LITHIUM

By Joyce A. Ober

The United States has been the largest producer and consumer of lithium and its compounds, and two U.S. companies have been the leading lithium carbonate producers in the world for many years. Chile, an increasingly important player in the lithium industry, may become the world lithium leader by the end of this century with the completion of a second lithium operation late in 1996.

Because lithium is electrochemically reactive and has other unique properties, there are many commercial lithium products. Producers sell lithium as mineral concentrate, brine, compound, or metal depending on the end use. Most lithium compounds are consumed in the production of ceramics, glass, and primary aluminum.

Legislation and Government Programs

During the 1950's and 1960's, the U.S. Government nuclear weapons programs required lithium hydroxide monohydrate for the recovery of the lithium-6 isotope used in the production of tritium, a compound necessary for nuclear fission reactions. When the U.S. Department of Defense discontinued these programs, a stockpile of lithium hydroxide monohydrate remained, about 75% of which had been depleted of the lithium-6 isotope. The processed material contained up to 8 or 9 parts per million of mercury. The U.S. Department of Energy (DOE) took over administration of the stockpile in 1988.

In 1993, DOE completed an environmental assessment of the material to determine if sales of the mercury-contaminated material presented a risk to environmental quality. After issuing a "Finding of No Significant Impact," the material was offered for sale. After negligible sales in 1993 and 1994, the remaining stocks of about 41,000 metric tons of lithium hydroxide were sold in 1995.

Toxco, Inc., a lithium product recycler based in Anaheim, CA, bought about 31,000 tons of processed material, and Cyprus Foote Mineral Co., a major lithium producer based in Kings Mountain, NC, purchased 10,000 tons of virgin lithium hydroxide monohydrate. The sale was complicated by the condition that Toxco and Cyprus Foote could purchase only 70% of the stockpile processed material and virgin lithium hydroxide monohydrate, respectively, until DOE offered the remainder to the general public at the same prices paid by the two companies. In early 1996, the processed material was offered at 13¢ per pound, and the virgin material, at 18.3¢ (U.S. Department of Energy, 1995); no additional sales were announced. Toxco took delivery of about 900 tons of DOE lithium hydroxide monohydrate in 1996. Toxco intended to market the DOE material, as well as the lithium salts from its recycling operation, for use in the U.S. construction industry as an additive to Portland cement concrete. The company has formed a marketing division, LithChem International to market its material. This information was confirmed by William McLaughlin (Toxco, Inc., oral commun., 1997).

Production

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

Cyprus Foote produced about 6,400 tons of lithium carbonate from its brine deposit in Silver Peak, NV (Cyprus Amax Minerals Co., 1997). In addition to its Nevada operation, Cyprus Foote, the world's largest lithium company and a subsidiary of Cyprus Amax Minerals Co., owns a spodumene mine in Kings Mountain that has been inactive since 1991. The lithium carbonate plant in Kings Mountain was dismantled in 1994. A new lithium hydroxide production facility was completed at Silver Peak in the second quarter of 1996; the lithium hydroxide plant in Sunbright, VA, was closed in August. The company operates a butyllithium plant in New Johnsonville, TN. Cyprus Foote also owns and operates a large lithium operation in Chile.

FMC Corp., Lithium Div., mines spodumene, a lithium ore, from pegmatite dikes near Bessemer City, NC. FMC also produces lithium carbonate and a full range of downstream compounds, including lithium metal and some organic lithium compounds, at a chemical plant near the mine and operates a butyllithium plant in Bayport, TX. FMC is developing a large lithium brine operation in Argentina. Upon the completion of this project, expected in early 1997, FMC intends to phase out mining in North Carolina but will maintain all the other facilities at its operations there.

Lithium carbonate is the most important lithium compound produced from brine and ore deposits. 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 consumed directly in certain applications. Spodumene concentrates and brines are converted to lithium carbonate and then to other compounds for consumption in other end uses.

Extracting lithium from spodumene entails an energy-intensive chemical recovery process. After mining, spodumene is crushed and undergoes a flotation beneficiation process to produce concentrate. Concentrate is heated to 1,075 °C to 1,100 °C, changing the molecular 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.

Production of lithium carbonate from brine is much less energy intensive than that from spodumene. Nevada brines enriched in lithium chloride, averaging about 300 parts per million when operation 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 parts per million 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. Approximately the same process is used to recover lithium from the Chilean brines, with slight adjustments to account for their different chemistries.

Consumption

The aluminum, ceramics and glass, lubricating grease, and synthetic rubber industries consumed most of the lithium minerals and chemicals sold in 1996. Estimated domestic consumption increased slightly from 1995. Ceramics and glass production and aluminum smelters were the largest consumers of lithium carbonate and lithium concentrates in the United States, composing an estimated 20% and 18% of the lithium market, respectively. Other consuming industries were synthetic rubber and pharmaceuticals, 13%; chemical manufacturing, 13%; miscellaneous chemicals, 12%; lubricants, 11%; batteries, 7%; and air treatment, 4% (Cyprus Minerals Co., 1993).

The largest consumer of lithium compounds in the United States are lithium carbonate and mineral concentrate additions in ceramics and glass manufacturing processes. These additions lower process melting points, reduce the coefficient of thermal expansion and the viscosity, and eliminate the use of more toxic chemicals. The domestic manufacture of thermal shock-resistant cookware (pyroceramics) consumes the majority of lithium used in the ceramics and glass industry. The manufacture of black-and-white television picture tubes consume significant amounts of lithium concentrates overseas. Low-iron spodumene and petalite are sources of the lithium used to improve the physical properties of container and bottle glass and as a source of alumina, another important component of the glass. Glass manufacturers use lithium in container and bottle glass, enabling them to produce lighter weight, thinner walled products.

The second largest consumers, aluminum producers, add lithium carbonate to aluminum potlines to lower the melting point of the bath, allowing a lower operating temperature for the potline, and increasing the electrical conductivity of the bath. These factors contribute to increased production or reduced power consumption, as well as to the indirect benefit of lower fluoride emissions.

The third largest end use for lithium compounds is as catalysts in the production of synthetic rubbers, plastics, and pharmaceuticals. N-butyllithium initiates the reactions between styrene and butadiene that form abrasion-resistant synthetic rubbers that require no vulcanization. Other organic lithium compounds are catalysts for the production of plastics, such as polyethylene. Lithium metal and compounds also are used by pharmaceutical manufacturers in the production of vitamin A, some steroids, an anticholesterol agent, an analgesic, antihistamines, tranquilizers, sleep inducers, contraceptives, and other products. Pharmaceutical-grade lithium carbonate is approved directly for the treatment for manic-depressive psychosis. This is the only treatment approved by the U.S. Food and Drug Administration in which lithium is consumed by the patient.

The multipurpose grease industry was another of the important end uses for lithium in 1996. Lithium hydroxide monohydrate was the compound used for the production of lithium lubricants. Lithium-base greases are 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.

Almost all major battery manufacturers marketed some type of lithium batteries, and research and development continued. These batteries represent a growth area for lithium consumption, and new battery configurations continue to be developed. Continued interest in electrically powered vehicles spurred additional interest in battery research. New, more efficient types of rechargeable (secondary) lithium batteries have been developed and improved to meet the requirements of this market and of electronic equipment, such as portable telephones and video cameras. Work continued on lithium ion batteries. These batteries are of particular interest because they take advantage of the large power capacity available from lithium batteries with fewer safety problems than encountered when batteries contain lithium metal, a very reactive and volatile material when exposed to air and moisture.

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. The Galileo spacecraft, launched in October 1989 by the National Aeronautics and Space Administration (NASA) for its 6-year trip to explore the atmosphere of Jupiter, contained lithium sulfur dioxide batteries to power its scientific instruments when it reached its destination (Battery Technology, 1990). Recent modifications to the lithium sulfur dioxide battery have extended the life of the batteries to at least 10 years with little or no reduction in performance. The final disposition of lithium batteries is of concern. Until recently, no method was available for the safe and economic disposal of large lithium batteries, especially the military types. In 1994, Toxco developed a process for recycling lithium battery components and opened a facility for the neutralization, disposal, and recycling of lithium batteries, primarily large military types, in Trail, British Columbia (Vimmerstedt and others, 1995, p. 25, 26).

Aircraft manufacturers in several countries are using or are considering the use of aluminum-lithium alloys for wing and fuselage skin or structural members in different types of aircraft. Use of these alloys can 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, are attractive to the aircraft and aerospace industries because of their reduced density and superior corrosion resistance compared with those of conventional aluminum alloys. These alloys are not as widely used in aircraft manufacture as was hoped at the initial introduction of the alloys. In airplane construction, these alloys face direct competition from composite materials consisting of boron, graphite, or aramid fibers imbedded in polymers.

During 1996, NASA began testing a new design for the external fuel tank used on the space shuttle (the only part that is not reused). The super-light-weight tank, designed by Lockheed Martin Manned Space Systems, is constructed of an aluminum-lithium alloy containing 1% lithium, 4% copper, 0.4% silver, 0.4% magnesium, and the remainder aluminum. This alloy is 30% stronger and 5% less dense than the aluminum alloy previously used. The redesigned fuel tank will weigh about 3,400 kilograms less than the current design; the weight savings can be used to increase the payload capacity for future shuttle missions. Tests continued throughout the year at NASA's Marshall Spaceflight Center in Huntsville, AL, and results were expected early in 1997 (Lockheed Martin Corp., 1996). The new tank design is expected to be used first during the shuttle launches carrying the initial portions of the international space station (National Aeronautics and Space Administration, 1997).

Small quantities of other lithium compounds are important to many industries. Lithium chloride and lithium bromide are 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 contain lithium hypochlorite, as do dry bleaches for commercial laundries. Lithium metal is used as a scavenger to remove impurities from copper and bronze, and anhydrous lithium chloride is used as a component in fluxes for hard-to-weld metals, such as steel alloys and aluminum.

Prices

Yearend published prices for lithium carbonate, the largest volume lithium compound, were unchanged in 1996. Actual prices paid by customers, however, were believed to be significantly lower owing to the December entrance of a second Chilean producer into the lithium carbonate market with the capability of producing large quantities of low-cost carbonate at its operation. Lithium hydroxide monohydrate decreased about 5%, and technical-grade lithium metal increased about 4%. Price changes varied by compound, but overall, prices were stable. *(See table 2.)*

Foreign Trade

Total U.S. exports of lithium compounds were nearly 16% higher in 1996 than in 1995. About 64% of all U.S. exports of lithium compounds were to Germany, Japan, and the United Kingdom.

Imports of lithium compounds decreased 22%. Chile accounted for 92% of all imports, and virtually all the Chilean imports came from Cyprus Foote's operation. Lithium ore concentrates from Australia, Canada, and Zimbabwe were believed to have been consumed in the United States, but no import statistics were available. *(See tables 3 and 4.)*

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 Australia, Canada, Chile, China, Portugal, Russia, and Zimbabwe. Argentina, Brazil, and Namibia produced smaller quantities, primarily concentrates. Rwanda, South Africa, and Zaire are past producers of concentrates. 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 Argentina, Bolivia, China, and Israel. Companies in France, Germany, Japan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

Argentina.—FMC progressed in its construction of a lithium brine operation on the Salar de Hombre Muerto in the Argentine Andes. A proprietary selective purification process developed by FMC reduces the number of steps required to recover lithium chloride from the brine and reduces the cost of production compared with other lithium brine operations. A lithium carbonate plant also will operate at the site, and lithium chloride and lithium carbonate will be produced. Capacity is expected to be about 20,000 tons of lithium carbonate equivalent (Kendall, 1997, p. 51). FMC expects the Argentine operation to be completed in 1997, and reserves at the Salar should last at least 75 years at design capacity (FMC Corp., 1997, p. 14).

Australia.—Gwalia Consolidated Ltd., the only lithium ore concentrate producer in Australia and the largest in the world, was building a lithium carbonate plant at its spodumene mine at Greenbushes, Western Australia. The plant was expected to begin production in 1996 at a level of 1,000 tons per year lithium carbonate, with a design capacity of 5,000. Technical problems delayed expanded production and full capacity may not be reached until sometime in 1999 (Platt's Metals Week, 1996).

Canada.—The continued interest in lithium batteries and the potential growth of the industry if electric vehicles are powered by lithium batteries have prompted Lithos Corp. of Montreal to explore the possibility of producing lithium metal from lithium deposits in Quebec. Lithos sponsored a research project to develop a low-cost process for producing lithium metal from lithium carbonate and lithium chloride. Electricity prices in Quebec are lower than anywhere in North America, and the low-cost electricity will be instrumental in developing the process (Lithos Corp., 1996a).

The company announced plans at midyear to build a pilot plant to produce 20 to 30 tons of lithium metal per year. Lithos plans to commercialize its patented process for converting lithium carbonate to metal and eventually to produce 200 to 300 tons per year (Lithos Corp., 1996b). Initial production will be based upon purchased lithium carbonate because Lithos has not developed its lithium deposits or built a lithium carbonate plant.

Chile.—Sociedad Quimica y Minera de Chile, a Chilean fertilizer producer, completed development of the second phase of its project on the Salar de Atacama, known as Minsal S.A. The first stage was to produce raw material to supply its potassium nitrate plant. The lithium carbonate portion of the operation began continuous production in November and shipped its first commercial product at the end of 1996 from its plant in Antofagasta (Minsal S.A., 1996).

Minsal announced plans to enter the lithium carbonate market and offered lithium carbonate at $1.98 per kilogram ($0.90 per pound), less than half the Cyprus Foote and FMC prices listed at the time of the announcement. Production rates were expected to expand rapidly to reach more than 18,000 tons. The company expects significantly lower prices to help the company establish market share. Lower prices could lead to an increase in demand for lithium products in new uses for which the cost of lithium compounds has been prohibitive, resulting in enlarged markets for lithium products from all producers (McCoy, 1996, p. 5, 23).

Cyprus Foote began operating a lithium brine project on the same deposit in 1984. The company reported production of 14,000 tons of lithium from its lithium carbonate plant, also in Antofagasta, in 1996 (Cyprus Amax Minerals Co., 1997, p. 13). When both of these operations reach production capacity, Chile should surpass the United States as the world leader in lithium production in all forms.

China.—Details on lithium carbonate production were available for the first time in 1996 and are included in table 5. Lithium carbonate is produced at 13 small plants in 6 provinces (Henan, Hunan, Jiang Su, Jiangxi, Sichuan, and Xinjiang). The lithium carbonate is produced at a large number of small-capacity plants. The largest plant has the capacity to produce 8,000 tons per year, and 10 plants are capable of producing less than 2,000 tons per year. The lithium carbonate plants are reported to use spodumene from deposits in Xinjiang and Sichuan Provinces and lepidolite from Jiangxi Province. Gwalia's spodumene concentrates from Australia also are being used at some of these plants; and Chinese ceramics and glass producers use spodumene concentrates from Gwalia. Chinese lithium is consumed in the following industries: ceramics and glass, 30%; aluminum, 13%; air conditioning, 10%; miscellaneous chemicals, 9%; chemical manufacture, 9%; lubricants, 8%; and batteries, less than 1%. About 20% of China's lithium production is exported.

New Zealand.—Pacific Lithium Ltd. of Aukland, New Zealand, reached a long-term agreement with Toxco to purchase most of Toxco's lithium salts from its Trail, British Columbia, operation and much of the lithium hydroxide monohydrate Toxco acquired from DOE. Pacific Lithium will convert the Toxco material to high-grade lithium carbonate that will then be used in various forms for lithium batteries (Toxco Waste Management Ltd., 1997). Pacific Lithium also is developing a process for adsorbing and processing lithium contained in geothermal brines and seawater. If successful, this process would greatly expand the lithium resources worldwide (Pacific Lithium Ltd., 1997, p. 2).

Outlook

The health of the lithium industry continues to be closely tied to the performance of the primary aluminum industry, the ceramics and glass industry, and the economy in general. Changes in consumption of lithium in these industries determines 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. Demand for N-butyllithium is expected to continue to increase, and domestic producers have increased production capacity to meet that demand. Demand for lithium metal for batteries and to some extent for alloys should increase, but total consumption of metal will remain low in comparison with the demand for lithium compounds.

Lithium ion batteries, containing lithium in a form other than metal, appear to possess the greatest potential for growth for the entire lithium industry. Lithium ion battery sales in Japan surpassed those of nickel cadmium batteries for the first time in 1996 as a result of the increased popularity of mobile telephones, portable computers, and other consumer electronic products (Matsushita Battery Industry Co. Ltd., 1996). Indications are that major battery producers are confident enough in the success of their research that they have begun to investigate the available supply of lithium raw materials.

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 occur within the remainder of this century, probably not within the next 25 years, and perhaps never.

New uses of lithium in the remediation of premature deterioration of concrete through alkali silica reactivity could present another large market for lithium compounds; it may, however, take a few years for lithium hydroxide monohydrate additions to become common, if at all. Other uses of lithium to combat structural deterioration of concrete also are being investigated, but it is too early to predict if these new uses will ever become a significant market.

Chile should overtake the United States as the largest producer of lithium carbonate in 1997, if the Minsal operation reaches full capacity. In addition, when FMC's Argentine operation is phased in and its North Carolina mine is phased out, South America will become the predominant lithium production area in the world.

References Cited

Battery Technology, 1990, Varta lithium battery on Galileo's 6-year voyage: Battery Technology, v. 26, no. 6, p.1.

Cyprus Amax Minerals Co., 1997, Cyprus Amax 10-K report 1996: Englewood, CO, p. 13.

Cyprus Minerals Co., 1993, Cyprus Minerals annual report 1992: Englewood, CO, p. 14.

Engineering and Mining Journal, 1970, Silver Peak gives bright look to Foote Mineral's lithium picture: Engineering and Mining Journal, v. 171, no. 4, p. 72.

FMC Corp., 1997, FMC annual report 1996: Chicago, IL, 58 p.

Kendall, Tom, 1997, New project round-up—South America: Industrial Minerals (London), no. 352, p. 51-57.

Lithos Corp., 1996a, Lithos intends to become a world leader in the production of lithium metal: Lithos Corp. press release, January 11, 1996, 1 p. (Accessed April 15, 1997, on the World Wide Web at URL http://www.lithos.qc.ca/compress/1996/c960111e.htm)

———, 1996b, Lithos will produce a minimum of 20 tonnes of lithium metal thanks to a pilot plant to be built by yearend: Lithos Corp. press release, June 26, 1996, 1 p. (Accessed April 15, 1997, on the World Wide Web at URL http://www.lithos.qc.ca/compress/1996/c960626e.htm)

Lockheed Martin Corp., 1996, Space shuttle super lightweight tank: Lockheed Martin press release, December 16, 1996. (Accessed April 21, 1997, on the World Wide Web at URL http://www.lmco.com/manned/slwtank.html)

Matsushita Battery Industry Co. Ltd., 1996, Matsushita Battery betting on lithium ion cells: Matsushita Battery Industry Co., Ltd. Press release, November 8, 1996, 1 p. (Accessed April 15, 1997, on the World Wide Web at URL http://www.jpnco..jp/ nov96/jp5.html)

McCoy, Michael, 1996, Minsal to shake up lithium with its new chemical plant: Chemical Marketing Reporter, v. 250, no. 9, p. 5, 23.

Minsal S.A., 1996, Minsal ships first commercial lithium carbonate: Minsal S.A. press release, December 16, 1996, 1 p.)

National Aeronautics and Space Administration, 1997, Shuttle's new lighter, stronger external tank completes major performance tests: National Aeronautics and Space Administration press release, March 28, 1997, 1 p. (Accessed April 21, 1997, on the World Wide Web at URL ftp://ftp.hq.nasa.gov/pub/pao/pressrel/1997/97-058.txt)

Pacific Lithium Ltd., 1997, Company brochure: Pacific Lithium Ltd., 6 p.

Platt's Metals Week, 1996, Gwalia, FMC not competitors for the lithium carbonate market: Platt's Metals Week, v. 67, no. 35, p. 10.

Toxco Waste Mangement Ltd., 1997, Major breakthrough at Toxco: Toxco Waste Management Ltd. Press release, February 10, 1997, 1 p.

U.S. Department of Energy, 1995, DOE sells major portion of lithium stockpile: Department of Energy News, August 24, 1995, 1 p. (Accessed April 3, 1996, on the World Wide Web at URL http://www.doe.gov/whatsnew/pressrel/releases.html)

Vimmerstedt, L.J., Shan Ring, and C.J. Hammel, 1995, Current status of environmental, health, and safety issues of lithium ion electric vehicle batteries: National Renewable Energy Laboratory, Report NREL/TP-473-7673, 50 p.

SOURCES OF INFORMATION

USGS and USBM Publications

Lithium. Ch. in Mineral Commodity Summaries, annual.
Lithium Availability—Market Economy Countries.

Other

Canadian Minerals Yearbook, annual.
Chemical Marketing Reporter, weekly.
Chemical Week, weekly.
Engineering and Mining Journal, monthly.
European Chemical News (London), monthly.
Industrial Minerals (London), monthly.

TABLE 1
SALIENT LITHIUM STATISTICS 1/

(Metric tons of contained lithium)

	1992	1993	1994	1995	1996
United States:					
Production	W	W	W	W	W
Producers' stock changes	W	W	W	W	W
Imports 2/	770	810	851	1,140	884
Exports 2/	2,100	1,700	1,700	1,900	2,200
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,300	2,300	2,500	2,600	2,700
Rest of world: Production 3/	6,860 r/	7,250 r/	7,360 r/	9,900 r/	11,500 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.
1/ Data are rounded to three significant digits.
2/ Compounds.
3/ Mineral concentrate and carbonate.

TABLE 2
DOMESTIC YEAREND PRODUCERS' AVERAGE PRICES OF LITHIUM AND LITHIUM COMPOUNDS

	1995		1996	
	Dollars per pound	Dollars per kilogram	Dollars per pound	Dollars per kilogram
Lithium bromide, 54% brine: Truckload lots, delivered in drums	5.79	12.75	6.06	13.35
Lithium carbonate, technical: Truckload lots, delivered	1.97	4.34	1.97	4.34
Lithium chloride, anhydrous, purfied: Truckload lots, delivered	3.93	8.66	5.13	11.30
Lithium fluoride	7.70	16.96	7.70	16.96
Lithium hydroxide monohydrate: Truckload lots, delivered	2.55	5.62	2.50	5.51
Lithium metal ingot, battery grade: 1,000-pound lots, delivered	45.95	101.21	NA	NA
Lithium metal ingot, technical grade: 1,000-pound lots, delivered	39.05	86.01	40.60	89.43
N-butylithium in n-hexane (15%): Truckload lots, delivered	20.20	44.49	20.40	44.93

NA Not available.

Source: U.S. lithium producers.

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

Compound and country	1995 Gross weight (metric tons)	1995 Value (thousands)	1996 Gross weight (metric tons)	1996 Value (thousands)
Lithium carbonate:				
Australia	69	$314	80	$367
Belgium	--	--	60	213
Canada	783	2,850	1,100	2,860
France	--	--	73	221
Germany	928	2,970	1,460	4,520
India	114	450	44	172
Japan	2,190	7,690	2,700	10,500
Korea, Republic of	138	468	84	289
Mexico	89	348	189	697
Netherlands	341	1,240	493	1,710
Taiwan	--	--	75	276
United Kingdom	963	2,860	1,290	4,580
Venezuela	196	385	1	4
Other	230	1,090	225	815
Total	6,040	20,700	7,870	28,200
Lithium carbonate U.S.P.: 2/				
Argentina	--	--	3	10
Colombia	24	28	--	--
Dominican Republic	5	6	--	--
Hong Kong	10	20	--	--
India	--	--	10	38
Japan	22	141	(3/)	7
Mexico	11	22	--	--
United Kingdom	25	365	2	153
Venezuela	409	1,000	--	--
Other	6	208	1	12
Total	512	1,790	16	220
Lithium hydroxide:				
Argentina	100	427	76	320
Australia	92	390	149	660
Canada	114	537	117	476
Chile	--	--	121	424
Germany	682	2,770	981	3,720
India	573	2,180	353	1,400
Japan	933	4,270	1,100	5,350
Korea, Republic of	266	1,240	240	1,040
Mexico	176	685	137	555
Philippines	--	--	65	318
Singapore	149	667	82	362
Thailand	135	618	138	604
United Kingdom	373	1,200	356	1,470
Other	461	2,440	469	2,250
Total	4,060	17,400	4,390	18,900

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Pharmaceutical-grade lithium carbonate.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 4

U. S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS 1/

Compounds	1995 Quantity (metric tons)	1995 Value 2/ (thousands)	1996 Quantity (metric tons)	1996 Value 2/ (thousands)
Lithium carbonate:				
Chile	5,860	$16,500	4,330	$11,700
China	71	251	72	245
Hong Kong	34	126	--	--
Japan	--	--	8	47
Switzerland	--	--	180	510
Other	2	25	1	12
Total	5,970	16,900	4,590	12,500
Lithium hydroxide:				
China	83	328	108	449
Japan	17	216	15	898
Switzerland	--	--	1	38
Other	4	49	2	54
Total	104	593	126	1,440

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Customs value.

Source: Bureau of the Census.

TABLE 5

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

(Metric tons)

Country 3/	1992	1993	1994	1995	1996 e/
Argentina, spodumene and amblygonite e/	620 4/	300	400	400	400
Australia, spodumene	42,516	52,900 e/	45,987 r/	81,841 r/	117,944 4/
Brazil, concentrates e/	1,600	1,600	1,600	1,600	1,600
Canada, spodumene e/ 5/	18,500	18,900	20,000	21,000	22,000
Chile, carbonate from subsurface brine	10,823	10,369	10,439	14,000 r/	14,500
China, carbonate e/	7,220 r/	8,250 r/	9,050 r/	12,800 r/	15,000
Namibia, concentrates, chiefly petalite	1,162	742	1,861	2,611	2,400
Portugal, lepidolite	15,904 r/	13,289 r/	11,352 r/	10,000 r/ e/	8,000
Russia (minerals not specified) e/ 6/	45,000	40,000	40,000	40,000	40,000
United States, spodumene and subsurface brine	W	W	W	W	W
Zimbabwe (minerals not specified)	12,837	18,064	25,279	26,000 e/	25,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Estimated data are rounded to three significant digits.

2/ Table includes data available through Mar. 31, 1997.

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

4/ Reported figure.

5/ Based on all of 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.