# 2008 Minerals Yearbook

## LITHIUM [ADVANCE RELEASE]

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# LITHIUM

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In 2008, lithium consumption in the United States was estimated to be 2,300 metric tons (t) of contained lithium, 4% less than the revised consumption for 2007 and 8% less than in 2006. Decreased U.S. consumption was primarily the result of the economic slow-down in the United States. Lithium carbonate consumed and used as a raw material for other lithium compounds in the United States was produced at a domestic brine operation in Nevada and was imported from Argentina and Chile.

Lithium has historically been mined from two distinct sources—continental brines and hard rock ore. Chile has been the world's leading producer of lithium carbonate since 1997, the year that it first surpassed the United States in production. Production in Chile was from two lithium brine operations on the Salar de Atacama in the Andes Mountains. Concentrated brines were processed at two lithium carbonate plants in Antofagasta. In the United States, production continued at a lithium brine operation with an associated lithium carbonate plant in Nevada. Lithium carbonate and lithium chloride also were produced from brines from the Salar del Hombre Muerto in the Andes Mountains in Argentina. In China, lithium carbonate was produced from brines from the Zabayu Salt Lake in western Tibet, and the Dongtai and Xitai Salt Lakes in Qinghai Province.

Australia was, by far, the leading producer of lithium concentrates, and Brazil, Canada, China, Portugal, and Zimbabwe also produced significant quantities. China remained the only country that continued to produce large quantities of lithium carbonate from concentrates, mostly from imported Australian spodumene. A large percentage of the lithium carbonate produced in South America was exported to the United States for consumption in industrial applications and as feed material for the production of downstream lithium compounds, such as lithium hydroxide monohydrate, lithium metal, and organic lithium compounds.

## Legislation and Government Programs

In 2008, the U.S. Department of Energy funded its Advanced Technology Vehicles Manufacturing Incentive Program (ATVMIP) with $25 billion in direct loans to automobile manufacturers and component suppliers for projects that reequip, expand, and establish manufacturing facilities in the United States. The goal of the program was to produce advanced technology vehicles, and components for such vehicles, which provide meaningful improvements in fuel economy performance (U.S. Department of Energy, 2008). Lithium-ion battery technology figured prominently in the ATVMIP. Loan applicants included U.S. battery makers and technology companies seeking government support to build world-class lithium-ion battery manufacturing facilities. Automakers Chrysler, Ford, and General Motors received funds to advance more fuel-efficient automobile designs, which may use lithium-ion batteries (Smith, 2008; Shepardson, 2009).

## Production

The U.S. Geological Survey (USGS) collects domestic production data for lithium from a voluntary canvass of U.S. operations. The only U.S. lithium carbonate producer, Chemetall Foote Corp. (a subsidiary of the German company Chemetall GmbH, which is owned by Rockwood Holdings, Inc., of Princeton, NJ) responded to the survey, representing 100% of total production. Production and stock data were withheld from publication to avoid disclosing company proprietary data (table 1).

Chemetall Foote produced lithium carbonate from brines near Silver Peak, NV. The company's other U.S. lithium operations included a lithium hydroxide plant in Silver Peak; a butyllithium plant in New Johnsonville, TN; and facilities for producing downstream lithium compounds in Kings Mountain, NC. Chemetall Foote's subsidiary in Chile, Sociedad Chilena de Litio Ltda. produced lithium carbonate and lithium chloride from a brine deposit.

FMC Corp.'s Lithium Division produced a full range of downstream compounds, lithium metal, and organic lithium compounds at its facilities in Bessemer City, NC, and Bayport, TX. FMC met its lithium carbonate and lithium chloride requirements with material produced at its operation in Argentina. In 2008, FMC established the Center for Lithium Energy Advanced Research (CLEAR), a battery research and development facility in Bessemer City. CLEAR's mission was to test and demonstrate FMC's new rechargeable lithium-ion battery materials (Norris, 2009, p. 12).

In June, Canada Lithium Corp. (formerly Black Pearl Minerals Consolidated Inc.) acquired a lithium brine prospect in Esmeralda County, NV, from Gold Summit Corp. The lithium brine prospect is located within the Great Basin Province of the southwestern United States. Canada Lithium completed a gravity survey of the prospect to optimize selection of drill sites. The company also tested six additional locations within the Great Basin for indications of lithium brine (Black Pearl Minerals Consolidated Inc., 2008).

Simbol Mining Corp. received $6.7 million in venture capital funding to develop its process to extract lithium from geothermal fluids. Geothermal fluids may potentially supply significant quantities of lithium at low cost with minimal environmental impact (Kanellos, 2008).

In December, Western Lithium Canada Corp. (Vancouver, British Columbia, Canada) completed a resource estimate on the first of five lithium-rich hectorite clay deposits at its Kings Valley, NV, project. The study estimated that the deposit had

an indicated mineral resource of 129,000 t of contained lithium and an inferred mineral resource of an additional 114,000 t of contained lithium. Based on previous exploration of the area performed by Chevron Resources Co. in the 1980s, Western Lithium Canada Corp. estimated that a total of 2 million metric tons of contained lithium may be available (Western Lithium Canada Corp., 2009).

## Consumption

Lithium is sold as brines, compounds, metal, or mineral concentrates depending on the end use. Lithium's electrochemical reactivity and other unique properties have resulted in many commercial lithium products. For many years, most lithium compounds and minerals were used in the production of ceramics, glass, and primary aluminum. Growth in lithium battery use and decreased use of lithium in aluminum production has resulted in batteries gaining market share. For 2008, Chilean lithium producer Sociedad Química y Minera de Chile S.A. (SQM) listed the main global markets for lithium as follows—ceramics and glass, 31%; batteries, 23%; lubricating greases, 10%; air treatment, 5%; continuous casting, 4%; primary aluminum production, 3%; and other uses, 24% (de Solminihac, 2009, p. 13). The "other uses" category represents several smaller end uses that may include alloys, construction, dyestuffs, industrial bleaching and sanitation, pool chemicals, and specialty inorganics (FMC Corp., 2008). Roskill Information Services offered different consumption estimates for 2008, but confirmed that ceramics and glass remained the top global market for lithium with ceramics and glass, 37%; batteries, 20%; lubricating greases, 11%; primary aluminum production, 7%; air treatment, 5%; continuous casting, 5%; rubber and thermoplastics, 3%; pharmaceuticals, 2%; and other uses, 10% (Roskill Information Services Ltd., 2009, p. 156). Domestic end uses for lithium materials may not directly correspond to worldwide consumption, but the data necessary for making more reliable estimates were not available.

In 2008, the decline in U.S. lithium consumption can be attributed to decreased consumption in most end uses owing to a slowdown in the economy. Increased lithium consumption by foreign battery manufacturers and the rapidly developing economies of China and India, where demand for lithium is growing to support their manufacturing base, were not likely factors in reducing U.S. lithium consumption in 2008 as they were in 2007. If lithium concentrates are included in lithium consumption estimates, the leading use of lithium in the United States may be in ceramics and glass manufacturing processes. No lithium concentrates were produced in the United States for direct application in ceramics and glass manufacture, and import statistics do not specifically identify lithium ore imports, making it difficult to accurately estimate end uses.

Most lithium batteries were manufactured in Asia. Many major battery manufacturers marketed some type of lithium battery, exploiting the many advantages of lithium batteries compared with older battery technologies. Battery experts have been working to develop lithium batteries for decades because lithium's natural properties make it one of the most attractive battery materials of all the elements. In 2008, lithium battery production represented 70% of the total rechargeable battery market worldwide, and growth was expected to continue (Rockwood Holdings, Inc., 2008, p. 34). Worldwide, rechargeable lithium batteries power the majority of cellular telephones and laptop computers, and increasingly are being used to power heavy-duty power tools. Automakers were working on lithium batteries for hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and pure electric vehicles (EV).

U.S. primary aluminum production, and lithium consumption in that end use, declined during the second half of 2008 because aluminum production was curtailed owing to high electricity prices and a sharp drop in the price of aluminum. Previously in 2007 and the first half of 2008, domestic aluminum production increased considerably when idle aluminum smelters were restarted (Bray, 2009).

Additional information concerning additional lithium end uses can be found in the lithium chapter of the 2006 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

## Prices

In recent years, customs values for lithium carbonate imports to the United States seemed to be a good indication of the trends in lithium pricing, although they never exactly reflected the producers' prices for lithium carbonate. Import data indicated that lithium carbonate and lithium hydroxide prices increased in 2008. The average customs unit value for imported lithium carbonate was $4.44 per kilogram, about 26% higher than in 2007, a result of increased global demand—especially for lithium batteries—and rising energy, raw material, and freight costs. The average unit value of exported lithium carbonate was 26% higher than in 2007 and more than 30% higher than the average unit value of imported carbonate. This suggests that the material exported from the United States was higher quality lithium carbonate than that which was imported.

Average export values of lithium carbonate from Argentina, Chile, and China were reported by Roskill Information Services (2009, p. 320) as follows for 2008—Argentina, $4.62 per kilogram, 21% higher than in 2007; Chile, $5.20 per kilogram, 16% higher than in 2007; and China, $6.50 per kilogram, 3% lower than in 2007. At yearend, glass-grade spodumene (5% lithium oxide) was reported to be selling from $308 to $354 per metric ton (Industrial Minerals, 2008a).

## Foreign Trade

In 2008, total exports of lithium compounds from the United States remained approximately the same as those of 2007. About 60% of all U.S. exports of lithium compounds went to Germany and Japan. The remainder was divided among many other countries (table 2).

Imports of lithium compounds increased only slightly in 2008 from those of 2007. Of the 17,000 t of lithium compounds imported, 55% of lithium chemical imports came from Chile, 43% came from Argentina, and 2% from other countries (table 3). Lithium concentrates from Australia, Canada, and Zimbabwe may have entered the United States, but because these materials have no unique import code, no import data were available.

## World Review

Total world lithium production was calculated to be 25,400 t of lithium contained in minerals and compounds in 2008, remaining about the same as that of 2007. Gross weight production figures for lithium carbonate, lithium chloride, and lithium mineral concentrates are listed in table 4. A small number of countries throughout the world produced lithium concentrates and brine. Argentina, Chile, China, and the United States were the leading producers of lithium carbonate. Significant quantities of lithium compounds and concentrates also were produced in Argentina, Australia, Brazil, Canada, Portugal, and Zimbabwe. Congo (Kinshasa), Namibia, Russia, Rwanda, and South Africa have produced concentrates in the past. A spodumene mining operation was under development in Finland and a jadarite mining operation was under development in Serbia. Pegmatites containing lithium minerals have been identified in Afghanistan, Austria, France, India, Ireland, Mozambique, Spain, Sweden, and Zaire, 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, the Republic of Korea, Russia, Taiwan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

Total world lithium consumption was reported to be 21,280 t of lithium contained in minerals and compounds in 2008. Lithium consumption averaged 6% growth per year since 2000, with 2008 slowing to less than 4% growth owing to the waning worldwide economy (Roskill Information Services Ltd., 2009, p. 155). Using recent information from SQM and earlier research that estimated the lithium chemical market to be about 80% of total lithium consumption, an estimated 17,000 t of lithium was consumed in chemicals and the remainder as mineral concentrates in the ceramics and glass industry in 2008 (Ebensperger and others, 2005, p. 221; de Solminihac, 2009, p. 18; Sociedad Química y Minera de Chile S.A., 2009, p. 40). SQM estimated total lithium consumption for 2008 to be about 21,900 t, with a compound annual growth rate of 7.5% for the past 10 years, and only a 2% growth rate for 2008 (de Solminihac, 2009, p. 13; Sociedad Química y Minera de Chile S.A., 2009, p. 40). Talison Minerals Pty. Ltd. reported that approximately 20% of the global lithium chemical supply was obtained from lithium minerals in 2008 (Miller, 2009).

***Argentina.***—FMC has been operating its facility at the Salar de Hombre Muerto since 1998. It was initially 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 Mineral News, 1998). In 2008, its lithium carbonate capacity was 17,000 t/yr (Norris, 2009, p. 8). Lithium carbonate production was supplemented by lithium chloride production that varies from 7,250 t/yr to an estimated 8,800 t/yr (Minera-Net, 2003). Although lithium carbonate production was less than production capacity in 2008, production has increased steadily since 2002, when production was first reported. Production of lithium carbonate was estimated to be 10,000 t, an increase of 13% from that of 2007. Production of lithium chloride was estimated to be 7,800 t, a decrease of 12% from that of 2007.

At the end of 2008, Admiralty Resources NL's lithium brine project at the Salar del Rincón in Salta Province was sold to The Sentient Group, a Cayman Island-based private equity company (Admiralty Resources NL, 2008). Admiralty had previously developed the project to the active pilot-plant stage at the end of 2007, and planned to have commercial production of lithium carbonate by mid-2009. Admiralty designed the lithium operation to produce 17,000 t/yr of lithium carbonate (Moores, 2008).

Australian exploration company Orocobre Ltd. acquired exploration rights to the Salar de Olaroz in northwestern Argentina, and in March 2008, its Olaroz Lithium Project began a surface sampling program to confirm the presence and grade of lithium. By December, Orocobre completed a two-stage drilling program which further defined the grade of lithium and performed a series of hydrological tests at the drill sites (Orocobre Ltd., 2008, p. 4–5; 2009).

In 2008, Canadian exploration company Latin American Minerals Inc. formed the Salares Potash-Lithium Project on the Puna plateau in northwestern Argentina. The company also agreed to purchase a second property located on Argentina's Cauchari Salt Lake. Latin American Minerals started a surface sampling program on its properties; a total of 93 samples of salt crust and 113 samples of brine were collected (Latin American Minerals Inc., undated).

***Australia.***—About 60% of the world's supply of lithium minerals was produced by Talison in 2008. The company reported that its deposit in Western Australia is the largest spodumene deposit in the world (Department of Industry and Resources, 2008, p. 39). In 2008, Talison's spodumene concentrate capacity was 250,000 t/yr (Moores, 2009). Spodumene concentrates were sold worldwide for consumption in ceramics and glass and were exported to China, where it was used in glass and as a raw material for the production of lithium carbonate. In 2008, to meet future lithium demand and optimize their lithium resource, Talison began improvements at the high-grade and low-grade sections of their lithium minerals plant with additional equipment and a new process to increase the lithia content in their spodumene concentrate (Miller, 2009).

Galaxy Resources Limited completed a definitive feasibility study for its Mt. Cattlin Lithium/Tantalum Project, located near Ravensthorpe in Western Australia, at the end of 2008. The study suggested that the Mt. Cattlin project was economically and technically viable, and spodumene concentrate production was expected to be 150,000 t/yr. Galaxy Resources anticipated mine development and processing plant construction to commence in late 2009, with spodumene concentrate production to begin in late 2010 (Galaxy Resources Limited, 2009).

***Bolivia.***—Bolivia's undeveloped Salar de Uyuni is the largest salt flat in the world, with an area of more than 4,000 square miles. In April, the Bolivian Government approved construction of a new lithium pilot plant in the Salar to determine its economic viability. The plant was designed to produce lithium carbonate at a rate of 40 metric tons per month, and was to be operated by the state mining company Corporación Minera de Bolivia (Comibol). In September, New World Resource Corp. announced that it had signed a letter of intent with a private Bolivian vendor to acquire 99% interest in the lithium-potash

Pastos Grandes brine project located in southwestern Bolivia (Moores and Wan, 2008; Roskill Information Services Ltd., 2009, p. 56).

***Canada.***—Tantalum Mining Corp. of Canada Ltd. (a subsidiary of Hudson Bay Mining Co.) has operated a spodumene mine and concentrating plant at Bernic Lake, Manitoba, on a commercial scale since 1986. Its last reported spodumene concentrate capacity was 24,000 t/yr (Cabot Corp., 2002).

Having worked toward developing the Separation Rapids petalite deposit near Kenora, Ontario, since 1998, Avalon Ventures Ltd., in 2008, continued investigating the possibility of applying hydrometallurgical extraction technology to recover a lithium product suitable for the lithium-ion battery market. The company also began efforts to secure a mining lease for the Separation Rapids deposit and neighboring lands that may be needed for development work (Avalon Ventures Ltd., 2008, p. 18–19).

An independent technical and economic assessment prepared for GlobeStar Mining Corp. was completed in December 2008. It incorporated the results of a 12-hole diamond drilling program at its pegmatite deposit near Moblan, Quebec, and provided an estimate of mineral resources and a preliminary assessment predicting spodumene concentrate production of 22,000 t/yr (GlobeStar Mining Corp., undated).

Canada Lithium Corp. acquired the Quebec Lithium property from IAMGOLD Corp. in 2008. Quebec Lithium was an underground mine, surface concentration plant, and a chemical plant that previously operated from 1955 to 1965 and produced lithium carbonate, lithium chloride, lithium hydroxide monohydrate, and spodumene concentrate. Canada Lithium was working in conjunction with SGS Lakefield Research to complete metallurgical tests to resume the production of lithium carbonate and spodumene concentrate (Canada Lithium Corp., 2009).

Channel Resources Ltd. signed a letter of intent with Polaris Capital Ltd. for the acquisition of the Fox Creek Lithium Brine Project in Alberta. A previous study of the area by the Government of Alberta indicated potentially economic concentrations of lithium in the aquifer, comparable with that of the brine found in Clayton Valley, NV. The company planned to continue the assessment of the lithium resource (Channel Resources Ltd., 2008).

***Chile.***—SQM reported a downturn in revenues from its lithium products as a result of the global economic slowdown in 2008. Sales volume was slightly lower than in 2007, at 27,900 t, and the value of sales declined by 4% to $172.3 million. The company reported that its share of the world lithium carbonate market was 30% (Sociedad Química y Minera de Chile S.A., 2009, p. 38, 54). The company's expansion of its lithium carbonate capacity to 40,000 t/yr was completed in mid-2008. Additionally, a plant for the production of lithium hydrochloride with a capacity of 6,000 t/yr commenced operation in 2005 (de Solminihac, 2009, p. 18).

Total lithium carbonate capacity for Chemetall Foote's operations in Chile and the United States increased to 27,000 t/yr in 2008. Capacity was planned to increase an additional 22% to 33,000 t/yr by 2010, to 40,000 t/yr by 2015, and to 50,000 t/yr by 2020, depending on market conditions (Haber, 2009, p. 15). Chemetall produced an estimated 18,800 t of lithium carbonate and 4,000 t of lithium chloride in 2008 (Roskill Information Services Ltd., 2009, p. 75). The company used lithium carbonate as feedstock for some of its downstream chemical production in the United States and supplied the operations of Chemetall in Germany and Taiwan. Chemetall reported a 50% share of the global market for its lithium products, with lithium carbonate accounting for 30% of the global market (Haber, 2009, p. 11).

***China.***—China is the only country that continued to produce large quantities of lithium carbonate from both domestic and imported spodumene. Domestic lithium mineral concentrates were thought to be low grade and were most likely used in glass and ceramic applications. Higher grade spodumene concentrates imported from Australia were generally used in the production of battery-grade lithium carbonate. Ronghui (Jiangsu Province), Sichuan Tianqi Lithium Industries, Inc. (Sichuan Province), and Xinjiang Non-Ferrous Metals Industry Co., Ltd. (Xinjiang Province) were 80% to 100% reliant on Australian spodumene. Current capacity of lithium carbonate produced from minerals was estimated to be 41,000 t/yr; however, 2008 production was estimated to be about 13,000 t, well below capacity. Additional lithium carbonate was imported into China from Argentina and Chile. Lithium minerals were estimated to contain 35% of China's lithium reserves, while lithium brines were estimated to contain the remaining 65% of the reserves (Baylis, 2009, p. 6–7, 11, 13; Roskill Information Services Ltd., 2009, p. 89–91).

The Tibet Lithium New Technology Development Co. has operated a 5,000 t/yr lithium carbonate plant at the Zabayu Salt Lake in western Tibet since 2005. Capacity was expected to eventually increase to 20,000 t/yr. CITIC Guoan Lithium Science & Technology Co., Ltd.'s 35,000-t/yr lithium carbonate plant (currently operating at a rate of 5,000 t/yr) was brought online in 2007 at the Taijinaier Salt Lake in Qinghai Province. It was the largest lithium carbonate plant in China (Tahil, 2007, p. 10, 13). Qinghai Salt Lake Industry Group Co., Ltd. operated a 3,000-t/yr lithium carbonate plant at the Dongtai Salt Lake in Qinghai Province. Capacity was expected to eventually increase to 20,000 t/yr. Total lithium carbonate production in 2008 from these three brine operations was estimated to be 5,000 t, well below their total capacity of 13,000 t/yr. Qinghai Salt Lake Lanke Lithium Industry Co. Ltd. continued construction of a 10,000-t/yr lithium carbonate project in the Chaerhan Salt Lake zone in Qinghai Province (Baylis, 2009, p. 11).

***Finland.***—In early 2008, Norwegian mining company Nordic Mining ASA purchased a controlling stake in Finnish spodumene mining company Keliber Oy. The company acquired a lithium deposit in the Lantta area of western Finland and planned to establish a 4,000-t/yr lithium carbonate plant, with production scheduled to begin in 2010. At the end of 2008, Nordic was preparing to complete the Lantta mine plan, investigate other lithium deposits surrounding the Lantta mine, and establish a plan to explore these deposits. When production begins, Nordic will be the first European producer of lithium carbonate from domestic ore (Industrial Minerals, 2008b; Grondahl, 2009, p. 9–10).

***Serbia.***—Jadarite, a new mineral species discovered in 2004 by Rio Tinto plc at Jadar, Serbia, was found to contain a high percentage of lithium oxide. An order of magnitude feasibility study and a lower bed resource study of the area were completed at the end of 2008 identifying a potentially substantial amount of contained lithium. A further study, due in early 2009, was being conducted by Rio Tinto to refine their estimate of lithium content (Kellie, 2009, p. 5–6).

## Outlook

The amount of lithium consumed globally for use in batteries has been increasing by more than 20% per year during the past few years. Demand for lithium-ion and lithium-polymer batteries appears to have the greatest potential for growth. Global sales of these rechargeable batteries were estimated to be $7.4 billion in 2008 (Global Industry Analysts, Inc., 2008). Other lithium end uses are increasing also, but at lower rates than batteries. Roskill Information Services Ltd. (2009, p. 156) indicated that lithium consumed for pharmaceuticals has averaged a 17% growth rate for the past 8 years, while lithium consumed for continuous casting and greases had 8-year growth rates of 8% and 6%, respectively.

As part of the American Recovery and Reinvestment Act of 2009, the U.S. Department of Energy funded $2.4 billion in grants in 2009 to accelerate the development of U.S. manufacturing capacity for batteries and electric drive components and deployment of electric drive vehicles. The grants, designed to help launch an advanced battery industry in the United States, represent the single largest investment ever made in advanced battery technology for hybrid and electric drive vehicles. Lithium-ion battery technology figured prominently in the grant awards, as approximately $940 million in grant money went to lithium battery materials suppliers, lithium battery manufacturers, and a lithium battery recycler (U.S. Department of Energy, 2009). The Department of Energy's 2009 grant awards are in addition to its 2008 ATVMIP that included $25 billion in direct loans.

Research in nanotechnology, the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, has advanced lithium-ion battery technology and further improvements are probable. By altering the nanostructures of the lithium-ion battery's anode and cathode, researchers have been able to increase battery capacity, output power, lifespan, and stability, while decreasing the time required to charge the battery (Harrop, 2008). Used in power tools, nanotechnology has enabled lithium-ion batteries to provide power surges of up to 10 times that of conventional lithium-ion battery (Bullis, 2008). In hybrid vehicles, power surges from the lithium-ion battery enable the vehicles to accelerate faster than other batteries of the same size (Pontin, 2007). A promising new technology, the lithium metal-air battery, may be capable of delivering 10 times more energy density than today's best lithium-ion technology, effectively offering the same energy density as gasoline. Development of lithium metal-air battery technology was expected to take between 5 and 10 years (Luoma, 2009).

Increased consumption of larger lithium-ion batteries can be attributed in part to use in heavy-duty power tools because lithium-ion batteries are replacing nickel-cadmium batteries in power tools in spite of the current economic condition (Rockwood Holdings, Inc., 2009). The amount of lithium-ion batteries used for power tools is expected to increase 15-fold between 2006 and 2012 (Nanoexa, 2009).

Most global automobile manufactures have announced plans to use lithium-ion batteries in current and future generations of HEVs, PHEVs, and EVs, in order of expected market entry. PHEVs and EVs with lithium-ion batteries from companies such as BYD Co. Ltd. (China) and Tesla Motors, Inc. (United States) saw limited release in 2008. Lithium-ion HEVs, PHEVs, and EVs are scheduled for release in 2009 and 2010 by General Motors, Hyundai, Mercedes-Benz, Mitsubishi, Nissan, Toyota, and Volkswagen. Major automobile manufacturers have also formed partnerships with established battery manufacturers to build battery plants for hybrid vehicles and begin mass production of lithium-ion batteries as early as 2009.

The use of lithium-ion batteries in HEVs, PHEVs, and EVs could greatly increase demand for lithium. As demand and prices rise, spodumene and other lithium resources that had been considered uneconomic might once again yield economically feasible raw materials for the production of lithium carbonate. New lithium mineral operations currently being developed throughout the world specifically to produce battery-grade lithium carbonate demonstrate a changing economic climate conducive to increased sales of lithium.

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TABLE 1
SALIENT LITHIUM STATISTICS[1]

(Metric tons of contained lithium)

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| United States: | | | | | |
| Production | W | W | W | W | W |
| Exports[2] | 1,690 | 1,720 | 1,500 | 1,440 | 1,450 |
| Imports[2] | 2,910 | 3,580 | 3,260 | 3,140 r | 3,160 |
| Consumption, estimated | 1,900 | 2,500 | 2,500 | 2,400 r | 2,300 |
| Rest of world, production[3] | 18,400 | 21,500 | 24,400 | 25,400 r | 25,400 |

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Data are rounded to no more than three significant digits.
[2]Compounds. Source: U.S. Census Bureau.
[3]Mineral concentrate and lithium carbonate.

TABLE 2

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

| Compound and country | 2007 Gross weight (metric tons) | 2007 Value[2] (thousands) | 2008 Gross weight (metric tons) | 2008 Value[2] (thousands) |
|---|---|---|---|---|
| Lithium carbonate: | | | | |
| Canada | 161 | $593 | 164 | $611 |
| Germany | 972 | 3,290 | 561 | 3,490 |
| India | 54 | 295 | 37 | 157 |
| Japan | 798 r | 4,440 | 1,290 | 7,710 |
| Korea, Republic of | 59 | 463 | 100 | 678 |
| Malaysia | 114 | 640 | 117 | 693 |
| Netherlands | 73 | 289 | 3 | 46 |
| United Kingdom | 75 | 428 | 313 | 1,160 |
| Other | 89 r | 432 r | 75 | 316 |
| Total | 2,400 | 10,900 | 2,660 | 14,900 |
| Lithium carbonate, U.S.P.:[3] | | | | |
| Argentina | 36 | 22 | -- | -- |
| India | 2 | 69 | 12 | 130 |
| Mexico | -- | -- | 20 | 4 |
| Saudi Arabia | 13 | 38 | (4) | 7 |
| United Kingdom | 94 | 536 | 15 | 137 |
| Other | 9 r | 206 r | 10 | 533 |
| Total | 154 | 871 | 57 | 811 |
| Lithium hydroxide: | | | | |
| Argentina | 140 | 1,520 | 146 | 1,600 |
| Australia | 54 | 406 | 41 | 313 |
| Canada | 259 | 1,060 | 107 | 446 |
| China | 118 | 746 | 123 | 867 |
| Colombia | 129 | 934 | 74 | 510 |
| Egypt | 102 | 674 | 58 | 394 |
| Germany | 904 | 4,470 | 996 | 5,860 |
| Hong Kong | 100 | 540 | (4) | 5 |
| India | 10 | 71 | 267 | 1,500 |
| Japan | 2,340 | 17,000 | 2,210 | 16,400 |
| Korea, Republic of | 313 | 2,490 | 268 | 2,100 |
| Mexico | 75 | 607 | 70 | 584 |
| Netherlands | 226 | 1,110 | 230 | 1,250 |
| Russia | 378 | 2,460 | 315 | 1,680 |
| Saudi Arabia | 15 | 70 | 55 | 388 |
| Singapore | 16 | 119 | 53 | 344 |
| South Africa | 79 | 823 | 79 | 824 |
| Taiwan | 45 | 356 | 85 | 588 |
| Thailand | 187 | 1,210 | 240 | 1,590 |
| United Kingdom | 205 | 2,650 | 102 | 1,620 |
| Venezuela | 17 | 146 | 56 | 496 |
| Other | 127 r | 1,240 r | 105 | 1,310 |
| Total | 5,840 | 40,700 | 5,680 | 40,700 |

[r]Revised. -- Zero.

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

[2]Free alongside ship values.

[3]Pharmaceutical-grade lithium carbonate.

[4]Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3

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

| Compound and country | 2007 Gross weight (metric tons) | 2007 Value[2] (thousands) | 2008 Gross weight (metric tons) | 2008 Value[2] (thousands) |
|---|---|---|---|---|
| Lithium carbonate: | | | | |
| Argentina | 6,100 | $23,300 | 7,300 | $33,600 |
| Chile | 8,510 | 27,100 | 8,110 | 34,400 |
| Other | 37 r | 170 | 22 | 197 |
| Total | 14,600 | 50,600 | 15,400 | 68,200 |
| Lithium carbonate, U.S.P., Chile[3] | 901 | 4,340 | 341 | 1,890 |
| Lithium hydroxide: | | | | |
| Belgium | 13 | 302 | -- | -- |
| Chile | 865 | 5,560 | 816 | 5,410 |
| China | 296 | 1,320 | 279 | 1,480 |
| India | 75 | 596 | 20 | 187 |
| Japan | -- | 13 | 7 | 131 |
| Norway | 13 | 26 | 24 | 54 |
| Romania | 16 | 45 | 3 | 17 |
| United Kingdom | 25 | 139 | 11 | 58 |
| Other | 5 r | 46 r | 4 | 65 |
| Total | 1,310 | 8,050 | 1,160 | 7,400 |

[r]Revised. -- Zero.

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

[2]Customs value.

[3]Pharmaceutical-grade lithium carbonate.

Source: U.S. Census Bureau.

TABLE 4

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

(Metric tons)

| Country[3] | 2004 | 2005 | 2006 | 2007 | 2008[e] |
|---|---|---|---|---|---|
| Argentina:[4] | | | | | |
| Lithium carbonate | 4,961 r | 7,288 r | 8,228 r | 8,863 r | 10,000 |
| Lithium chloride | 6,315 r | 8,416 r | 8,336 r | 8,843 r | 7,800 |
| Australia, spodumene | 118,451 | 173,635 | 222,101 | 192,277 r | 200,000 |
| Brazil, concentrates | 9,084 | 8,924 | 8,585 r | 7,991 r | 8,000 p |
| Canada, spodumene[e, 5] | 22,500 | 22,500 | 22,500 | 22,500 | 22,000 |
| Chile:[4] | | | | | |
| Lithim carbonate from subsurface brine | 43,971 | 43,595 | 50,035 | 55,452 r | 52,520 [6] |
| Lithium chloride | 494 | 681 | 1,166 | 4,185 r | 4,360 |
| China, carbonate[e] | 14,000 | 15,000 | 15,000 | 16,000 | 17,500 |
| Portugal, lepidolite | 28,696 | 26,185 | 28,497 | 34,755 r | 35,000 p |
| United States, subsurface brine | W | W | W | W | W |
| Zimbabwe, amblygonite, eucryptite, lepidolite, petalite, and spodumene | 13,710 | 37,499 | 30,000 | 30,000 r | 25,000 |

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through April 1, 2009.

[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, but output is not reported, and no valid basis is available for estimating production levels.

[4]New information was available from Argentine and Chilean sources, prompting major revisions in how lithium production was reported.

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

[6]Reported figure.