that the supply agreement with SQM would be more economical than continuing to produce lithium carbonate from its own operation in Argentina that was completed in 1997 (FMC Corp., 2001). FMC produced lithium chloride and minor quantities of lithium carbonate in Argentina in 2000.

LithChem International, a subsidiary of ToxCo, Inc., both of Anaheim, CA, produced lithium carbonate and lithium hydroxide at its facilities 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 plans to use 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. The lithium electrolyte compounds used in lithium ion batteries currently (2000) are produced commercially by only one company in Japan (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 operations began in 1966 (Engineering and Mining Journal, 1970), are pumped from the ground and progress through a series of evaporation ponds. Over the course of 12 to 18 months, concentration of the brine increases to 6,000 ppm lithium through solar evaporation. 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).

Until the last domestic mine closed in 1998, spodumene was the major raw material required 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 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 the 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 2000. Estimated domestic consumption has been stable since 1997. Ceramics and glass production and aluminum smelters were the largest consumers of lithium carbonate and lithium concentrates worldwide, representing an estimated 50% of the total lithium market. Other consuming industries were lubricants, 18%; batteries, 9%; catalysts for synthetic rubber and pharmaceuticals, 9%; and other uses, 14% (Schmitt, 2000). Domestic end uses differ from global consumption and are described below.

The largest use of lithium in the United States was in ceramics and glass manufacturing processes. These additions, which can be made as lithium carbonate or ore concentrates, lower process melting points, reduce the coefficient of thermal expansion and the viscosity, and eliminate the use of more toxic compounds. Lithium ore concentrates were consumed exclusively in the production of ceramics and glass products. The domestic manufacture of thermal shock-resistant cookware (pyroceramics) consumed the majority of lithium used in the ceramics and glass industry. The manufacture of black-and-white television picture tubes consumed significant amounts of lithium concentrates overseas. Low-iron spodumene and petalite were sources of the lithium used to improve the physical properties of container and bottle glass, and sources of alumina, another important component of the glass. Glass manufacturers used lithium in container and bottle glass, enabling them to produce lighter weight, thinner walled products. Until 1997, lithium ore concentrates were the only lithium products that were acceptable for most ceramics and glass applications because of their low cost in comparison to lithium carbonate. Applications sensitive to other elements and impurities that came with ore concentrates and the price of lithium carbonate were not able 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).

The second largest use is in primary aluminum production, especially at older smelters. Adding lithium carbonate to aluminum potlines lowers the melting point of the bath, allows a lower operating temperature for the potline, 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 addition to aluminum potlines—reducing fluorine emissions by 20% to 30% (Chemetall GmbH, 2001, Lithium applications, accessed April 2, 2001at URL http://www.chemetalllithiumcom/lithium/lithium.nsf/Frame/25083639DDB37807C125693D00491D90).

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 initiated 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. 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 2000. 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 military, industrial, automotive, aircraft, and marine applications.

The use of lithium in batteries and the belief that lithium batteries may be the best way to power electric vehicles (EVs) have spurred tremendous interest in lithium and lithium deposits to provide resources for the anticipated increased demand. Almost all major battery manufacturers marketed some type of lithium battery, and research and development continued. New battery configurations continued to be developed and continued interest in EVs drove additional interest in battery research. New, more efficient types of rechargeable (secondary) lithium batteries have been developed and older designs improved to meet the requirements of the EV market and of electronic equipment, such as portable telephones, portable computers, and video cameras. Research continued on lithium-ion batteries. These batteries were of particular interest 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. Nissan Motor Corp. U.S.A. introduced its first EV available in the United States at the 1998 Los Angeles Auto Show. The four-passenger minivan was powered by lithium-ion batteries developed jointly by Nissan and Sony Corp. This was the first EV from any automobile company that used lithium-ion batteries (Advanced Battery Technology, 1998).

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 watches, microcomputers, cameras, small appliances, electronic games, and toys. The military purchased large and small lithium batteries for a variety of military applications. In 2000, two lithium oxyhalide reserve batteries were qualified for use in different missile programs, the High Altitude Area Defense and the Boeing Ground Based programs. Reserve batteries 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 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 boron, graphite, or aramid fibers imbedded 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 National Aeronautics and Space Administration selected a new design by Lockheed Martin Manned Space Systems for the external space shuttle fuel tank; this is the only part that is not reused. The superlightweight tank 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 aluminum alloy previously used. 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. Reynolds Metals and McCook Metals were to produce 25 of the redesigned fuel tanks (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 swimming pools, commercial glassware, and public restrooms contained lithium hypochlorite, as did dry bleaches for commercial laundries. Lithium metal was used as a scavenger to remove impurities from copper and bronze, and anhydrous lithium chloride was used as a component in fluxes for hard-to-weld metals, such as steel alloys and aluminum.

**Prices**

Although yearend 2000 published prices for lithium carbonate were the same as those listed in trade publications in 1999, actual prices paid by customers were believed to be significantly lower than those published. The vigorous entrance into the market of SQM in 1998 prompted Chemetall Foote and FMC to reduce their prices comparably, although actual price lists and quotations have been difficult to obtain since the price reductions began. SQM entered the market offering lithium carbonate at about $2.00 per kilogram ($0.90 per pound); effective October 1, 1999, the company raised its price by about 10% to around $2.20 per kilogram ($1.00 per pound) (Industrial Minerals, 1999b). Chemetall and FMC announced price increases of 8% and $0.22 per kilogram ($0.10 per pound), respectively, at the end of 2000, although no specific prices were published (Industrial Minerals, 2000b).

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 46% from 1996 to 1999; the average value increased almost 7% in 2000. The unit value for lithium carbonate from Chile has decreased steadily from $2.70 per kilogram in 1996 to $1.45 in 2000. Imports from Argentina were recorded for the first time in 1998; the unit value for this material in 2000 was $3.06 per kilogram. Even the highest values listed here were significantly lower than the published price of $4.47 per kilogram (table 2).

## Foreign Trade

Total exports of lithium compounds from the United States decreased significantly in 1998 as compared with the previous years; exports have continued at the lower level. Because of the closures of the spodumene mine and lithium carbonate plant in North Carolina, lithium carbonate production in the United States has decreased substantially. The reduced production made lower exports inevitable. Commitments to overseas customers were supplied from operations in South America. About 68% of all U.S. exports of lithium compounds were to Canada, Germany, India, Japan, and the United Kingdom (table 3).

Imports of lithium compounds increased nearly 10% in 2000. In 2000, 88% of lithium imports was from Chile; and lithium carbonate from Argentina was 7.5% of total imports (table 4). 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 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, Canada, Chile, China, Portugal, Russia, and Zimbabwe. Brazil produced smaller quantities, primarily concentrates; Namibia, Rwanda, South Africa, and Zaire are past producers of concentrates. Production figures for lithium ore concentrates and lithium carbonate are shown in table 5. 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.

Argentina.—After only one 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 in July (Brown, 1999) except for limited production for a specialized market (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), but technical problems and poor market conditions 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, 1999a). A proprietary selective purification process developed by FMC reduced the number of steps required to recover lithium chloride from the brine and reduced the cost of production (FMC Corp., 1998).

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. Avalon Ventures Ltd. was developing the company's Separation Rapids rare metals project in northwestern Ontario not far from the Tanco operation. Avalon was increasing the capacity of its flotation pilot plant to be able to produce large enough volumes to provide potential customers with enough high-grade petalite concentrate for sampling. The company expected to market most of its product to glass and ceramics producers in the Ohio River Valley in the United States (North American Mineral News, 2000b, p. 12).

The Tanco operation and the Avalon project are on opposite ends of a pegmatite body that extends for more than 8 kilometers (5 miles) from Manitoba into Ontario. Amzin Minerals Ltd., the offshore holding company of Bikita Minerals Ltd., the Zimbabwe petalite producer, planned to produce petalite at a site owned by Emerald Fields Resource Corp., a Canadian company, on the same pegmatite body between the Tanco and Avalon operations. This operation was named the Big Mack. A sample was evaluated and approved by Corning Inc. for its acceptability for ceramics and glass uses. Another sample was sent to Zimbabwe to determine if it was appropriate for beneficiation using Bikita technology. If all the tests turned out as expected, construction of a plant with an initial production capacity of 15,000 t/yr of petalite concentrate was to begin by the spring of 2001. Resources at the Big Mack are conservatively estimated at 300,000 metric tons; but only a small portion of Emerald Fields' 18,200 hectares (45,000 acres) have been drilled (Industrial Minerals, 2000a).

Lithium Metal Technologies Inc. (Limtech), a subsidiary of Lithos Corp., both Canadian companies, was evaluating options for expanding its high-purity lithium carbonate plant to produce more than its current 300 t/yr for sale to specialty glass manufacturers. Limtech purifies technical-grade lithium carbonate from about 99.3% purity to a high-purity 99.999% product that can sell for $50 to $70 per kilogram. The company was considering an additional production line with capacity of 1,000 t/yr (North American Mineral News, 2000a).

Raymor Industries Inc. announced the successful development of a process to produce lithium metal directly from spodumene. The process was developed and tested at McGill University's Department of Mining and Metallurgical Engineering under contract with Raymor Industries. Raymor Industries asserted that the new process would entail the lowest production costs and highest purity for lithium metal production. The company was granted exclusive rights to the new technology that was to be patented. For feed stock, Raymor Industries intended to use spodumene mined from its La Motte deposit in Quebec and purchased spodumene (Raymor Industries Inc., 2000). A drilling project at the La Motte deposit estimated reserves at 4.55 million metric tons (Mt) at 1.07% $Li_2O$ from the surface to the depth of 100 meters (m) with an additional 2.5 Mt below 100 m. The first phase of development involved the construction of a concentration plant to process the ore from an open pit mine. Following the completion of the processing plant, Raymor Industries planned to use the new process to produce lithium metal directly from the spodumene ore without going through the steps required by more traditional lithium metal production (North American Minerals News, 1999).

Chile.—With two large brine operations at the Salar de Atacama and their associated lithium carbonate plants, Chile has become 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 its parent company Chemetall's operations in Germany and Taiwan. SQM completed its first full year of production in 1997 and was planning to increase capacity by 8% to 10% from the original 20,000 t/yr (Industrial Minerals, 1999c); the company was considering expanding into downstream compounds by building a butyllithium plant in Texas and facilities to produce battery materials (Schmitt, 2000). Both companies transport concentrated brines from the Salar 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 smaller quantities from China and Russia (McCoy, 1999).

China.—Lithium carbonate production in China is from domestic and Australian spodumene ore. Production was limited in 1999 because of the availability of lower cost material from Chile (McCoy, 1999). No significant increase in production was expected in the near future. Tibet Lithium New Technology Development Co., formed as a joint venture by China's Geological Research Institute (20%), Tibet Mineral Development Co. (40%), and Yuxin Trading Co. (40%), was developing a lithium project at the Zabuye Salt Lake in Tibet. A 10-year study at the salt lake identified high concentrations of boron, bromine, cesium, lithium, and potassium. Lithium production within 3 years was the goal of the company (Saller and O'Driscoll, 2000, p. 47). Another lithium project at salt lakes in the Qinghai Province was being considered. Pacific Lithium Ltd., a New Zealand company, reached agreement with the Qinghai Province to create Qinghai Lithium Ltd. (QLL), a joint venture, to study and develop the salt lake resource that was discovered in 1965. QLL's lithium resources were estimated at 1 Mt lithium, more than 1 Mt boron, and more than 17 Mt potassium (Pacific Lithium Ltd., 2000, Qinghai Lithium Limited, accessed April 4, 2000, at URL http://www.pacificlithium.com/technology/associations.html).

Germany.—Chemetall GmbH, 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. In 2000, the company expanded its capacity for the production of lithium aluminum hydride by 50%; another facility was built to produce lithium aluminum hydride solutions. Chemetall is the world's leading producer of lithium aluminum hydride, a versatile reducing agent used in the synthesis of active substances in the pharmaceutical industry. It is marketed as a powder, in tablet form, and in solution (Chemetall GmbH, 2000). Chemetall opened a butyllithium plant in Taiwan in 1999 in response to the growth in demand for organic lithium catalysts (Industrial Minerals, 1999a).

## 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. 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 are becoming more important. Demand for N-butyllithium continued to increase, and producers considered more capacity increases to meet that demand. 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.

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, Applications markets, accessed April 4, 2000, at URL http://www.pacificlithium.com/profile/markets.html). 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 rate or quite probably more quickly.

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. 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 were perfected. This is not expected to take place within the next 25 years and may never occur.

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TABLE 1
SALIENT LITHIUM STATISTICS 1/

(Metric tons of contained lithium)

| | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|
| United States: | | | | | |
| Production | W | W | W | W | W |
| Producers' stock changes | W | W | W | W | W |
| Exports 2/ | 2,200 | 1,880 | 1,340 | 1,330 | 1,310 |
| Imports 2/ | 884 | 975 | 2,590 | 2,640 | 2,880 |
| Consumption: | | | | | |
| Apparent | W | W | W | W | W |
| Estimated | 2,700 | 2,800 | 2,800 | 2,800 | 2,800 |
| Rest of world production 3/ | 12,700 r/ | 14,200 r/ | 14,300 r/ | 13,800 r/ | 14,000 e/ |

e/ Estimated. 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
DOMESTIC YEAREND PRODUCERS' AVERAGE PRICES OF LITHIUM AND LITHIUM COMPOUNDS

| | 1999 e/ | | 2000 e/ | |
|---|---|---|---|---|
| | Dollars per kilogram | Dollars per pound | Dollars per kilogram | Dollars per pound |
| Lithium bromide, 54% brine: Truckload lots, delivered in drums | 12.83 | 5.83 | 12.83 | 5.83 |
| Lithium carbonate, technical: Truckload lots, delivered | 4.47 | 2.03 | 4.47 | 2.03 |
| Lithium chloride, anhydrous, purified: Truckload lots, delivered | 11.00 | 5.00 | 11.00 | 5.00 |
| Lithium fluoride | 16.94 | 7.70 | 16.94 | 7.70 |
| Lithium hydroxide monohydrate: Truckload lots, delivered | 5.74 | 2.61 | 5.74 | 2.61 |
| Lithium metal ingot, technical grade: 1,000-pound lots, delivered | 85.92 | 39.05 | 85.92 | 39.05 |
| N-butyllithium in n-hexane (15%): Truckload lots, delivered | 44.88 | 20.40 | 44.88 | 20.40 |

e/ Estimated.

Source: Chemical Market Reporter, v. 258, no. 25, December 18, 2000, p. 23 and 26, and v. 257, no. 7, February 14, 2000, p. 39 and 42. Chemical prices for week ending December 15, 2000, for 2000 data, and February 11, 2000, for 1999 data.

TABLE 3
U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY 1/

| | 1999 | | 2000 | |
|---|---|---|---|---|
| Compound and country | Gross weight (metric tons) | Value (thousands) | Gross weight (metric tons) | Value (thousands) |
| Lithium carbonate: | | | | |
| Australia | 8 | $92 | 32 | $187 |
| Canada | 683 | 2,450 | 562 | 2,020 |
| China | 189 | 681 | 97 | 349 |
| Germany | 346 | 1,480 | 765 | 2,240 |
| India | 14 | 51 | 8 | 29 |
| Japan | 901 | 3,090 | 903 | 3,140 |
| Korea, Republic of | 33 | 114 | 51 | 184 |
| Mexico | 11 | 50 | 7 | 29 |
| Netherlands | 70 | 250 | 47 | 170 |
| Taiwan | 25 | 90 | 28 | 100 |
| United Kingdom | 274 | 739 | 179 | 624 |
| Other | 132 | 471 | 58 | 216 |
| Total | 2,690 | 9,550 | 2,740 | 9,280 |
| Lithium carbonate U.S.P.: 2/ | | | | |
| Israel | (3/) | 18 | 1 | 19 |
| Mexico | 18 | 28 | 3 | 6 |
| Netherlands | -- | -- | 23 | 30 |
| Other | 5 | 69 | 3 | 299 |
| Total | 23 | 115 | 30 | 354 |

See footnotes at end of table.

TABLE 3--Continued
U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY 1/

| Compound and country | 1999 Gross weight (metric tons) | 1999 Value (thousands) | 2000 Gross weight (metric tons) | 2000 Value (thousands) |
|---|---|---|---|---|
| Lithium hydroxide: | | | | |
| Argentina | 132 | $489 | 126 | $446 |
| Australia | 205 | 851 | 218 | 6,860 |
| Canada | 150 | 591 | 144 | 566 |
| Chile | 95 | 380 | 27 | 108 |
| China | 19 | 80 | 3 | 100 |
| Germany | 545 | 1,770 | 627 | 2,020 |
| India | 450 | 1,410 | 383 | 1,080 |
| Japan | 1,410 | 7,870 | 1,340 | 6,930 |
| Korea, Republic of | 226 | 948 | 146 | 612 |
| Mexico | 141 | 979 | 99 | 427 |
| Netherlands | 161 | 571 | 142 | 333 |
| New Zealand | 54 | 224 | 188 | 780 |
| Philippines | -- | -- | 26 | 104 |
| Singapore | 108 | 466 | 60 | 253 |
| Thailand | 74 | 222 | 137 | 377 |
| Taiwan | 33 | 130 | 2 | 25 |
| United Kingdom | 178 | 612 | 241 | 2,220 |
| Other | 960 | 3,660 r/ | 873 | 7,840 |
| Total | 4,940 | 21,200 | 4,780 | 31,100 |

r/ Revised. -- Zero.

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

2/ Pharmaceutical-grade lithium carbonate.

3/ Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS BY COMPOUND AND COUNTRY 1/

| Compound and country | 1999 Gross weight (metric tons) | 1999 Value 2/ (thousands) | 2000 Gross weight (metric tons) | 2000 Value 2/ (thousands) |
|---|---|---|---|---|
| Lithium carbonate: | | | | |
| Argentina | 911 | $1,710 | 1,160 | $3,550 |
| Canada | (3/) | 13 | (3/) | 3 |
| Chile | 12,800 | 18,700 | 13,500 | 19,600 |
| Germany | 17 | 66 | (3/) | 4 |
| Japan | 15 | 75 | 2 | 36 |
| New Zealand | 21 | 88 | 113 | 522 |
| Other | 23 | 81 | 22 | 63 |
| Total | 13,800 | 20,800 | 14,800 | 23,800 |
| Lithium hydroxide: | | | | |
| Chile | -- | -- | 91 | 224 |
| China | 96 | 249 | 367 | 962 |
| Japan | 25 | 572 | 19 | 252 |
| Taiwan | 14 | 50 | (3/) | 6 |
| Other | 119 | 755 | 138 | 659 |
| Total | 254 | 1,630 | 615 | 2,100 |

-- 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 5
LITHIUM MINERALS AND BRINE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

| Country 3/ | 1996 | 1997 | 1998 | 1999 e/ | 2000 e/ |
|---|---|---|---|---|---|
| Argentina: e/ | | | | | |
| Spodumene and amblygonite | 400 | 697 4/ | 700 | 700 | 700 |
| Carbonate from subsurface brine | -- | -- | 6,000 | 1,000 | 1,000 |
| Australia, spodumene | 117,094 r/ | 88,399 | 63,190 r/ | 75,824 r/ 4/ | 76,000 |
| Brazil, concentrates e/ | 1,600 | 1,600 | 1,600 | 1,600 | 1,600 |
| Canada, spodumene e/ 5/ | 22,000 | 22,500 | 22,500 | 22,500 | 22,500 |
| Chile, carbonate from subsurface brine | 14,180 | 24,246 | 28,313 | 28,000 | 28,500 |
| China, carbonate e/ | 15,000 | 15,500 | 13,000 | 12,500 | 13,000 |
| Namibia, concentrates, chiefly petalite | 1,972 | 1,019 | 500 | -- | -- |
| Portugal, lepidolite | 7,626 | 6,883 | 7,000 e/ | 7,000 | 7,000 |
| Russia (minerals not specified) e/ 6/ 7/ | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |
| United States, spodumene and subsurface brine | W | W | W | W | W |
| Zimbabwe 8/ | 30,929 | 49,833 | 28,055 | 36,691 r/ 4/ | 37,000 |

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.
1/ Table includes data available through March 29, 2001.
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 avail 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.
8/ Amblygonite, eucryptite, lepidolite, petalite, and spodumene.