LITHIUM

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With the closure of the last spodumene mine and lithium carbonate plant in North Carolina early in 1998, the shift in dominance of lithium production from the United States to South America was complete. Chile was the leading producer of lithium carbonate with two brine operations, and Argentina's single brine operation completed its first full year of production. A large percentage of the material produced in South America was exported to the United States to replace the lost production resulting from the closure of the facilities in North Carolina. The United States remained the leading producer of value-added lithium compounds and also the leading lithium consumer, despite the production shift to South America. Australia, Canada, and Zimbabwe were important sources of lithium ore concentrates.

Because lithium is electrochemically reactive and has other unique properties, many commercial lithium products are available. 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

In 1997, the U.S. Naval Surface Warfare Center in Crane, IN, awarded a $10.5-million contract to recycle lithium batteries that had been used as backup power sources at underground missile silos. ToxCo, Inc., a recycling company based in Anaheim, CA, began processing the batteries at its Trail, British Columbia, Canada, plant in early 1998. Each battery weighs more than 250 kilograms (kg), and ToxCo will receive and process more than 1 million kilograms of batteries during the 4-year term of the contract. Aluminum, lithium, nickel, and stainless steel were being recovered from the batteries and recycled to use (McLaughlin, 1998). On December 1, 1998, ToxCo processed the one thousandth battery under this contract (W.J. McLaughlin, ToxCo, Inc., written commun., 1998).

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.)

On October 13, 1998, the German company Chemetall GmbH, a subsidiary of Metallgesellschaft AG, completed its purchase of Cyprus Foote Mineral Co. from Cyprus Amax Minerals Co. of Englewood, CO, for $305 million (Cyprus Amax Minerals Co., 1998). Included in the sale were Cyprus Foote's lithium brine deposit and lithium carbonate and lithium hydroxide plants in Silver Peak, NV; its butyllithium plant in New Johnsonville, TN; and its facilities for producing downstream lithium compounds and an idle spodumene (a lithium aluminum silicate ore) deposit in Kings Mountain, NC. Cyprus Foote's brine operation and lithium carbonate plant in Chile were also part of the agreement (North American Minerals News, 1998b).

FMC Corp., Lithium Division, closed its spodumene mine and lithium carbonate plant near Bessemer City, NC, early in the year. The company's lithium carbonate operation in Argentina, completed in 1997, will eliminate the need for the higher cost lithium carbonate from North Carolina. Lithium from Argentina will be used as feedstock for FMC's full range of downstream compounds, including lithium metal and some organic lithium compounds that they produce in North Carolina and butyllithium produced in Bayport, TX (North American Minerals News, 1998a).

Lithium carbonate is the most important lithium compound produced from brine and ore deposits. In fact, other lithium compounds require lithium carbonate as a feedstock for further processing. With the closure of FMC's mine in North Carolina, domestic production of lithium carbonate is limited to a single brine 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. Approximately the same 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 mine closure 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 concentrates that can be consumed 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 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.

Consumption

The aluminum, ceramics and glass, lubricating grease, and synthetic rubber industries consumed most of the lithium minerals and chemicals sold in 1998. Estimated domestic consumption was unchanged from that of 1997. 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 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, reduced the coefficient of thermal expansion and the viscosity, and eliminated the use of more toxic chemicals. 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 as a source 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.

The second largest use, aluminum production, added lithium carbonate to aluminum pot lines to lower the melting point of the bath, allowing a lower operating temperature for the pot line, and increasing the electrical conductivity of the bath. These factors contributed to increased production or reduced power consumption, as well as to the indirect benefits of lower fluoride emissions.

The third largest 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 also were 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 was approved for the treatment for 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 1998. 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 (EV's) 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 EV's 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 this market and of electronic equipment, such as portable telephones and video cameras. Work 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 uses 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. The *Mars Pathfinder* spacecraft, launched in December 1996 by the National Aeronautics and Space Administration (NASA), landed on Mars in July. It contained lithium thionyl chloride batteries that powered communications between *Pathfinder* and NASA during the journey, provided backup power to the solar-powered Mars rover *Sojourner* in the event of the failure of the solar panels, and kept *Sojourner's* electronics operating during the night (ITE Battery Newsletter, 1998).

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 those of 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. Reynolds Metals Co. 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. The alloy was produced at Reynolds' McCook, IL, plant (Light Metal Age, 1998).

NASA 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 super-lightweight tank was made with another Reynolds aluminum-lithium alloy containing 1% lithium, 4% copper, 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 kg less than the original design; the weight savings was used to increase the payload capacity for shuttle missions. Reynolds was to produce 25 of the redesigned fuel tanks (Light Metal Age, 1998). The first new tank was used for the October 29, 1998, launch of the shuttle *Discovery*, on which astronaut John Glenn returned to space, almost 37 years after he became the first American to orbit the Earth in 1962 (Etris, 1999; National Aeronautics and Space Administration, October 29, 1998, STS-95—Mission Control Center—Status report #1, accessed March 25, 1999, at URL http://spaceflight.nasa.gov/shuttle/archives/sts-95/reports/STS-95-01.html).

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 published prices for lithium carbonate were slightly higher than those of 1997, actual prices paid by customers were believed to be significantly lower. The vigorous entrance into the market of Minsal S.A., now known as SQM Chemicals S.A., a Chilean company with an aggressive pricing strategy, apparently forced Cyprus Foote and FMC to reduce their prices comparably, although actual price lists and quotations have been difficult to obtain since the price reductions began.

Although Customs values for lithium carbonate entering the United States from Chile have never reflected exactly the producers' average prices for lithium carbonate, they are, however, a good indication of the trends in lithium pricing. The average unit value calculated from U.S. Bureau of the Census data using Customs value and quantity imported, showed unit value of lithium carbonate has decreased by 38% since 1996. The unit value for lithium carbonate from Chile has gone from $2.70 per kilogram in 1996 to $1.96 in 1997 and to $1.67 in 1998. Imports from Argentina were recorded for the first time in 1998; unit value for this material was $1.82 per kilogram. All these values were significantly lower than the published price of $4.47 per kilogram. (See table 2.)

Foreign Trade

Total U.S. exports of lithium compounds were nearly 29% lower in 1998 than those of 1997. This followed a 13% decrease from 1996 to 1997. Because 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 64% of all U.S. exports of lithium compounds were to Canada, China, Germany, Japan, and the United Kingdom (table 3).

Imports of lithium compounds increased by 166%, a dramatic increase that resulted from FMC's Argentina operation reaching full production and the North Carolina carbonate plant closure. Further increases are likely to occur in 1999. Chile accounted for 53% of all imports; and lithium carbonate from Argentina accounted for 43% 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. Argentina, 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. Brazil and Namibia produced smaller quantities, primarily concentrates; Congo (Kinshasa) when it was known as Zaire, Namibia, and South Africa 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 Bolivia, China, and

Israel. Companies in France, Germany, Japan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

Argentina.—FMC produced lithium carbonate from its lithium brine operation at the Salar de Hombre Muerto in the Argentine Andes. At yearend, lithium carbonate production was approaching full capacity, and the lithium chloride circuit was expected to reach full capacity in early 1999. 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, 1998a). 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. Reserves at the Salar should last at least 75 years at design capacity (FMC Corp., 1998).

Australia.—Gwalia Consolidated Ltd. is the largest producer of lithium ore concentrates in the world and the only lithium producer in Australia. In 1997, the company closed its lithium carbonate plant. The plant, which began operating in 1996, had technical problems from the start. By the time those problems had been solved, the market had eroded to the point that the project could not be profitable under the prevailing conditions. The company's spodumene concentrate production and sales remained strong (Industrial Minerals, 1997). The company did, however, lose sales to China and Russia when those countries chose to import low-cost lithium carbonate from Chile rather than import spodumene from Australia as feedstock for their lithium carbonate plants (John Linden, Marketing Manager, Sons of Gwalia, Ltd., Australia, November 20, 1998, A view from the lithium minerals side, accessed February 16, 1999, at URL http://www.amm.com/inside/roskanal/1998/ rk112098.htm).

Canada.—In addition to the spodumene mine and concentrating plant at Bernic Lake, Manitoba, operated by Tantalum Mining Corp. of Canada Ltd., a subsidiary of Hudson Bay Mining Co., Avalon Ventures Ltd. proceeded with its investigation into the possibility of developing the company's Separation Rapids rare metals project in northwestern Ontario. A drilling program at the Big Whopper petalite deposit showed excellent internal continuity in the formation. New zones of tantalum mineralization were also identified on the property. On the basis of these findings, the development of a successful flotation process to separate petalite from rubidium-potassium feldspar minerals, and the completion of a positive market study, a prefeasibility study was initiated to outline a development plan for the project (Avalon Ventures Ltd., 1998).

Results from tests performed on petalite concentrates from the Big Whopper deposit showed the material exceeded specifications for raw materials for a variety of glass and ceramic products. The chemical analysis determined an aluminum oxide content of 16.4%; lithium oxide, 4.54%; sodium oxide, 0.36%; potassium oxide, 0.19%; and total iron, 0.021%. Because the lithium content is higher than normal for petalite concentrates and the iron content is lower than normal, the material is especially attractive to ceramics and glass producers. Although the potassium and sodium levels were acceptable, additional work was completed on the flotation process to improve the separation, to increase the lithium oxide content, and to reduce the potassium and sodium content. The same independent laboratory was to evaluate the improved concentrate. Other tests were performed to evaluate the applicability of Avalon's petalite concentrate as a raw material in ceramics and glass production. Results were favorable, resulting in Avalon advancing the timetable for completion of the prefeasibility study to spring 1999 (Avalon Ventures Ltd., 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. The operation that was purchased by Chemetall from Cyprus Amax in 1998 first produced lithium carbonate in 1984. SQM Chemicals S.A. completed its first full year of production in 1997. Both companies transport concentrated brines from the Salar to lithium carbonate plants in Antofagasta.

China.—Lithium carbonate production in China is primarily from spodumene ore, some produced domestically and some imported from Australia. In 1998, a large brine deposit containing large quantities of lithium, boron, potassium, and cesium was discovered in Tibet. Lithium reserves were reported to exceed 1 million tons (China Online, February 18, 1999, Huge lithium and boron reserves discovered in Tibet's remote Zhabuye Salt Lake, accessed March 23, 1999, at URL http://www.chinaonline.com/top_stories/today_b020913.html).

Outlook

The health of the lithium industry continues to be 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. 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 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. The lithium-polymer battery sales have been predicted to exceed $500 million per year within 10 years, a tremendous increase considering that sales of this type of battery were limited in 1997 (Chemical Week, 1997). Add a comparable increase in the sales of lithium-ion batteries, and the figures are astounding. No estimates of the amount of lithium required for these batteries, however, have been made.

Too many unknowns remain 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 EV's will comprise 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, perhaps, ever.

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.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT LITHIUM STATISTICS 1/

(Metric tons of contained lithium)

	1994	1995	1996	1997	1998
United States:					
Production	W	W	W	W	W
Producers' stock changes	W	W	W	W	W
Imports 2/	851	1,140	884	975 r/	2,590
Exports 2/	1,700	1,900	2,200 r/	1,880 r/	1,340
Consumption:					
Apparent	W	W	W	W	W
Estimated	2,500	2,600	2,700	2,800	2,800
Rest of world: Production 3/	8,540 r/	11,000 r/	12,700 r/	14,200 r/	14,900 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

	1997		1998 e/	
	Dollars per pound	Dollars per kilogram	Dollars per pound	Dollars per kilogram
Lithium bromide, 54% brine: Truckload lots, delivered in drums	5.89	12.96	5.89	12.96
Lithium carbonate, technical: Truckload lots, delivered	2.03	4.47	2.03	4.47
Lithium chloride, anhydrous, purfied: Truckload lots, delivered	5.00	11.00	5.00	11.00
Lithium fluoride	7.43	16.35	7.43	16.35
Lithium hydroxide monohydrate: Truckload lots, delivered	2.61	5.74	2.61	5.74
Lithium metal ingot, technical grade: 1,000-pound lots, delivered	43.33	95.33	43.33	95.33
N-butylithium in n-hexane (15%): Truckload lots, delivered	20.40	44.88	20.40	44.88

e/ Estimated.

Source: Chemical Market Reporter. V. 253, no. 1, January 5, 1998. p. 23-26. Chemical prices for week ending January 2, 1998.

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

Compound and country	1997 Gross weight (metric tons)	1997 Value (thousands)	1998 Gross weight (metric tons)	1998 Value (thousands)
Lithium carbonate:				
Australia	34	$214	23	$141
Belgium	12	42	--	--
Canada	794	2,850	788	2,830
China	163	562	279	1,010
France	10	36	--	--
Germany	268	998	492	1,810
India	49	158	20	61
Japan	1,820	6,570	846	2,840
Korea, Republic of	245	900	12	41
Mexico	94	310	43	157
Netherlands	166	594	34	121
Taiwan	75	237	29	104
United Kingdom	1,070	4,040	614	2,220
Venezuela	2	8	--	--
Other	149	542	62	231
Total	4,950	18,100	3,240	11,600
Lithium carbonate U.S.P.: 2/				
Bahamas, The	14	28	--	--
Germany	5	6	--	--
India	(3/)	10	--	--
Israel	--	--	13	27
Japan	25	57	6	119
Korea, Republic of	1	7	--	--
Mexico	7	13	3	6
Netherlands	15	31	--	--
Netherlands Antilles	7	14	--	--
Taiwan	--	--	1	45
United Kingdom	2	31	2	443
Venezuela	--	--	14	40
Other	1	26	--	--
Total	77	223	39	679
Lithium hydroxide:				
Argentina	87	373	141	517
Australia	205	871	167	679
Canada	104	417	91	359
Chile	97	373	181	659
China	232	716	20	103
Germany	1,160	4,780	590	2,210
Hong Kong	58	161	71	214
India	783	3,330	419	1,520
Japan	994	4,740	1,160	5,560
Korea, Republic of	187	803	147	632
Mexico	167	739	117	506
Netherlands	91	321	216	772
New Zealand	112	361	16	67
Philippines	57	270	30	167
Singapore	151	666	101	435
Taiwan	361	1,180	21	76
Thailand	104	412	21	69
United Kingdom	364	1,460	2	443
Other	370	2,250	846	2,940
Total	5,680	24,200	4,360	17,900

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/

	1997		1998	
Compounds	Gross weight (metric tons)	Value 2/ (thousands)	Gross weight (metric tons)	Value 2/ (thousands)
Lithium carbonate:				
Argentina	--	--	5,890	$10,700
Canada	--	--	10	36
Chile	5,050	$9,940	7,320	12,200
China	--	--	7	17
Germany	(3/)	18	257	434
Japan	5	37	3	24
New Zealand	35	150	16	33
Other	1	9 r/	(3/)	8
Total	5,090	10,200	13,500	23,500
Lithium hydroxide:				
Chile	--	--	29	160
China	66	269	241	478
Japan	16	170	5	148
Mexico	26	139	--	--
Taiwan	--	--	42	142
Other	5	104	2	70
Total	113	682	319	998

r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Customs value.
3/ Less than 1/2 unit.

Source: Bureau of the Census.

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

(Metric tons)

Country 3/	1994	1995	1996	1997	1998 e/
Argentina:					
Spodumene and amblygonite e/	400	400	-- r/	-- r/	--
Carbonate from subsurface brine	--	--	--	--	6,000
Australia, spodumene	45,987	81,841	117,944	88,399	68,666 4/
Brazil, concentrates e/	1,600	1,600	1,600	1,600	1,600
Canada, spodumene e/ 5/	20,000	21,000 r/	22,000 r/	22,500 r/	22,500
Chile, carbonate from subsurface brine	10,439	12,943	14,180	24,246 r/	25,000
China, carbonate e/	9,050	12,800	15,000	15,500	16,000
Namibia, concentrates, chiefly petalite	1,861	2,611	1,972 r/	1,019 r/	1,400
Portugal, lepidolite	11,352	8,740 r/	7,626 r/	8,000 r/ e/	8,000
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/	25,279	33,498	30,929	49,833 r/	50,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.
1/ Table includes data available through March 29, 1999.
2/ Estimated data are rounded to 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.
8/ Amblygonite, eucryptite, lepidolite, petalite, and spodumene.