Age, 1998).

The superlightweight external fuel tank for the National Aeronautics and Space Administration's space shuttle was made with another aluminum-lithium alloy containing 4% copper, 1% lithium, 0.4% silver, 0.4% magnesium, and the remainder aluminum. This alloy was 30% stronger and 5% less dense than the more traditional aluminum alloy that it replaced. The redesigned fuel tank weighed about 3,400 kilograms less than the original design; the weight savings were used to increase the payload capacity for shuttle missions (Light Metal Age, 1998).

Small quantities of other lithium compounds were important to many industries. Lithium chloride and lithium bromide were used in industrial air-conditioning and commercial dehumidification systems and in the production of sophisticated textiles. Sanitizers for commercial glassware, public restrooms, and swimming pools contained lithium hypochlorite, as did dry bleaches for commercial laundries. Lithium metal was used as a scavenger to remove impurities from bronze and copper, and anhydrous lithium chloride was used as a component in fluxes for hard-to-weld metals, such as aluminum and steel alloys.

Prices

Since lithium pricing became very competitive when SQM entered the market in 1998, it has become difficult to obtain reliable price information from the companies or trade publications. The companies may announce price hikes, but they are relative only to previous prices. Producers negotiate with consumers on an individual basis, and usually, no actual price information is reported. For instance, FMC announced a 7% increase in butyllithium prices but did not state what the base or increased price would be (FMC Corp., 2001b). Another report stated that lithium carbonate prices were up between 4% and 5%, but the unit price that was stated as the base was the same as that of 1998 (Schmitt, 2001). Reports in 1999 and 2000 stated that prices had risen in each of those years. Based on published price increases since 1998, the price of lithium carbonate in 2001 was probably about $2.30 per kilogram ($1.05 per pound).

Customs values for lithium carbonate entering the United States from Chile are a good indication of the trends in lithium pricing, although they have never reflected exactly the producers' average prices for lithium carbonate. The average unit value calculated from the U.S. Census Bureau data using customs value and quantity imported, showed that the unit value of lithium carbonate decreased by 46% from 1996 to 1999; the average value increased by almost 7% in 2000 but decreased by the same amount in 2001. The customs unit value for lithium carbonate from Chile has decreased steadily from $2.70 per kilogram in 1996 to $1.45 per kilogram in 2000 and $1.44 per kilogram in 2001. Imports from Argentina were recorded for the first time in 1998; the customs unit value for this material was $3.06 per kilogram in 2000 and $1.60 per kilogram in 2001.

Foreign Trade

Total exports of lithium compounds from the United States increased by 12% in 2001 compared with the previous year. About 55% of all U.S. exports of lithium compounds were to Canada, Germany, Japan, and the United Kingdom (table 2).

Imports of lithium compounds decreased by nearly 31% in 2001 as a result of significantly decreased demand. In 2001, 86.2% of lithium imports was from Chile, and lithium carbonate from Argentina was 7.6% of total imports (table 3). Lithium ore concentrates from Australia, Canada, and Zimbabwe were believed to have been consumed in the United States, but no import statistics were available.

World Review

A small number of countries throughout the world produced lithium ore and brine. Chile, China, and the United States were the leading producers of lithium carbonate. Significant quantities of lithium compounds and ore concentrates also were produced in Argentina, Australia, Brazil, Canada, Chile, Portugal, Russia, and Zimbabwe. Namibia, Rwanda, South Africa, and Zaire are past producers of concentrates. Production figures for lithium ore concentrates and lithium carbonate are shown in table 4. Pegmatites containing lithium minerals have been identified in Austria, France, India, Ireland, Mozambique, Spain, and Sweden, but economic conditions have not favored development of the deposits. Lithium has been identified in subsurface brines in Bolivia, China, and Israel. Companies in France, Germany, Japan, Taiwan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

The total lithium compound market was estimated to be about 45,000 t of elemental lithium contained in compounds in 2001 (Schmitt, 2001). Global consumption of lithium minerals was estimated to be around 158,000 t in 2000, the last year for which such information was available (Glass International, 2001).

Argentina.—In 1999, after only 1 full year of lithium carbonate production from its lithium brine operation at the

Salar del Hombre Muerto in the Argentine Andes, FMC shuttered the facility except for limited production for a specialized market (Brown, 1999; Saller and O'Driscoll, 2000, p. 45). The operation was designed to produce about 12,000 metric tons per year (t/yr) of lithium carbonate and about 5,500 t/yr of lithium chloride (North American Minerals News, 1998). Technical problems and poor market conditions, however, forced FMC to reevaluate its project, choosing to close the facility and purchase most of its lithium carbonate requirements from other sources, SQM in particular. The lithium chloride production line continued to operate (Industrial Minerals, 1999).

Brazil.—Two companies produce lithium minerals in Brazil. Companhia Brasileira de Litio produces spodumene concentrates from the underground Cachoeira Mine in Araçuaí. This material is used as feedstock for lithium carbonate and lithium hydroxide production at a plant in Aguas Vermelhas in Minas Gerais. Arqueana de Minérios e Metals Ltda. produces a mixture of spodumene, petalite, and lepidolite at several mines in Araçuaí and Itinga. In Brazil, lithium compounds and minerals are used in greases and lubricants, primary aluminum production, ceramics, batteries, and nuclear reactors (Ramos, 2001).

Canada.—Tantalum Mining Corp. of Canada Ltd. (Tanco) (a subsidiary of Hudson Bay Mining Co.) operates a spodumene mine and concentrating plant at Bernic Lake, Manitoba. Development of Avalon Ventures Ltd.'s Separation Rapids rare metals project in northwestern Ontario and Emerald Fields Resource Corp.'s Big Mack petalite project, on the same pegmatite body between the Tanco and Avalon operations, was being considered, but neither deposit had been developed for commercial production.

Chile.—With two large brine operations at the Salar de Atacama and their associated lithium carbonate plants, Chile was the largest lithium carbonate producer in the world. Chemetall Foote's plant first produced lithium carbonate in 1984; it uses its lithium carbonate as feedstock for its downstream chemical production in the United States and supplies the operations of its parent company Chemetall in Germany and Taiwan. SQM completed its first full year of production in 1997 and has the capacity to produce about 23,000 t/yr; the company was building a butyllithium plant in Bayport, TX (Schmitt, 2001). Both Chilean companies transport concentrated brines from the Salar de Atacama to lithium carbonate plants in Antofagasta. Because of SQM's agreement to supply FMC's lithium carbonate requirements, the global market was divided evenly between Chemetall Foote and SQM except for small quantities from China and Russia (McCoy, 1999).

Germany.—Chemetall (the parent company of Chemetall Foote) has been a major producer of lithium compounds for many years at its lithium operations in its Langelsheim plant. The company has lithium operations in Chile, Germany, Taiwan, and the United States.

Outlook

The health of the lithium industry remains closely tied to the performance of the primary aluminum and the ceramics and glass industries and the economy in general. Changes in consumption of lithium in these industries determine the performance of the entire lithium industry. With nearly one-third of U.S. aluminum capacity idle in 2001, lithium consumption suffered as a result. The slowing economy resulted in further decreased consumption. Because these uses represent such a high percentage of the total lithium market, growth in other areas has a much smaller influence, although battery and catalyst applications have become more important. Demand for N-butyllithium continued to increase although at a lower rate than was expected in previous years. The demand for lithium catalysts for protease inhibitors decreased unexpectedly because HIV/AIDS patients developed a tolerance for the drugs and medications and switched to other treatments that did not require lithium catalysts for their production (Schmitt, 2001).

Demand for lithium metal for batteries and to some extent for alloys will probably increase, but total consumption of metal will remain low in comparison with the demand for lithium compounds. For the first time, automakers were considering the use of aluminum-lithium alloys to reduce the weight of vehicles and increase fuel efficiency (Lipsitt and Sherman, 2001). This could represent a significant new market for the alloys, but research was in its beginning phase, and it could take years for this potential to be realized, if ever.

Lithium-ion and lithium-polymer batteries appear to possess the greatest potential for growth for the entire lithium industry. First introduced in 1993 with minimal sales, the market for these rechargeable batteries grew to $3 billion in 1998 and is expected to top $6 billion by 2005 (Pacific Lithium Ltd., 2000§). No estimates of the amount of lithium required for these batteries have been made, but the value of lithium materials sold for battery production was estimated to be $111 million in 1997, with forecasts of an average annual increase of 16% through 2008 (Saller and O'Driscoll, 2000, p. 41). This kind of value growth indicates that material demand could increase at a comparable or faster rate.

Too many unknowns remain, however, to allow for a reliable forecast of the quantity of lithium that will be required for the future EV market. Not only is there the question of whether lithium will be part of the superior EV batteries, but also whether batteries or fuel cells will be the preferred sources of power. Developments in 2001 indicated that fuel cells might eventually become the preferred power sources for EVs. In addition, questions as to when and if EVs will make up a significant portion of new car sales in the United States and around the world have been raised. Sales and leases currently lag behind expectations.

Other markets should remain stable with slight growth. Lithium demand could increase dramatically if the technology for nuclear fusion was perfected. This is not expected to take place within the next 25 years and may never occur.

References Cited

Brown, Robert, 1999, FMC upgrades its core industrial, specialty chemicals: Chemical Market Reporter, v. 256, no. 11, September 13, p. 32, 37.
Engineering and Mining Journal, 1970, Silver Peak gives bright look to Foote Mineral's lithium picture: Engineering and Mining Journal, v. 171, no. 4, April, p. 72.
FMC Corp., 1998, FMC annual report 1998: Chicago, FMC Corp., 51 p.
FMC Corp., 2001a, FMC annual report 2000: Chicago, FMC Corp., 66 p.

FMC Corp., 2001b, FMC Lithium announces butyllithium price increase: Chicago, FMC Corp. press release, April 9, 2 p.
Glass International, 2001, Lithium minerals market is in stable mode: Glass International, v. 24, no. 4, July-August, p. 28-29.
Industrial Minerals, 1999, FMC suspends Li_2CO_3 production: Industrial Minerals, no. 383, August, p. 9.
Hunter, David, 2000, LithChem buys Atofina's Ozark Unit: Chemical Week, v. 162, no. 31, August 16, p. 17.
Light Metal Age, 1998, Aluminum-lithium alloys: Light Metal Age, v. 56, no. 1-2, February, p. 102-105.
Lipsitt, H.A., and Sherman, A.M., 2001, Aluminum alloy design methodology: Advanced Materials & Processing, v. 159, no. 10, October, p. 37-39.
McCoy, Michael, 1999, Chilean inorganics muscle into the market: Chemical & Engineering News, v. 77, no. 31, August 2, p. 11.
McHale, John, 2000, Eagle-Picher designs lightweight batteries for missile applications: Military & Aerospace Electronics, v. 11, no. 7, July, p. 1, 8.
North American Mineral News, 1998, FMC closes Cherryville spodumene—Bessemer City plant now importing Argentine Li_2CO_3: North American Mineral News, no. 37, March, p. 4.
Plunkert, P.A., 2002, Aluminum in December 2001: U.S. Geological Survey Mineral Industry Surveys, February, 7 p.
Ramos, L.J., 2001, Lithium: Brasilia, Brazil, Ministry of Mines and Energy Mineral Summary 2001, p. 69-70.
Saller, Marcus, and O'Driscoll, Mike, 2000, Lithium takes charge: Industrial Minerals, no. 390, March, p. 37-47.
Schmitt, Bill, 2001, End-use market snags hurt lithium chemicals: Chemical Week, v. 163, no. 38, October 17, p. 40.
Sheets, Jack, and Rios, Sebastian, 1999, Market change encourages lithium carbonate demand in glass: Glass, v. 76, no. 11, November, p. 356.

Internet References Cited

Chemetall GmbH, 2001, Lithium applications, accessed April 10, 2002 via, URL http://www.chemetalllithium.com.
Pacific Lithium Ltd., 2000, Applications markets, accessed April 4, 2000, at URL http://www.pacificlithium.com/profile/markets.html.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Lithium. Ch. in Mineral Commodity Summaries, annual.
Lithium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Lithium. International Strategic Minerals Inventory Summary Report, Circular 930-I, 1990.
Lithium Resources and Requirements by the Year 2000. Professional Paper 1005, 1976.

Other

Chemical Market Reporter, weekly.
Chemical Week, weekly.
Engineering and Mining Journal, monthly.
European Chemical News, monthly.
Industrial Minerals, monthly.
Lithium. Ch. in Minerals Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Lithium. U.S. Bureau of Mines Information Circular 9102, 1986.
Roskill Information Services Ltd.

TABLE 1
SALIENT LITHIUM STATISTICS 1/

(Metric tons of contained lithium)

	1997	1998	1999	2000	2001
United States:					
Production	W	W	W	W	W
Producers' stock changes	W	W	W	W	W
Exports 2/	1,880	1,340	1,330	1,310	1,480
Imports 2/	975	2,590	2,640	2,880	1,990
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,800	2,800	2,800	2,800	1,400
Rest of world, production 3/	14,200	14,400 r/	14,400 r/	15,700 r/	15,000

r/ Revised. W Withheld to avoid disclosing company proprietary data.
1/ Data are rounded to no more than three significant digits.
2/ Compounds.
3/ Mineral concentrate and lithium carbonate.

TABLE 2
U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY 1/

	2000		2001	
Compound and country	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Lithium carbonate:				
Australia	32	$187	--	--
Canada	562	2,020	410	$1,470
China	97	349	29	108
Germany	765	2,240	865	2,360
India	8	29	22	78
Japan	903	3,140	1,080	4,020
Korea, Republic of	51	184	26	92
Mexico	7	29	3	14
Netherlands	47	170	88	317
Taiwan	28	100	9	33
United Kingdom	179	624	247	763
Other	58	216	136	556
Total	2,740	9,280	2,920	9,810
Lithium carbonate U.S.P.: 2/				
Australia	(3/)	11	50	226
China	--	--	20	35
Germany	(3/)	3	64	117
Netherlands	23	30	--	--
Singapore	--	--	19	39
Sweden	--	--	13	57
Venezuela	--	--	100	170
Other	7 r/	310 r/	15	186
Total	30	354	281	830

See footnotes at end of table.

TABLE 2--Continued

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY 1/

Compound and country	2000 Gross weight (metric tons)	2000 Value (thousands)	2001 Gross weight (metric tons)	2001 Value (thousands)
Lithium hydroxide:				
Argentina	126	$446	96	$324
Australia	218	6,860	189	788
Canada	144	566	326	1,290
Chile	27	108	39	142
China	3	100	15	36
Germany	627	2,020	516	1,540
India	383	1,080	298	858
Japan	1,340	6,930	910	4,780
Korea, Republic of	146	612	237	909
Mexico	99	427	98	344
Netherlands	142	333	172	431
New Zealand	188	780	266	1,100
Philippines	26	104	32	100
Singapore	60	253	86	359
Thailand	137	377	109	286
Taiwan	2	25	36	163
United Kingdom	241	2,220	245	1,490
Other	873	7,840	1,630	7,510
Total	4,780	31,100	5,300	22,400

r/ Revised. -- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ United States Pharmaceutical-grade lithium carbonate.

3/ Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS BY COMPOUND AND COUNTRY 1/

Compound and country	2000 Gross weight (metric tons)	2000 Value 2/ (thousands)	2001 Gross weight (metric tons)	2001 Value 2/ (thousands)
Lithium carbonate:				
Argentina	1,160	$3,550	808	$1,290
Chile	13,500	19,600	9,160	13,200
Germany	(3/)	4	10	28
Italy	--	--	20	49
Japan	2	36	1	6
Mexico	2	5	113	87
New Zealand	113	522	145	577
Other	20 r/	61 r/	2	29
Total	14,800	23,800	10,300	15,300
Lithium hydroxide:				
Chile	91	224	--	--
China	367	962	341	901
Japan	19	252	5	66
United Kingdom	11	64	15	246
Other	127 r/	601 r/	1	23
Total	615	2,100	362	1,240

r/ Revised. -- Zero.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

2/ Customs value.

3/ Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 4

LITHIUM MINERALS AND BRINE: ESTIMATED WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1997	1998	1999	2000	2001
Argentina:					
Spodumene and amblygonite	697 4/	700	700	700	700
Carbonate from subsurface brine	--	6,000	1,000	1,000	1,000
Australia, spodumene	88,399 4/	63,190 4/	75,824 4/	81,891 r/ 4/	63,443 4/
Brazil, concentrates	6,948 r/ 4/	9,485 r/ 4/	11,122 r/ 4/	10,875 r/ 4/	11,000
Canada, spodumene 5/	22,500	22,500	22,500	22,500	22,500
Chile, carbonate from subsurface brine	24,246 4/	28,377 r/ 4/	30,231 r/ 4/	35,869 r/ 4/	36,000
China, carbonate	15,500	13,000	12,500	13,000	13,000
Namibia, concentrates, chiefly petalite	1,019 4/	500	--	--	--
Portugal, lepidolite	6,883 4/	7,000	14,862 r/ 4/	9,352 r/ 4/	10,000
Russia (minerals not specified) 6/ 7/	2,000	2,000	2,000	2,000	2,000
United States, spodumene and subsurface brine	W	W	W	W	W
Zimbabwe, amblygonite, eucryptite, lepidolite, petalite, and spodumene	49,833 4/	28,055 4/	36,671 r/ 4/	41,957 r/ 4/	35,000

r/ Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

1/ Table includes data available through March 29, 2002.

2/ Estimated data are rounded to no more than three significant digits.

3/ In addition to the countries listed, other nations may produce small quantities of lithium minerals. Output is not reported; no valid basis is available for estimating production levels.

4/ Reported figure.

5/ Based on all Canada's spodumene concentrates (Tantalum Mining Corp. of Canada Ltd.'s Tanco property).

6/ These estimates denote only an approximate order of magnitude; no basis for more exact estimates is available.

7/ Lithium contained in concentrates and brine.