Magnesium

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World production of primary and recycled magnesium increased to an estimated 585 000 t in 2000, up 6% from an estimated 530 000 t in 1999.[1] Magnesium use figures for 1999 were published in 2000 by the International Consultative Group on Nonferrous Metals Statistics. Prices for magnesium generally weakened during the year, due mainly to continued high shipment levels from China.

The International Magnesium Association (IMA) reports that Western primary magnesium production (which excludes China, the former Soviet Union and Israel) decreased by 17% (41 900 t) to 210 300 t in 2000 from 252 200 t in 1999. That decrease was due primarily to the closure of The Dow Chemical Company's plant in the United States.

The IMA also reported that shipments of magnesium in North America from primary producers were 176 700 t in 2000 compared to 215 200 t shipped in 1999. This decrease reflects changes in the methodology for collecting statistics, resulting from about a 30 000-t decrease in die-casting sector shipments, where shipments of recycled scrap from primary producers were previously included. North America (48%) and Western Europe (33%) are the largest magnesium-using regions.

IMA data also indicate that inventories of primary magnesium increased in 2000 to 46 500 t at year-end compared to 45 900 t at the end of 1999. This inventory represents approximately 46 days of world production of primary magnesium. (Further information from the IMA can be obtained at http://www. intlmag.org.)

Canadian Developments

In 2000, Canada was the third largest magnesium producer in the world after China and the United States.

Norsk Hydro Canada Inc. (Norsk Hydro), a wholly owned subsidiary of Norsk Hydro ASA of Norway, has produced magnesium metal at a 43 000-t/y Bécancour, Quebec, plant using an electrolytic process since 1989. The plant also recycles magnesium scrap produced by its customers. Norsk Hydro has focussed on debottlenecking the existing operations and making them more efficient. Expansion may take place in the future provided sufficient customer contractual commitments for the production are in place. Cost-cutting measures have been implemented at the plant and, as part of these measures, the company laid off 85 people in early 2001. The company has developed a new alloy for use in environments with elevated temperatures. (Additional information is available on the Internet at http://www.magnesium.hydro.com.)

Timminco Limited produces high-purity metal (up to 99.98% pure) for specialized market applications at its 6000-t/y magnesium plant at Haley Station, Ontario. The company also produces highly corrosion-resistant magnesium die-casting alloys and extruded anode rods for hot-water heaters. Timminco's magnesium products are used for a variety of applications such as alloying agents for aluminum and calcium, in Grignard reagents for the pharmaceutical industry, and in electronic products. Timminco uses the Pidgeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort. Timminco mines the dolomite at the plant site but purchases the ferrosilicon feed on the open market.

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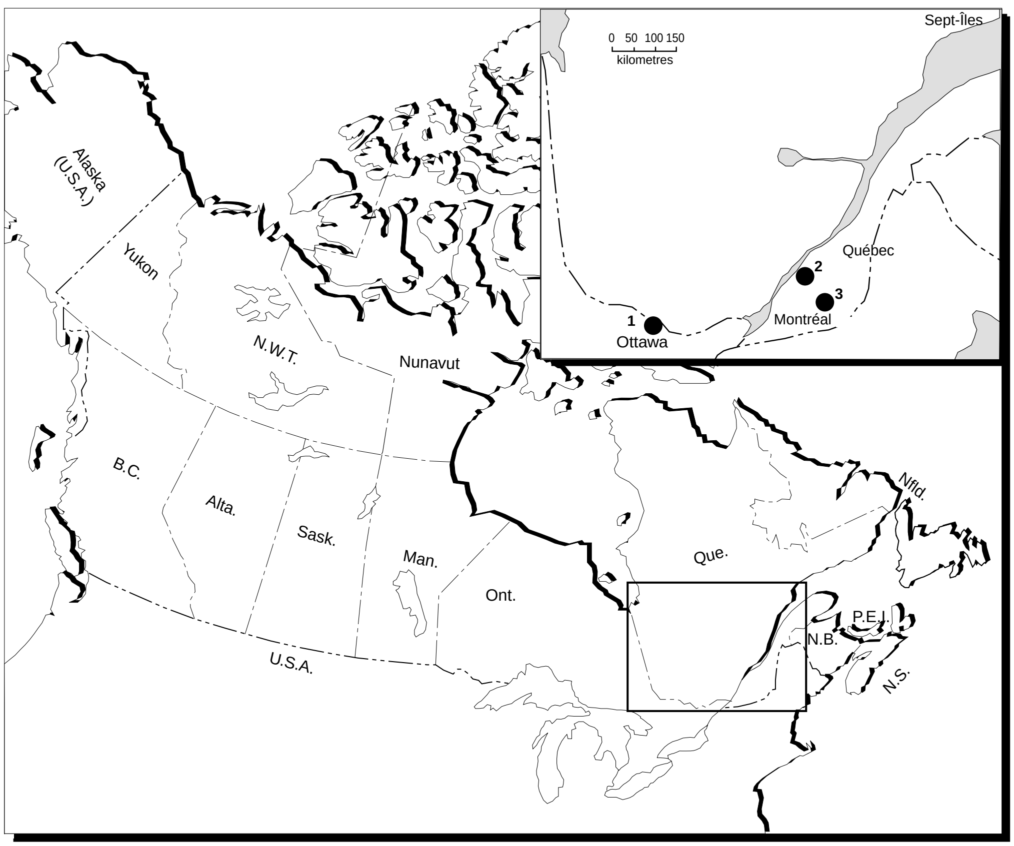
[1] Magnesium statistics vary between sources. Readers are cautioned to ensure data are appropriate for their needs. Including the China Magnesium Association's production figure, the comparable figures are a production in 2000 of 614 000 t, up 10% from 567 000 t in 1999. Note that statistics on magnesium use produced by both the IMA and Natural Resources Canada (NRCan) for casting and other uses have included, and may include, scrap components and may be/may have been overstated. The IMA has changed its reporting system and work is under way at NRCan to resolve these potential problems in the Canadian statistics.

In 2000, Timminco restructured and streamlined its operations to become more profitable. The company closed its corporate offices in Toronto and Haley Station, Ontario, and in Illinois, to focus on its corporate operations in Denver. In November 2000, both induction furnaces and related electrical cooling and control systems in a new, technically advanced, $25 million cast-house were damaged after a metal spill. The metal spill caused one of the cooling lines to rupture and resulted in a fire that required a temporary shut-down of the facility, including layoffs of some staff, until early 2001. The new cast-house re-opened in early 2001 and commercial production was to start in the second quarter. The casting facility at Haley Station provides magnesium billets for Timminco's extrusion facilities at Haley Station, Ontario, and Aurora, Colorado. On a longer-term basis, the company intended to expand operations in the wrought products area. (Timminco has an Internet site at http://www.timminco.com.)

In early 2001, Magnola Metallurgy Inc. (owned 80% by Noranda Inc. and 20% by Société générale de financement du Québec) completed construction of its 58 000-t/y commercial magnesium plant in Danville, Quebec. The $950 million plant started producing magnesium metal in October 2000, creating 350 jobs. The metal produced at the plant is of high quality and has had excellent reviews. Although the company faced some start-up problems, it expected to produce about 10 000 t of metal in 2001 and to reach full production levels in early 2003.

Figure 1
Magnesium Smelters, 2000



Smelter	**Company**	**Capacity (t/y)**
1. Haley Station, Ontario	Timminco Limited	6 000
2. Bécancour, Quebec	Norsk Hydro Canada Inc.	43 000
3. Danville, Quebec	Magnola Metallurgy Inc.	58 000

Noranda Magnesium Inc. has developed a new high-temperature alloy system based on magnesium-aluminum-strontium. The alloy demonstrates better creep resistance at higher temperatures than most other magnesium alloys. The alloy, which also has good corrosion resistance, shows great potential to provide an affordable composition for applications such as automotive power trains. Noranda is now marketing this alloy, as well as pure magnesium and magnesium-aluminum alloys. The company is now a full-service magnesium supplier offering a range of pure and alloy products, as well as technical and research and development support to its customers.

Magnola Metallurgy Inc. cast its first magnesium ingot at a pilot plant in Salaberry-de-Valleyfield, Quebec, in March 1997. The ingot was the first of its kind and was produced by an innovative process that was developed over the last 10 years by researchers at the Noranda Technology Centre. Noranda's proprietary process enables the production of magnesium metal from the mining residues of local asbestos mines. The plant is expected to be the world's lowest-cost producer of magnesium. (Additional information is available on the Internet at http://www.norandamagnesium.com.)

In Canada, as in the rest of the world, there has been continued interest in the production of magnesium metal from dolomite deposits or from previously mined asbestos deposits. The Canadian projects include: Gossan Resources Limited at Inwood, Manitoba; Cassiar Mines and Metals Inc. at Cassiar, British Columbia; Globex Mining Enterprises Inc.'s magnesite-talc project at Timmins, Ontario; Canadian Magnesium Corporation at Baie Verte, Newfoundland; and another asbestos-based project at Thetford Mines, Quebec.

Gossan Resources Limited has maintained its interest in a dolomite property at Inwood, Manitoba, with a dolomite resource estimated at 67 Mt grading 21.6% magnesium oxide, with additional inferred resources. Tests on this material have shown that production of commercial-grade magnesium metal is possible using the Magnetherm process. Gossan discussed production from the deposit with metal producers in South Africa and the United States, and completed an economic assessment study of the proposed project, which shows a 15% internal rate of return. (Gossan has an Internet site at http://www.gossan.ca.)

Cassiar Mines and Metals Inc. continues planning for a US$600 million magnesium metal project with a capacity of 70 000-90 000 t/y based on asbestos mining residues in northern British Columbia. The company has a stockpile of 23 Mt of serpentine tailings that grade approximately 24% magnesium. The metal project could be carried out in addition to the company's project to recover asbestos fibre from tailings at the former Cassiar Asbestos Corporation Limited's asbestos mine at Cassiar in northern British Columbia although, in December 2000, a fire damaged the fibre mill, slowing that project. In 2000, the company converted all of its debt to common shares and planned to complete financing and other studies, including a banking report due in early 2001. If discussions on senior financing are successful, the company plans to start production in late 2003. The company changed its name in mid-2001 to Cassiar Resources Inc. (Cassiar has an Internet site at http://www.cassiarmagnesium.com.)

Canadian Magnesium Corporation (CMC) has proposed a project to extract magnesium oxide from serpentine in the tailings at the former Baie Verte asbestos mine in Newfoundland. In 1999, CMC completed pre-feasibility studies and bench-scale testing on mineral residues. Results of the work were positive and indicated that a clean product could be produced. The company continues to review its financing options prior to committing to piloting and marketing studies.

In early 2000, Globex Mining Enterprises Inc., a mining exploration company based in northwestern Quebec, acquired the Deloro magnesite deposit located 13 km southeast of Timmins, Ontario. The company reports that previous exploration on the magnesite-talc deposit has delineated approximately 100 Mt of material grading more than 50% magnesite, with 25-30% talc, to a depth of 120 m in a zone 1800 m by up to 300 m, open at depth. Reports on previous metallurgical work have also indicated the potential to produce high-purity magnesia and magnesium metal from the deposit. In addition, the work has shown that by-products of talc and silica may also be obtained from the deposit. The talc is fibre-free and light-coloured and can be used for cosmetics or the pulp and paper industry. Local markets may also be developed for the silica component of the mineralization. In early 2001, the company signed a contract with Hatch Associates to conduct a scoping study and outline a work plan for a bankable feasibility study for the project. (Globex Mining has an Internet site at http://www.globexmining.com.)

The town of Thetford Mines, Quebec, started a prefeasibility study on a proposal to process mining residues from asbestos mines into magnesium metal. The town reports that more than 300 Mt of material grading approximately 24% magnesium is available in the area for processing. Work was under way to find and license a process that could be used to extract the magnesium. Discussions were also under way with possible partners in the project.

Canadian magnesium production data are confidential due to the limited number of companies reporting. Figures quoted in Table 3 are those estimated by the U.S. Geological Survey and provided to the International Consultative Group on Nonferrous Metals Statistics. These estimates include recycled magnesium.

WORLD DEVELOPMENTS

The most important factor in the world magnesium market situation continues to be the increased production (and exports) of magnesium from China. Production from China has rapidly increased over the past nine years from about 5000 t in 1990 to 193 567 t in 2000, as reported by the China Magnesium Association. This increase has resulted in a decrease in the price of magnesium, especially in markets that are not protected by tariff barriers. Continued availability of this lower-priced magnesium is expected to result in the increased use of magnesium, but not without cost to existing producers.

The second most important factor in the magnesium market remains the large number of proposed new projects. If only a few advance to fruition, global primary magnesium metal production would expand considerably. While it is unlikely that all of these projects will proceed, it is likely that magnesium supplies could be available for an accelerated rate of growth in demand should prices not decrease substantially from their present levels.

According to the IMA, shipments of primary magnesium from producers in 2000 were 366 900 t, down 8600 t, or approximately 2% from the reported record 375 500 t in 1999. It must be remembered, however, that approximately 30 000 t of recycled magnesium were removed from the shipment statistics from primary producers, and this drop results from a change in the methodology for collecting statistics. Shipments for aluminum alloys were up 3%, reflecting the increased aluminum production, and shipments for desulphurization were up 23%, reflecting increased shipments of lower-priced Chinese magnesium into this market.

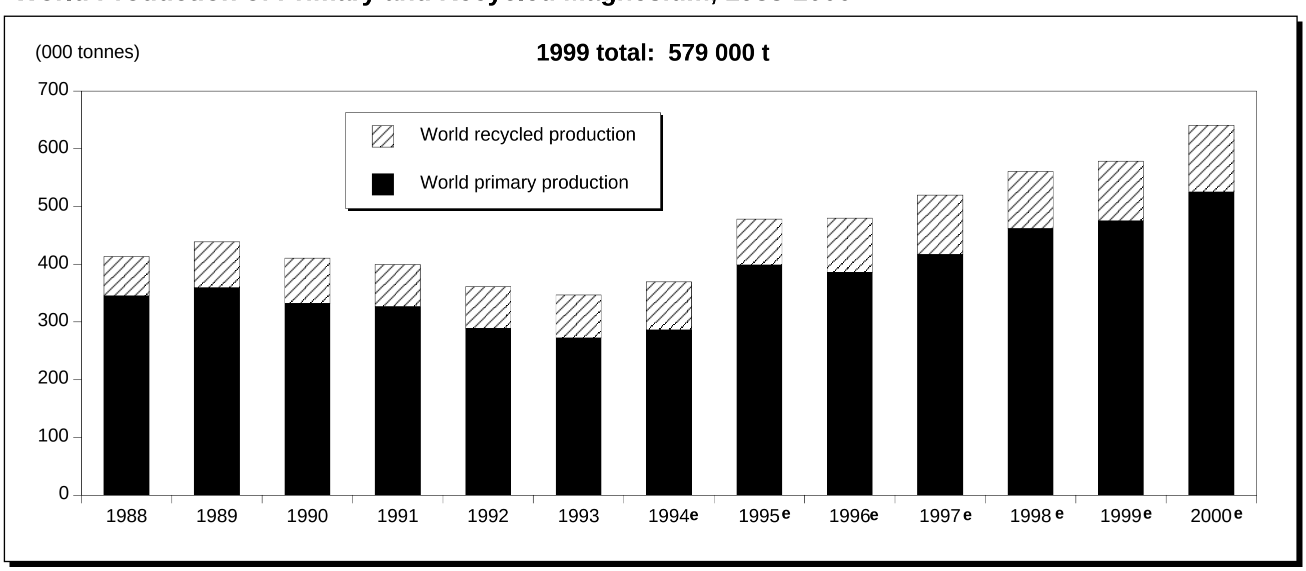
As in the aluminum industry, the magnesium industry, including the casters and other industry users of unwrought metal, as large users of energy, have been affected by higher energy prices. For example, the reported tripling of energy costs for the production of die castings has required some North American casters to impose energy surcharges on shipments. At the time of writing, plant closures had not occurred but, for companies suffering with other problems, closures could occur.

United States

At the end of 2000, the United States had two operating primary magnesium smelters. These were Magnesium Corporation of America (Magcorp), which operates a 43 000-t/y electrolytic plant in Rowley, Utah, and Northwest Alloys, Inc., which operates a 38 000-t/y silicothermic magnesium plant in Addy, Washington.

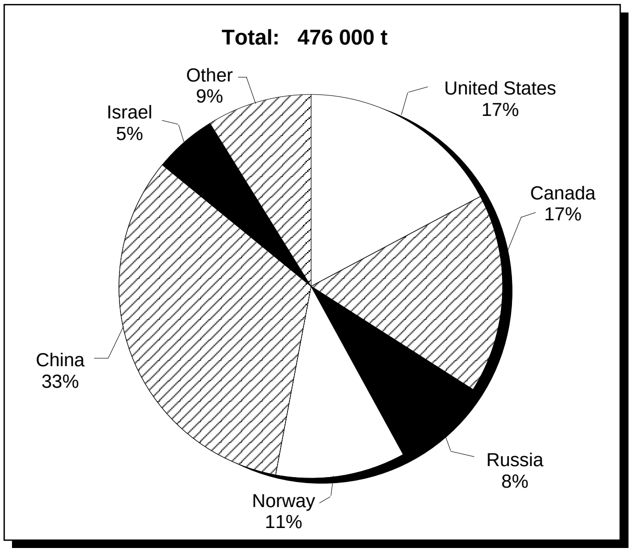
Magcorp, a wholly owned subsidiary of Renco Metals, Inc., concentrates brine from the Great Salt Lake in Utah to produce a magnesium chloride feedstock. The resulting magnesium chloride is reduced in electrolytic cells and the resulting metal is then refined

Figure 2
World Production of Primary and Recycled Magnesium, 1988-2000



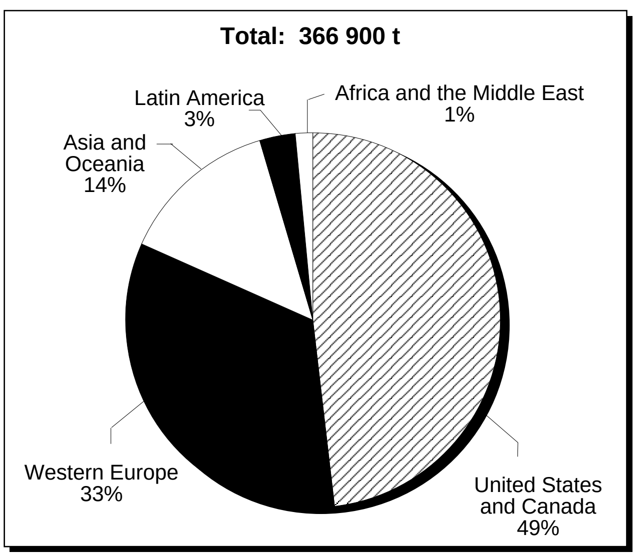
Sources: International Consultative Group on Nonferrous Metals Statistics; China Magnesium Association (China production data); Natural Resources Canada.
[e] Estimated.

Figure 3
World Primary Magnesium Production,[e] 1999



Sources: International Consultative Group on Nonferrous Metals Statistics (ICG); China Magnesium Association (CMA); Natural Resources Canada.
e Estimated.
Note: The ICG reports that China produced 70 500 t while the CMA reported production of 157 000 t. The latter figure is used for China's production.

Figure 4
Destination of Magnesium Shipments, 2000[e]



Source: International Magnesium Association.

and cast into various products. As the company has been reported to generate a 25 000-t/y chlorine surplus, some of which is emitted, it has started efforts to reduce those emissions. In 2000, the company continued work on an upgrading program that began in 1997 to develop a more efficient electrolytic cell technology and to meet new environmental standards for chlorine emissions. In early 2001, the U.S. Environmental Protection Agency filed a lawsuit against Magcorp for past emissions and site clean-up.

Magcorp started conversion of cells in late 2000 and planned to start producing magnesium from these cells in mid-2001. The conversion is expected to reduce Magcorp's metal production over the two years required to complete the work, but the replacement of cells in one half of the plant was expected to increase the plant's capacity by 33%. Once completed, the company expected to construct a line of new cells to further increase the plant's capacity to 60 000 t/y. (Additional information is available on the Internet at http://www.epa.gov and http://www. magnesium-corp.com.)

Northwest Alloys, Inc., a subsidiary of Alcoa Inc., uses the Magnetherm silicothermic process at its Addy plant to produce magnesium by reducing dolomite with ferrosilicon. The bulk of Northwest Alloy's production is shipped for use by Alcoa subsidiaries in aluminum alloys. The company planned to operate at a reduced rate of 30 000 t/y in 2001, due in part to closures of aluminum smelting operations in the western United States.

In October, Xstrata AG finalized the purchase of magnesium scrap processing technology from JCD Ltd. and completed a feasibility study on construction of its first scrap facility in the United States. JCD's process was reported to make high-purity alloys from magnesium scrap at a more competitive cost than other processes. In January 2001, subsidiary Xstrata Magnesium Corporation announced that it had selected Anderson, Indiana, as the location for its first scrap recycling facility in the mid-western United States. The company will invest US$23 million to convert an existing building. Local and state tax credits and grants to Xstrata amounted to over US$1 million. Xstrata's future plans include possible additional plants in Europe and Asia. (Xstrata has an Internet site at http://www.xstrata.com.)

The U.S. Department of Commerce's International Trade Administration (ITA) completed a full five-year sunset review for pure and alloy magnesium from Canada. *The Uruguay Round Agreements Act* requires the U.S. Department of Commerce and the U.S. International Trade Commission (ITC) to conduct these sunset reviews no later than five years after an anti-dumping or countervailing duty order is issued. Final results of the sunset review, published in July 2000, maintained the countervailing duty orders on pure and alloy magnesium from Canada and the anti-dumping duty order on pure magnesium. The ITC determined and imposed a countervail rate of 1.84% on imports from Norsk Hydro and 7.34% on all others, and an anti-dumping rate of 21.6%. In late 2000, the Government of Quebec filed a request for a review of this decision by an independent bi-national panel under Chapter 19 of the North American Free Trade Agreement (NAFTA) but, at the time of writing, no final decisions had been made. The Department of Commerce also conducted an administrative review of countervailing duty orders on pure and alloy magnesium for the period from January 1, 1998, to December 31, 1998, and determined the rate for the period as 1.38% and, in an administrative review of the anti-dumping duty for the period August 1, 1998, through July 31, 1999, determined a margin of 0%. The Department, however, declined to revoke the anti-dumping duty order for Norsk Hydro as it does not have three consecutive years of sales in commercial quantities. (Additional information is available on the Internet at http://www.usitc.gov and http://www.nafta-sec-alena.org/english/index.htm.)

The U.S. ITA completed an anti-dumping duty sunset review of pure magnesium from China and determined that revocation of the anti-dumping duty order would likely lead to continuation or recurrence of dumping and determined a percentage weighted-average margin on a country-wide rate of 108.26%.

In late 2000, the U.S. ITA also initiated anti-dumping duty investigations on pure magnesium from Israel, the Russian Federation and China. In the case of Israel, the ITA made a preliminary determination in February 2001 of a countervail duty subsidy rate at 13.39% ad valorem and, shortly thereafter, that sales at less than fair value had taken place and the anti-dumping margin was 12.68%. In the case of China, the ITA also made a preliminary determination on dumping in early 2001, determining the rate was 8.75% for one exporter and 305.56% for all others, but postponed the final decision. In the case of the investigation on pure magnesium from Russia, the ITA made a preliminary determination that sales had not taken place at less than fair value. (Additional information is available on the Internet at http://ia.ita.doc.gov.)

In early 2001, the United States Automotive Materials Partnership (USAMP), as part of the United States Council for Automotive Research (USCAR), began a new structural cast magnesium development project to resolve the critical issues that limit the large-scale application of structural cast magnesium castings in automotive components. In addition, work is also being conducted through the Partnership for a New Generation of Vehicles (PNGV) on new power-train components, including ones from cast magnesium alloys. (Additional information is available on the Internet at http://www.uscar.org/news/releases/castmagnesium.html.)

Additional information on magnesium production in the United States, as well as other general information on magnesium, is available on the U.S. Geological Survey's Internet site at http://minerals.er.usgs.gov.

Europe

The Antheus Magnesium Project Group continued work on a proposed new magnesium metal plant in the Eemsmond region in Delfzijl metal park in the northeastern **Netherlands**. The Project Group included: Nedmag Industries Mining and Manufacturing, a producer of dead-burned magnesia and other magnesium compounds; Corus Aluminum; Noordelijke Ontwikkelings Maatschappij; and the Netherlands Ministry of Economic Affairs. The group completed a pre-feasibility study in 2000 and planned to start a bankable feasibility study with completion scheduled in 2001. The proposed magnesium plant could have an initial capacity of 30 000 t/y and would use magnesium salts produced by Nedmag. A decision on construction was expected in late 2001. The plant (with an associated casting and recycling operation) would start production in 2005 and would be built to easily accommodate a doubling of the production rate. (Additional information may be found on the Internet at http://www.nom.nl/uk/antheus.htm, http://www.nedmag.nl/home.htm, and http://www. antheus.nl.)

The European Commission (EC) continued its review of imports of unwrought unalloyed magnesium from China following a complaint by the Comité de Liaison des Industries de Ferro-Alliages of Euro Alliages (the European Alloys Association) on behalf of Pechiney SA's wholly owned subsidiary, Pechiney Électrométallurgie of France. (In 2000, Pechiney was the sole producer of magnesium in the European Union.)

In October 2000, the EC doubled the existing anti-dumping duty on imports of magnesium. The duty for unrelated parties remains the same as previously determined, that is, the difference between the minimum import price of 2622 ECU/t and any lower c.i.f. community frontier price. All other cases are subject to a revised ad-valorem duty of 63.4%. Later, in December, the Commission amended these anti-dumping measures, removing magnesium alloy ingots, including those for anode castings, from the original duty. As a result, magnesium-aluminum-zinc and magnesium-manganese alloys were added to the list of exclusions effective December 18, 2000. (Additional information is available on the Internet at http://europa.eu.int.)

Pechiney considered the closure of its 16 000-t/y plant in Marignac in southwestern **France** and started discussions with its workers on the closure in early 2001. (Pechiney has an Internet site at http://www.pechiney.com.)

With the increasing use of magnesium and the demand for recycling, a number of European facilities have been expanded or have announced the construction of new recycling facilities. These include Magnesium Elektron's new plant in Prague. The company decided to construct this new magnesium recycling plant in the **Czech Republic** in preference to previous plans for a site in Germany. The company expected the 10 000-t/y plant to use scrap from Germany and to produce at a rate of 7500 t/y in mid-2001, with operation at full capacity expected in 2002. Plans include an increase in capacity to 20 000 t/y when volumes of recycled metal increase. (Additional information is available on the Internet at http://www.luxfer.com and http://www.magnesium-elektron.com.)

Russia

Solikamsk Magnesium Works announced in early 2000 that it would construct a new US$95 million facility to increase its magnesium and magnesium alloy capacity by 15 000 t/y to bring it to 45 000 t/y. The company planned to obtain funds from existing shareholders and bank loans. Construction of the plant was expected to take two years. The new plant would use a new process developed in cooperation with the Russian Titanium & Magnesium Institute, based on one used at Solikamsk. A feed of synthetic carnallite would be produced from magnesium oxide with a brucite source for the magnesium oxide (to avoid the production of excess chlorine when natural carnallite or other magnesium chloride salts are used).

Russia's second primary magnesium producer is the Avisma Titanium-Magnesium Works at Berezniki, also in the Perm region. Avisma announced plans to increase the production of magnesium and magnesium alloys to 18 000 t/y and to increase its production capacity by 5000-7000 t annually to reach a capacity of 40 000 t/y by 2002. The company also continued its investigation into the use of alternate source feeds for magnesium production and tested a process using synthetic carnallite. The company planned to convert some of the capacity at its existing plant to the new feed and to reduce costs in this manner. The brucite would be sourced in the Khabarovsk district of eastern Russia where it is mined for the production of refractory materials. In conjunction with its expansion plans, Avisma was reported to have signed a renewable three-year agreement with Alcan to supply magnesium for use in alloys used for rolled and foil products. The company planned to produce 23 500 t of magnesium and magnesium alloys in 2000.

The Uralasbest Ural Asbestos Ore Mining and Processing Enterprise, JSC Uralasbest, in the Sverdlovsk region, sought investors for a proposed US$300 million plant to produce 50 000 t/y of magnesium. The company expected that construction of a plant would take three years. It had tested the extraction of magnesium and produced magnesium metal from its asbestos tailings in a pilot plant in 1999. It expected the proposed plant could produce magnesium metal for US$1640/t and that the plant could be in operation in 2005 once funding was obtained. The technology, which would be used for the production of magnesium at the company's asbestos mine, was developed at the Solikamsk Magnesium Works.

Ukraine

MMD Mineral, a mining company, studied the feasibility of re-opening the Kalush Potassium and Magnesium Works in the Ivano-Frankovsk region with a feed of bischoffite from its mine. The electrolytic plant, which had closed in January 1999, had an original capacity of more than 20 000 t/y but had been operating at a much lower rate using a magnesium salt feed from the Oriana fertilizer plant.

Kazakhstan

The Government of Kazakhstan continued work to privatize its remaining ownership in Ust-Kamenogorsk Titanium and Magnesium and expected to complete the sale of its 15.5% interest in 2001. The plant has produced magnesium for use in the production of titanium but has not produced significant quantities of magnesium since early 1994. This privatization is part of a state program to privatize a number of state-owned companies.

Israel

Dead Sea Magnesium Ltd. (DSM), a subsidiary of Israel Chemicals Ltd. and Volkswagen AG, completed its fourth full year of operation at its plant at Sdom, Israel. The plant was reported to have produced 28 000 t in 1999 and the company expected to increase its production capacity to 35 000 t/y in 2000. The company also considered construction of a die-casting plant in Dimonea, 40 km from the smelter, but postponed the start of construction until the metal plant became more profitable. (Additional information is available on the Internet at http://www.magnesium.co.il.)

Asia

China

As a result of the rapid development of China's primary magnesium industry and the limited demand in its domestic market, China has become a major exporter of primary magnesium to the Western World in recent years. China's exports have increased from almost none in 1990 to more than one third of world primary shipments in 2000. Since the United States imposed anti-dumping duties on China's unwrought magnesium, China's primary magnesium exports have been mainly focussed on European and Japanese markets.

China's magnesium metal production capacity, in approximately 500 plants, has been estimated at approximately 220 000 t/y. As most magnesium plants in China use a batch silicon thermal reduction process, the opening and closing of plants is relatively easy. In addition, the cost of ferrosilicon, an essential input into the production process, is relatively low within China, giving Chinese magnesium producers a cost advantage. However, power costs have increased and, coupled with government initiatives to reduce environmental damage and lower prices, the production growth rate will likely remain the same or decline in 2001.

Due to the current low prices for Chinese magnesium, many small plants are currently closed, but these could be re-opened should prices rise. Production in 2000 was reported by the China Magnesium Association to be 193 567 t. The Association expects that production will grow to about 205 000 t in 2001. It is working with Tsinghua University to develop the die-casting industry in the provinces of Guangdong and Shanxi. Reported plans and changes in operations have included:

- Wenxi Yinguang opened a new plant in Shanxi Province near its existing plant to expand capacity by 5000 t/y. The company is focussing on this expansion to provide alloys to local die-cast alloy consumers.

- Top Magnesium Co. in Shanxi Province planned to increase capacity to 10 000 t/y by the end of 2000.

- The Chinese government conducted studies for construction of a new 50 000-t/y plant in Qinghai Province using salt brines. Partners included the government and Minhe Magnesium.

- Norsk Hydro ASA started construction of a 10 000-t/y magnesium alloy ingot foundry in China in Xi'an, approximately 800 km southwest of Beijing. Norsk Hydro intends to produce high-quality alloy ingot from locally produced magnesium for export to traditional markets for die-casting alloys. Construction was expected to be completed in 2001.

- Taiyuan Minwei Magnesium Industry Co. Ltd., a joint venture between Minmet Financing Co. (60%) and Yi Wei Magnesium Group, established a 3000-t/y plant in Taiyuan City, Shanxi, for the production of pure magnesium and alloys.

Japan

Japan has no primary magnesium production but does have companies that use magnesium and recycle magnesium scrap to produce recycled magnesium. As is the case elsewhere in the world, there was increased interest in the recycling of magnesium in Japan as increasing amounts of consumer products containing magnesium reached the end of their life. As of April 2001, a new law required manufacturers to take back appliances, whether imported or locally manufactured. As a result, there has been an increased interest in recycling the contained metals, including magnesium. Nippon Kinzoku Corp. completed construction of a 2400-t/y magnesium recycling plant in Kitakami Iwate prefecture in northern **Japan**. The company expected that this plant would be operating at full capacity in early 2001. The company's recycling capacity in Japan will be 8000 t/y with this fourth plant.

A subsidiary of Sumitomo Metal Industries Ltd., Sumitomo Metals (Naoetsu) Ltd., a company producing precision rolled stainless steel and clad sheet products, conducted research into hot and cold rolling of magnesium. The company has produced sheet magnesium and continues to research the rolling of different alloys and increasing size ranges. The company expects to develop an integrated forming process from melting of the ingot through casting to hot and cold rolling.

Taiwan

Hydro Magnesium and CS Aluminum discussed a joint venture for a magnesium alloy recycling plant in **Taiwan** that would refine recycled die-casting magnesium to high-purity alloys.

India

In early 2000, the assets of Tamil Nadu Magnesium and Marine Chemicals Ltd. were liquidated to pay for debts incurred by the company. The company owned a 600-t/y silicothermic magnesium metal plant, constructed originally in 1990, but which had not recently been in operation.

Republic of the Congo (Brazzaville)

Magnesium Alloy Corporation (MagAlloy) continued work on its Kouilou project in the Republic of the Congo (Brazzaville). The project is based on two 2400-km^2 exploration permits in the Kouilou region. Previous exploration work for potash and oil has indicated the presence of potassium and magnesium salts, including carnallite, sylvanite and bischoffite.

In 1999, the company completed a feasibility study on a proposed 60 000-t/y plant in Pointe-Noire to solution mine the salt beds and to produce magnesium metal. The study by Salzgitter Anlagenbau GmBH proposed a US$514 million plant with an operating cost of US55¢/lb of magnesium. By-product chlorine, sodium chloride and potassium chloride would potentially provide additional revenue. The Russian National Aluminium and Magnesium Institute (VAMI) and the Ukrainian Titanium Institute's magnesium extraction technology would be used in the plant.

Magnesium Alloy signed a Memorandum of Understanding with Siemens AG for the completion of energy-related infrastructure for the Kouilou project. Work also continued on financing the project and, in 2001, the company entered into a financing framework agreement with Amphora Group Holding Luxembourg S.A., a European-based group. Under the Agreement, MagAlloy will form two Luxembourg-based companies, Magnesium Alloy Holding and Mag-Energy Holding. Amphora will secure a 75% interest in both companies in consideration of arranging funding to the companies of US$520 million and US$200 million, respectively. MagAlloy will hold a 25% interest in Magnesium Alloy Holding and a 20% interest in Mag-Energy Holding (5% will be held by third parties).

MagAlloy currently plans to begin production by 2005 at a rate of 60 000 t/y of magnesium metal and high-purity magnesium alloys. (MagAlloy has an Internet site at http://www.magnesiumalloy.ca.)

In 2000, the Congolese government announced a new mining and investment code that will offer incentives and guarantee security of tenure to mining companies to improve the investment climate by streamlining transfers of mineral rights and standardizing conditions on mining title. The government expected to release the code in 2001.

Australia

In late 2000, the Australian government started work on a Light Metals Industries Action Agenda to develop a strategic framework for the continued growth of sustainable and internationally competitive Australian light metals industries. Work will include an analysis and review of the industry. (Further information is available on the Internet at http://www.isr.gov.au/agendas/Sectors/LightMetals.)

Australian Magnesium Corporation (AMC), based in Brisbane, continued work on a proposed magnesium metal plant. As part of an earlier feasibility study, the company produced its first batch of magnesium metal ingots in August 1999 at a 1500-t/y pilot plant located near Gladstone, Queensland. During 2000, the company received government and environmental approvals for construction of the plant. Although financing activities under way at year-end were expected to be completed in early 2001, financing arrangements for the project had not been completed as of September 2001.

AMC's feasibility study, conducted by Fluor Australia Proprietary Ltd., which had a 5% interest in the project, was released in early 2000. It proposed an A$1.13 billion project to construct and commission a metal plant with a capacity of 90 000 t/y of primary magnesium metal in Stanwell, Queensland. Magnesite feed would be obtained from Queensland Metals Corporation Limited's (QMC) existing mining/magnesia production operations at the Kunwara magnesite deposit approximately 50 km north of Stanwell. (Additional information is available on the Internet at http://www.austmg.com.)

Capital costs for the plant were projected to be A$746 million with the remainder of the budget being used for commissioning and contingency costs. Operating costs were estimated to be US64¢/lb. The company expected to make a final decision on the commercial plant and to complete debt financing of the project in 2001. Construction of the plant was expected to be completed in 2004, full production was expected in 2006, and an expansion to 360 000 t/y was planned as markets allow.

The proposed magnesium metal plant would use a chlorine-based process using an Alcan electrolytic cell. The process was developed over the last 10 years by the Commonwealth Scientific and Industrial Research Organization (CSIRO) for Queensland Metals, which provided expertise and contributed A$7 million to the project. As a non-equity partner, it will receive a royalty from the company. Ford Motor Company invested US$30 million in the project in exchange for a 10-year agreement to purchase 45 000 t/y of magnesium metal. To mid-2001, AMC had spent A$200 million on the project.

In late 2000, the Australian government committed A$50 million to commercialize the process through CSIRO, and the Queensland government committed another A$50 million to provide infrastructure. AMC has now combined all of its research and development activity with CSIRO and that organization will continue research to develop new applications and improvements to the production technology. In 2001, the two levels of governments made commitments for an additional A$200 million to assist in the funding package.

A number of other companies in Australia continued developing magnesite resources or magnesium-rich mineral residues to produce magnesium metal, including: Samag Ltd.'s project in South Australia, Crest Magnesium NL's property in Tasmania, Golden Triangle Resources NL's project in Tasmania, Mt. Grace Resources NL's project in Northern Territory, and Anaconda Nickel Limited's project in Western Australia.

Samag Ltd. continued work on a proposed metal plant based on magnesite deposits located near Leigh Creek in the Willouran Ranges region of South Australia. Samag has increased the size of its initial proposal and now expects to construct an A$700 million, 65 000-t/y smelter using Dow technology. Cash operating costs are estimated at under US60¢/lb. The company expected construction to start in 2002 with metal production in 2004.

During 2000, the company:

- chose a site for the proposed metal plant at Weeroona, near Port Pirie in South Australia;
- signed a metal sales agreement with Thyssen Krupp Metallurgie GmbH for all of the metal production from the proposed Port Pirie plant;
- worked to obtain environmental permits and agreements with Aboriginal people at all of its sites;
- signed an agreement with Australian National Power to provide power and gas for the proposed magnesium plant using gas supplied by a new A$200 million pipeline from west Victoria to a proposed power plant near Port Pirie;
- received Major Project Status from the Commonwealth and State governments; and
- worked on a feasibility study for an additional magnesium metal plant in New Zealand but later abandoned the project (http://www.pima.com.au).

Indcor Limited (formerly Crest Magnesium NL) completed reorganization of the company, which has a proposed 60 000-t/y magnesium metal plant near Bell Bay, Tasmania. The project is based on a magnesite property in the Arthur and Lyons rivers area in northwestern Tasmania. A 1998 study conducted by BHP Engineering Pty indicated that a project could be commercially viable with operating costs of US65¢/lb using the company's rights to technology from the Ukrainian National Research and Design Titanium Institute and the Russian National Aluminium and Magnesium Institute (VAMI). Indcor has had discussions with a number of potential partners for joint operation or sale of the company's wholly owned Tasmanian magnesium project. (Indcor has an Internet site at http://www.indcor.com.au.)

Pacific Magnesium Corporation Ltd. (formerly Golden Triangle Resources NL) continued work on its Woodsreef magnesium project in New South Wales based on feed from asbestos tailings. A prefeasibility study of the Woodsreef project was completed that indicated costs of A$681 million for an 80 000-t/y operation with operating costs of A92¢/lb. The company carried out second-stage feasibility work and environmental assessment work, and has decided on a site for its proposed magnesium refinery in the Latrobe Valley of Victoria, Australia. Pacific Magnesium envisages that a plant could be completed in 2004. The company had optioned and conducted work on a magnesium deposit at Mains Creek, but has dropped that option.

Pacific Magnesium produced metal ingots from the tailings in a pilot plant operated by the Russian Titanium and Magnesium Institute in November 2000 and planed to proceed with a definitive feasibility study on the Woodsreef project that would be completed in late 2001. The company also held discussions with possible partners.

The Joint Israeli-Russian Laboratory for Energy Research, in Beer Sheva, Israel, has conducted research for the company on the use of MHD (magnetohydrodynamic) technology for magnesium purification. Such a process could provide faster cleaning rates than have previously been possible. (Additional information is available on the Internet at http://www.goldentriangle.com.au.)

Mt. Grace Resources NL continued work on its Northern Territory Batchelor magnesium project 85 km south of Darwin. The company has licensed technology developed by Mintek in South Africa for continuous thermal magnesium production technology (silico-thermic DC [direct current] arc furnace magnesium reduction) and participated in a project using a Mintek pilot plant to produce metal from the Batchelor magnesite in early 2001. The Mintek process has been developed over the last 10 years to produce metal in a DC arc furnace at atmospheric pressure.

In early 2001, Mt. Grace announced a contract for the first stage of its Definitive Feasibility Study. Results from this work indicated that an initial A$76 million plant with a 14-MW furnace could have a capacity of 12 500 t/y of metal. Once the plant is running, depending on market conditions, the company would expand the operation to 50 000 t/y in 2007. The company planned to complete a bankable feasibility study by the end of 2001 and has signed an agreement for the sale of 10 000 t/y of metal with the Frank & Schulte Group. a subsidiary of Stinnes Interfer, which is a division of Stinnes AG, one of Germany's largest companies. The company hoped to begin construction in 2002 with first production in 2003. (Mt. Grace has an Internet site at http://www.mtgrace.com.)

In mid-1999, Anaconda Nickel Limited announced that it was considering a large magnesium metal production plant (100 000 t/y). The project would be based on a magnesite deposit close to Murrin Murrin, a nickel-cobalt project near the Leonora/Laverton-Mount Margaret district. (Refer to the Nickel chapter for details on this latter project.) Anaconda Industries plans to develop three magnesite deposits near its nickel laterite deposits for the production of magnesia (to be used as a reagent at the Murrin Murrin nickel project) and has also further studied the magnesium metal project. (Anaconda has an Internet site at http://www.anaconda.com.au.)

OCCURRENCE

Magnesium is the eighth most abundant element, comprising over 2% of the earth's crust. It is the third most abundant element dissolved in seawater with a concentration averaging 0.14% by weight. Magnesium does not naturally occur in its native or metallic state, but is found in more than 60 different minerals. The principal magnesium minerals include carbonate forms in dolomite and magnesite; as a silicate in olivine and brucite; as an oxide/silicate in serpentine; and as a chloride in seawater, natural brines and evaporites. In the past, magnesium metal has been produced from dolomite/magnesite, seawater, brines, brucite and residues from asbestos mines. Companies have also looked at producing magnesium from other magnesium-rich sources of fly ash.

TECHNOLOGY

Magnesium metal is produced by a number of methods that can be classed into two general processes. These are: metallothermic, in which a reducing agent such as ferrosilicon is mixed with magnesium oxide and heated in a furnace under vacuum to produce magnesium metal vapour; and electrolytic, in which molten magnesium chloride salts are electrolyzed/reduced to produce liquid metal. Larger plants generally use electrolytic methods, which account for over one half of the world's production capacity. Metallothermic methods require more labour and are more suitable for small batch operations; these have become more important with the increased production from China.

USE

Although magnesium is consumed in some applications (such as in flares or when magnesium is used in chemical reactions in the production of other metals), most use in industrial and consumer products is generally non-destructive and the metal can be recycled and re-used. The energy inherent in the metal remains and the process of recycling the metal recovers that energy in a repeating and sustainable manner. Discussions on metals taking place in a number of fora indicate that word usage in reports such as this yearbook should be modified to more appropriately reflect actual practice.

Magnesium metal is best known for its light weight and high strength-to-weight ratio, making it suitable for a wide range of applications. When used as a structural material, magnesium is alloyed with other elements including aluminum, manganese, rare-earth metals, silver, thorium, zinc and zirconium. When alloyed with one or more of these elements, the resulting alloys can have unusually high strength-to-weight ratios. Magnesium-aluminum alloys are the most common and are principally used in die-casting applications.

The use of magnesium in larger-scale structural applications is relatively "new" and metal and alloy development for specific applications is not as advanced as for better-known metals such as iron. In addition, ways to avoid potential problems with corrosion are not as well developed for magnesium as for other metals such as iron and steel. As a result, some magnesium alloys have had limitations on their use due to the creep that can occur in higher-temperature environments and the potential for corrosion in some environments. However, work by various metal producers such as Noranda and Hydro Magnesium has resulted in new creep-resistant alloys for use in higher-temperature environments. Engineering data on their physical properties are being generated to allow increased use in larger-component automotive applications such as transmission housings, oil pans and engine blocks.

The main application of magnesium is in its use as an alloying agent for aluminum. According to the IMA, Western World magnesium shipments for this application increased by 2% to reach 45% of Western World shipments of primary magnesium (165 100 t) in 2000. Magnesium use for this application is dependent on growth of aluminum use and is expected to continue to increase by 2-3% annually.

The second largest use of magnesium is in high-pressure die-cast products, which can be used in structural applications such as equipment cases for electronics equipment or instrument panel beams of automobiles. The IMA reported that shipments of magnesium for die-cast applications were 110 000 t in 2000. This is lower than the 133 000 t reported in 1999, the difference in part due to a change in the method of calculating shipments from primary producers, which previously have included recycled magnesium. During the next decade, high-pressure die-casting is expected to be the fastest-growing application.

Many automobile manufacturers expect the use of die-cast magnesium parts will help them reduce total vehicle weight while meeting consumer demand for larger vehicles. The increased interest in magnesium metal in the automotive market is largely due to weight savings of more than 30% compared to aluminum and a desire to increase fuel efficiency through weight reduction. Stricter fuel efficiency and emissions standards are also encouraging many auto manufacturers to reduce their vehicles' weight.

Increased consumer demand for sport utility vehicles and cars with added luxury items is also driving manufacturers to find ways to reduce automobile curb weight through the use of cast magnesium instrument panel beams and a host of other smaller pieces on vehicles from transfer cases to steering column supports and cam shaft covers.

Magnesium has good vibration-dampening characteristics. Its lower heat of solidification, which increases die-casting production capacity by 25%, results in major process energy savings. Its characteristics also allow the casting of thinner and more complex shapes, which can replace a number of parts made with other materials, which in turn can also reduce the cost of assembly. Dies for magnesium castings are reported to have more than twice the life of aluminum dies and, at a magnesium-to-aluminum price ratio of about 1.7:1.0 or less, many magnesium metal parts can be fabricated at a lower cost than those made from aluminum. In this regard, over the last few years, the increased price of aluminum and the decreased price of magnesium have made the use of magnesium relatively more economical.

In addition to automotive applications, die-cast magnesium products are widely used in portable tools and sporting goods. The use of magnesium in electronics equipment, such as laptop computer housings and components, video cameras and cellular phones, has grown substantially. This trend is expected to continue. Magnesium's advantages for these applications are its good strength-to-weight ratio, heat dissipation, electromagnetic field containment, and radio frequency interference dissipation.

The third largest use of magnesium is as a desulphurizing agent in the ferrous industry where it is consumed in the production of steel and cast iron. Magnesium shipments in 2000 for desulphurization, as reported by the IMA, totaled 51 600 t, an increase of 23% from the 41 700 t shipped in 1999. Most of this increase is from shipments from lower-priced Chinese magnesium into this market, which has resulted in a higher rate of increase. Although this sector has grown at high rates in the past, should prices increase, growth in the future would be slower due to advances in desulphurization methods that use lower quantities of magnesium in making low-sulphur steels.

Magnesium is introduced into the melt during the production of nodular iron, which is used primarily for the production of ductile iron pipes and die-cast parts for use in automobiles and farm equipment. Shipments fell again in 2000 to 8800 t from 8900 t in 1999, a 1% decline, much less than the 27% decline a year earlier. This application is expected to continue to face stiff competition as plastics penetrate the water pipe market.

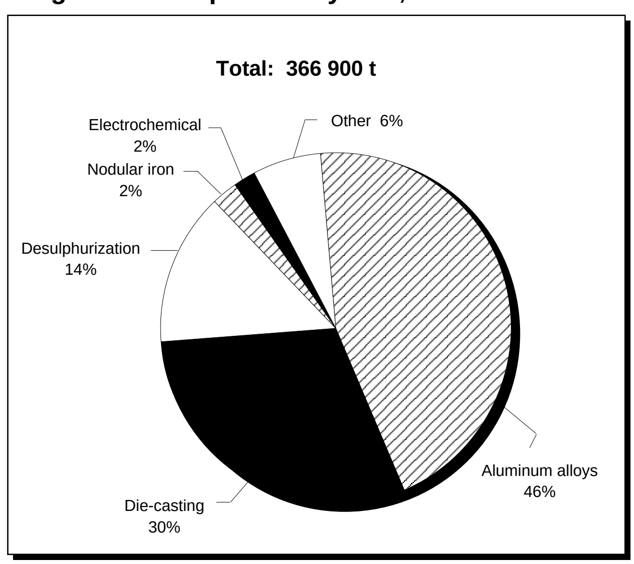
Electrochemical applications accounted for about 2% of magnesium shipments for use in the manufacture of batteries and in anodes for the cathodic protection of gas pipelines and water heaters. Chemical applications, with about 1.6% of shipments, include the manufacture of pharmaceutical products, perfumes and pyrotechnics. Wrought products, which accounted for about 1% of shipments, include extruded products except anodes, sheets and plates; gravity casting includes the production of complex or large parts by sand casting or casting with other materials. About 1% of magnesium shipments were used as a reducing agent in the production of titanium, beryllium, zirconium, hafnium and uranium.

Work continues on other ways of using magnesium and the lower prices prevalent during the year have stimulated further work. One potential use is in powder magnesium metal hydride storage systems for hydrogen for use in fuel cell-powered vehicles. Testing indicates such systems would hold more hydrogen per litre of volume than cryogenic systems. (Additional information is available on the Internet at http://www.ovonic.com.)

In Canada, the reported use of magnesium increased to 43 850 t in 1999 from 32 790 t in 1998 due to increases in reported use in castings and other uses. Previous growth in Canada's demand for magnesium has come from increased use in aluminum alloys and for castings and wrought products.

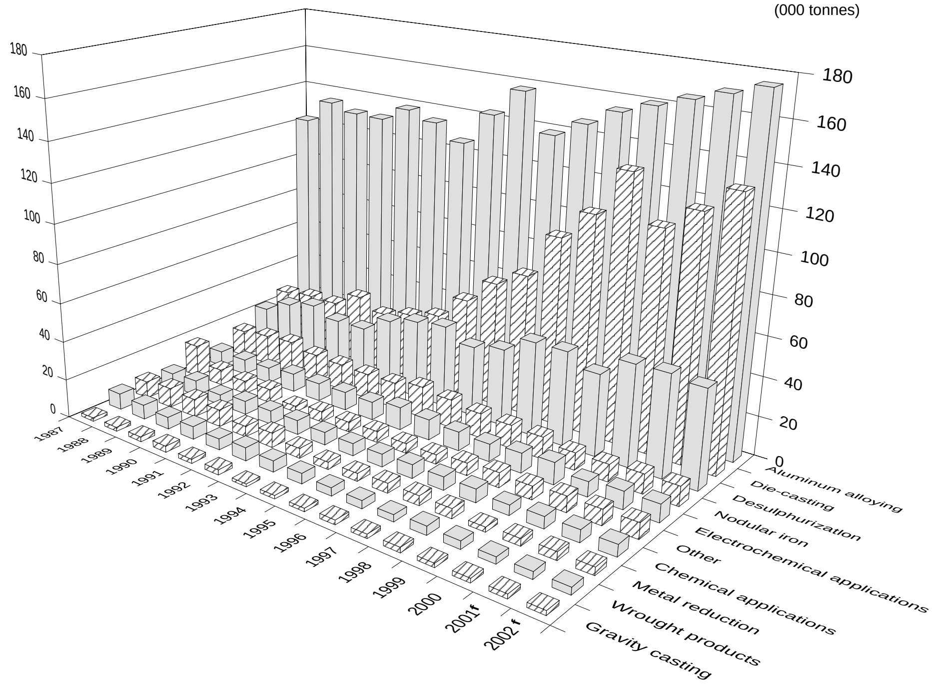
The biggest potential for growth in the use of magnesium lies in the aluminum alloy and automotive markets sectors. However, growth will be dependent on

Figure 5
Magnesium Shipments by Use, 2000



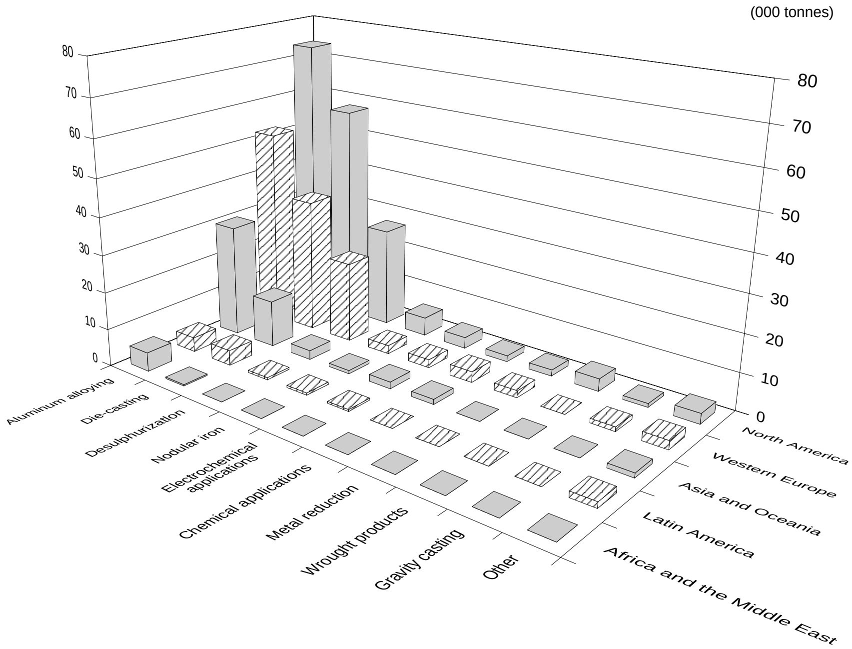
Source: International Magnesium Association.

Figure 6
Magnesium Shipments From Primary Producers, by Use, 1987-2002
2000 total: 366 900 t



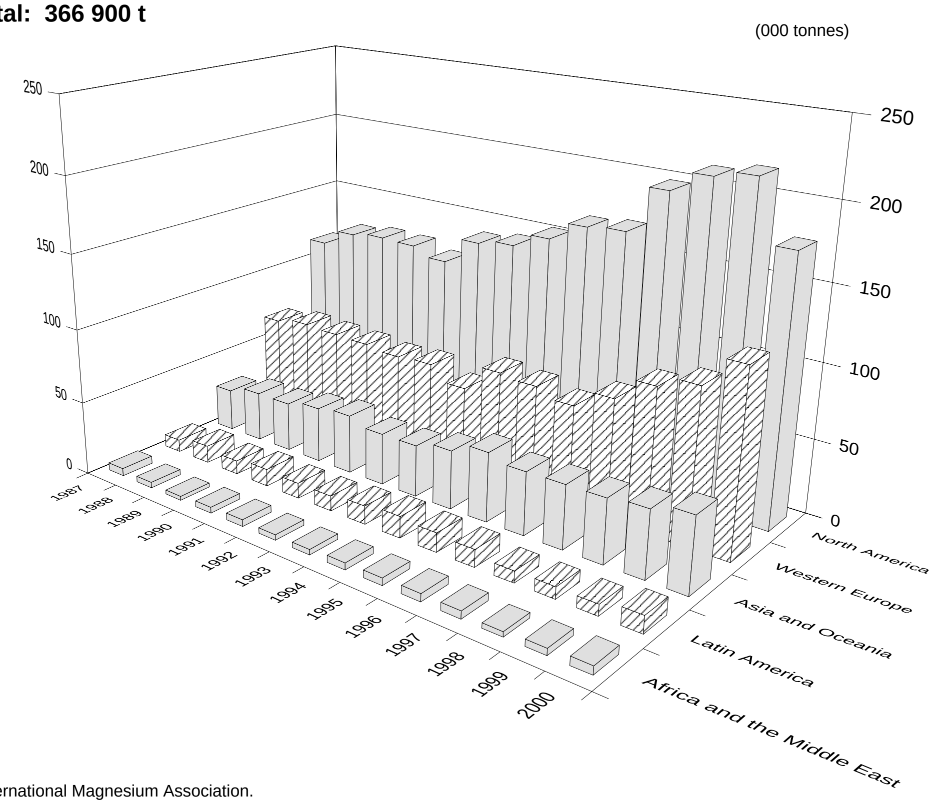
Sources: Natural Resources Canada; International Magnesium Association.
f Forecast.
Note: Die-casting does not use the total amount of material shipped. Shipment figures before 2000 may include recycled material; the die-casting figure for 2000 does not include this recycled material.

Figure 7
Primary Magnesium Shipments by Category and Area, 2000
2000 total: 366 900 t



Source: International Magnesium Association.

Figure 8
Primary Magnesium Shipments by Area, 1987-2000
2000 total: 366 900 t



Source: International Magnesium Association.

prices and price stability as magnesium continues to face stiff competition from other materials, including aluminum, steel and plastics, in the all-important automotive parts sector. New applications and increased awareness of the advantages of magnesium in certain applications are growing, particularly in the North American automotive industry.

RECYCLING

The production of recycled magnesium from metallic scrap requires about 5% of the energy required to produce primary magnesium. The recycling of old or post-consumer magnesium scrap is expected to increase with the anticipated growth in the use of magnesium die-cast automobile parts. In addition, casting operations produce a high proportion of new or process scrap in their operations that is recycled either on the site or at another location. Producers such as Norsk Hydro collect new magnesium scrap from their clients and recondition and recast the metal into a usable form and shape. This source of scrap is expected to increase with time as magnesium metal further penetrates the automotive and electronics markets and the vehicles and electrical equipment are scrapped. However, as technology and methods for recycling magnesium improve, it is likely that more recycling of producer and other clean new scrap will take place at casting operations. As figures are not collected on this run-around or new scrap, statistics on recycling magnesium may eventually show a decrease, although recycling would become more efficient.

Major North American auto manufacturers, including Chrysler, Ford Motor Company and General Motors Corporation, use magnesium alloy parts containing recycled magnesium. The recovery and use of this recycled magnesium reduces the cost of die-cast components and contributes to sustainable practices in metal use.

Several new magnesium recycling facilities and expansions of existing facilities were under way or announced during 2000 and early 2001. These include:

- Magnesium Elektron constructed its new 10 000-t/y magnesium recycling plant in Prague, in the **Czech Republic**, using scrap from Germany (http://www.luxfer.com and http://www.magnesium-elektron.com).

- Xstrata AG purchased technology from JCD Ltd. to convert magnesium scrap into high-purity recycled magnesium alloy and planned for the construction of a 25 000-t/y plant in Anderson, Indiana – its first scrap recycling facility in the mid-western **United States**.

- Remag Recycling GmbH purchased the equipment from closed **U.S.** magnesium recycler Alabama Cathodic Metals and planned to restart production in early 2001.

- Nippon Kinzoku Corp. completed construction of a 2400-t/y magnesium recycling plant in Kitakami Iwate prefecture in northern **Japan** and worked to commission the plant. The company expected to be operating at full capacity in early 2001. The company's recycling capacity in Japan will be 8000 t/y with this fourth plant.

- Hydro Magnesium and CS Aluminum discussed a joint venture for a magnesium alloy recycling plant in **Taiwan** that would refine alloy recycled die-casting magnesium to high-purity alloys.

Stocks and Prices

According to the IMA, 2000 year-end inventories of members totaled 46 500 t, up 1% from 1999 year-end inventories of 45 900 t. This inventory represents about 46 days of shipments from primary magnesium producers.

Magnesium is neither traded on the London Metal Exchange nor is it traded on the New York Mercantile Exchange (NYMEX). The quantity of magnesium produced and used is lower than other metals used for industrial and structural purposes. For example, primary magnesium production is about 2% of primary aluminum production. As a result, markets for the metal are not well developed. In addition, due to the limited market, magnesium prices are sensitive to supply and demand in end-use markets. As a result, there is little transparency in the price or information on stockpiles of product. Many producers have direct sales contracts with large consumers, often on a long-term basis. Although prices depend on location, metal quality, and pricing differentials caused by duties and other factors, prices for primary magnesium for the year generally trended downward.

Prices published by *Metals Week* for magnesium trended down throughout the year. The U.S. Spot Western Mean started the year at US$1.45/lb, slipping to US$1.26/lb in December, while the mean U.S. dealer import prices decreased from US$1.25/lb early in the year to US$1.10/lb in December. The *Metal Bulletin*'s World Free Market Price for minimum 99.8% magnesium metal started the year at US$2400-$2500/t and declined steadily to end the year at US$1950-$2050/t.

Norsk Hydro's European producer price for pure magnesium started the year at 2.61 euros/kg. The company decreased the price of pure magnesium twice: it was set at 2.45 euros/kg in January, 2.33 euros/kg in April, and subsequently 2.22 euros/kg in January 2001. Norsk Hydro's price for alloy of 2.79 euros/kg established in early January 2000 was reduced to 2.62 euros/kg in January 2001.

Reported prices of Chinese magnesium on a spot basis f.o.b. China remained at approximately US$1500/t throughout 2000, although prices have weakened further in 2001.

Outlook

World primary magnesium production is expected to be about 500 000 t in 2001. With increasing use in die-casting and intensity of use, particularly in automotive applications, magnesium use, especially in the die-casting areas, should continue to grow in the medium to long term.

Canadian production of magnesium increased dramatically at the start of the decade with the opening of Norsk Hydro's 43 000-t/y Bécancour smelter in 1989. Canada's installed primary magnesium production capacity has since remained stable, but it is set to rise again with the ramp-up of Magnola Metallurgy's 58 000-t/y plant at Danville, Quebec. Once completed, Canadian primary magnesium production capacity will rise to about 110 000 t/y.

The amount of magnesium used in automotive applications is relatively low compared to the use of other materials. Although some models contain larger quantities of magnesium, the average vehicle has been estimated to contain approximately 4.5 kg of magnesium, while the plastic content is estimated at over 100 kg. As a result, a relatively minor increase in magnesium used in automotive parts could result in a large increase in magnesium use overall.

Another major factor that will influence magnesium prices in the longer term will be the change in supply over the next decade as the result of expansions/re-openings of existing capacity, or the opening of new plants in China, Canada, Australia, Iceland and the Middle East in the near and medium term. The tonnages of metal that would be produced in these plants, should they become operational and remain economic, is impressive and would more than double current total global production. This potential increase in production continues to present both opportunities and challenges to existing producers while presenting new opportunities to large consumers.

The forecasting of magnesium prices is complicated at this time due to relatively rapid changes that are occurring in production levels, the opening and closings of plants, new and potential applications for use, and the imposition of duties. It is likely, however, that prices will remain weak and potentially volatile on a short-term basis until new widespread transportation uses increase demand. On the other hand, the use of magnesium in the all-important automotive sector is dependent on prices being competitive with other materials.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 65. (2) Information in this review was current as of March 30, 2001. (3) Some differences are noted in some data from independent sources. Work is under way to determine the reasons for these differences. (4) This and other reviews, including previous editions, are available on the Internet at http://www.nrcan.gc.ca/mms/cmy/index_e.html.

NOTE TO READERS

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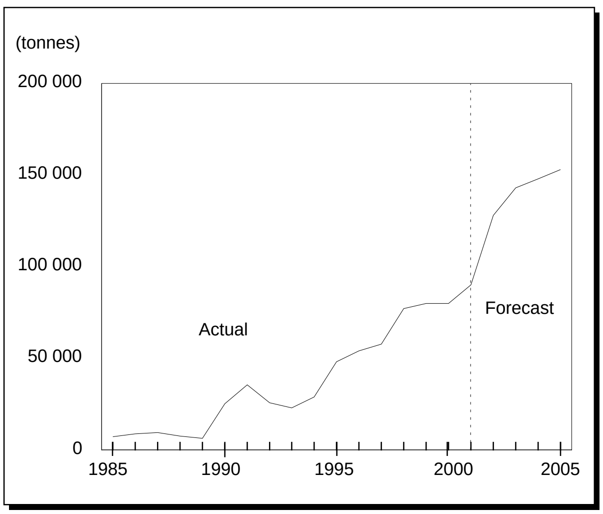
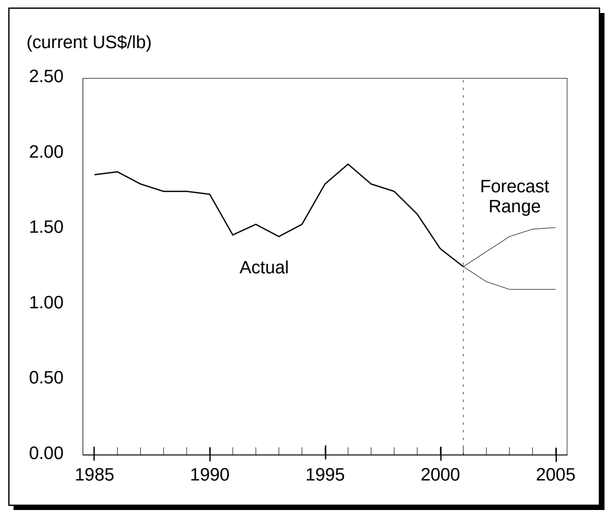
Figure 9
Canadian Magnesium Production, 1985-2005



Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.
Notes: Canadian production data are confidential. Estimated data from the International Consultative Group on Nonferrous Metal Statistics includes recycled material.

Figure 10
Magnesium Prices, 1985-2005



Source: *Metals Week* (U.S. Spot Western Mean).

TARIFFS[1]

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States[2] Canada	EU[2] MFN	Japan[3] WTO
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium	2.5%	Free	Free	Free	5.3%	Free-3%
8104.19	Magnesium unwrought, other						
8104.19.10	Magnesium-rare earth, magnesium-didymium, magnesium-thorium, magnesium-zirconium and magnesium-thorium-neodymium-rare earth for use in the manufacture of magnesium castings	Free	Free	Free	Free	4%	Free-3%
8104.19.90	Other	2.5%	Free	Free	Free	4%	Free-3%
8104.20	Magnesium waste and scrap	Free	Free	Free	Free	Free	2.1%
8104.30	Magnesium raspings, turnings and granules, graded according to size; powders	2.5%	Free	Free	Free	4%	3%
8104.90	Other magnesium	2.5%	Free	Free	Free	4%	3%

Sources: *Customs Tariff*, effective January 2001, Canada Customs and Revenue Agency; *Harmonized Tariff Schedule of the United States*, 2001; *Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of the European Union* (40th Annual Edition: 2000); *Custom Tariff Schedules of Japan*, 2000.
[1] Does not include countervail or anti-dumping duties, which may be applied to material of certain origin. [2] Duty suspension may apply for certain goods.
[3] WTO rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITY AND COUNTRY, 1999 AND 2000

Item No.		1999		2000p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS					
8104.11	Magnesium unwrought, containing by weight at least 99.8% magnesium				
	United States	3 916	19 940	3 098	15 047
	Germany	1 492	5 817	1 783	6 467
	Japan	874	4 125	1 368	5 350
	Austria	684	2 258	1 190	4 003
	United Kingdom	238	1 798	331	2 292
	Other countries	731	3 391	362	1 281
	Total	7 935	37 329	8 132	34 440
8104.19	Magnesium unwrought, other				
	United States	28 841	145 503	21 273	105 641
	Norway	29	122	779	2 693
	Netherlands	280	1 971	226	1 243
	Australia	280r	1 852r	140	852
	United Kingdom	131	920	92	627
	Other countries	832r	2 825r	514	2 087
	Total	30 393r	153 193r	23 024	113 143
8104.20	Magnesium waste and scrap				
	United States	2 152	4 665	6 450	19 316
	Norway	3 361	6 907	562	1 798
	Other countries	99	326	76	184
	Total	5 612	11 898	7 088	21 298
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	5 236	19 261	5 993	17 943
	Ireland	232r	1 799r	231	1 794
	South Korea	138	760	310	1 712
	Other countries	106	905	264	2 104
	Total	5 712r	22 725r	6 798	23 553
8104.90	Magnesium and articles thereof, other				
	United States	84	625	1 842	10 439
	Australia	–	–	182	1 076
	Other countries	11	150	89	664
	Total	95	775	2 113	12 179
	Total exports	49 747r	225 920r	47 155	204 613
IMPORTS					
8104.11	Magnesium unwrought, containing by weight at least 99.8% magnesium				
	Russia	193	706	4 030	15 015
	United States	806r	4 018r	2 738	11 421
	China	3 498r	10 194r	3 763	8 782
	Israel	1 634	7 722	747	3 110
	Brazil	241	982	719	2 818
	Other countries	2 299r	10 912r	593	2 175
	Total	8 671r	34 534r	12 590	43 321
8104.19	Magnesium unwrought, other				
	United States	1 472r	7 100r	4 476	21 989
	Norway	2 977r	14 100r	3 173	13 833
	China	2 954	9 435	2 171	9 878
	France	1 155	3 435r	639	2 794
	United Kingdom	103	1 390	181	2 273
	Other countries	846	3 708	295	1 275
	Total	9 507r	39 168r	10 935	52 042
8104.20	Magnesium waste and scrap				
	United States	16 798r	67 015r	6 860	24 758
	Russia	184	200	717	3 157
	Other countries	–	–	1 187	3 363
	Total	16 982r	67 215r	8 764	31 278
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	350	1 565	474	2 217
	Switzerland	42	171	21	80
	Other countries	69r	288r	17	70
	Total	461r	2 024r	512	2 367
8104.90	Magnesium and articles thereof, other				
	United States	2 232r	11 989r	960	9 010
	China	2	60	53	338
	Other countries	35	300	21	165
	Total	2 269r	12 349r	1 034	9 513
	Total imports	37 890r	155 290r	33 835	138 521

Source: Statistics Canada.
– Nil; p Preliminary; r Revised.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, MAGNESIUM USE,[1] 1993-99

	1993[a]	1994	1995[a]	1996	1997	1998	1999[a,p]
				(tonnes)			
Castings and wrought products[2]	7 678	8 940	12 488	11 197	16 795	16 687	27 383
Aluminum alloys	10 174	12 389	12 323	14 022	14 793	13 417	13 741
Other uses[3]	2 162	2 234	2 329	2 357	2 438	2 459	1 520
Total	20 014	23 563	27 140	27 576	34 026	32 563	42 643

Source: Natural Resources Canada.
[p] Preliminary.
[a] Increase in number of companies being surveyed.
[1] Available data as reported by users. [2] Die, permanent mould and sand castings, structural shapes, tubings, forgings, sheet and plate. [3] Cathodic protection, reducing agents, deoxidizers and other alloys.
Note: Numbers may not add to totals due to rounding.

TABLE 3. WORLD PRODUCTION OF MAGNESIUM, 1994-2000

Country	Rank in 2000	1994	1995	1996	1997	1998	1999	2000[e]
					(000 tonnes)			
PRIMARY PRODUCTION								
China[2]	1	11.0	93.6[r]	73.2[r]	76.0[r]	70.5	120.7	165.0
United States	2	128.5	142.1	133.1	124.8	106.1	75.0	70.0
Canada[1,e]	3	28.9	48.1	54.0	57.7	77.1	71.0	75.0
Norway	4	27.6	28.0	37.8	34.2	35.4	40.8	40.0
Russia	5	35.4	37.5	31.5[r]	33.0[r]	34.1[r]	35.2	35.0
Israel	6	–	–	–	7.4[r]	24.5[r]	30.0	35.0
Kazakhstan	7	3.0	9.0	13.4	17.9[r]	20.9[r]	21.2	21.0
France	8	12.3	14.5	14.0	13.8	14.7	15.0	15.0
Brazil	9	8.8	9.7	9.0	9.0	9.0	9.0	9.0
India	10	1.0	1.0	1.0	1.0	1.5	1.5	1.5
Serbia & Montenegro	11	–	2.6	3.1	3.9[r]	4.0[r]	1.2	1.0
Ukraine	12	12.0	13.0	12.9	7.7	5.0	–	–
Japan	13	3.4	–	–	–	–	–	–
Total primary		271.9	399.1[r]	383.0[r]	386.4[r]	402.8[r]	420.6	467.5
RECYCLED PRODUCTION[3]								
United States	1	62.1	65.1	71.2[r]	77.6	77.1[r]	87.3	90.0
Japan	2	19.0	11.8	21.2	22.8	20.0	20.0	24.0
United Kingdom	3	0.5	0.5	0.5	0.5	0.5	1.0	2.0
Brazil	4	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Austria	5	0.1	0.1	–	–	–	–	–
Total secondary		83.3	79.1	94.5[r]	102.5	92.2[r]	109.9	117.6
Total production		355.2	478.2[r]	477.5[r]	488.9[r]	502.0[r]	530.5	585.1

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics; industry publications.
– Nil; [e] Estimated; [p] Preliminary; [r] Revised.
[1] Estimate per USGS, includes secondary. [2] Numbers used in table from International Consultative Group on Nonferrous Metal Statistics. China Magnesium Association reports higher numbers for Chinese production: 1994 - 25 000 t; 1997 - 92 000 t; 1998 - 120 000 t; 1999 - 157 000 t; 2000 - 194 000 t. [3] Recycled magnesium facilities exist in other locations, including Canada, which have not reported separate production figures for recycled magnesium due to confidentiality reasons and other considerations.

TABLE 4. WORLD USE OF MAGNESIUM, 1995-2000

Country	Rank in 1999	1995	1996	1997	1998	1999	2000[e]
				(000 tonnes)			
PRIMARY PRODUCTION							
United States	1	174.0	172.9	171.9	171.9	170.9	. .
Japan	2	44.9	52.5	52.5	50.9	54.6	. .
Canada[e]	3	27.1	27.6	34.0	32.6	42.6	51.8
Russia	4	25.0	25.0	25.0	25.0	25.0	. .
France	5	17.0	18.7	20.1	20.0	20.0	. .
Germany	6	19.9	19.6	21.9	20.0	15.2	. .
China	7	22.0	22.0	22.0	22.0	11.1	. .
Italy	8	5.4	6.2	9.3	9.0	10.7	. .
Venezuela	9	10.0[r]	10.0[r]	10.0[r]	10.0	10.0	. .
Brazil	10	10.0	10.0	10.0	10.0	9.7	. .
Norway[e]	11	6.0	6.0	6.0	6.0	6.0	. .
South Korea	12	2.0	3.1	3.6	3.5	5.5	. .
United Kingdom	13	6.0	5.2	4.9	5.1	5.3	. .
Switzerland	14	2.1	2.4	3.3	3.5	4.8	. .
Taiwan	15	3.0	1.7	2.9	3.0	4.4	. .
Australia[e]	16	4.0	4.0	4.0	4.0	4.0	. .
Spain	17	1.5	1.5	2.3	2.5	3.1	. .
Belgium/Luxembourg	18	4.0	1.3	5.1	3.0	2.8	. .
South Africa	19	0.8	2.5[r]	2.5[r]	2.5	2.5	. .
Austria	20	3.5	1.6	2.2	2.0	2.0	. .
India	21	1.8	1.8	1.8	1.8	1.8	. .
Other Asia	22	1.7	1.7	1.7	1.7	1.7	. .
Sweden	23	2.2	1.7	1.6	1.5	1.2	. .
Netherlands	24	1.2	1.2	1.2	1.2	1.2	. .
Egypt[e]	25	1.2	1.0	1.0	1.0	1.0	. .
Mexico	26	1.0	1.0	1.0	1.0	1.0	. .
New Zealand[e]	27	1.0[r]	1.0[r]	1.0[r]	1.0	1.0	. .
Greece	28	0.1	0.1	0.1	0.1	0.9	. .
Argentina	29	0.4	0.4	0.4	0.4	0.9	. .
Poland	30	0.7	0.8	0.8	0.8	0.8	. .
Turkey	31	1.5	0.5	0.5	0.5	0.5	. .
Czech Republic	32	0.3	0.3	0.3	0.3	0.3	. .
Romania	33	0.3	0.3	0.3[r]	0.3	0.3	. .
Other America	34	0.2	0.2	0.2	0.2	0.2	. .
Hungary	35	0.2	0.2	0.2	0.2	0.2	. .
Former Yugoslavia	36	0.2	0.2	0.2	0.2	0.2	. .
Cameroon	37	0.1	0.1	0.1	0.1	0.1	. .
Ghana	38	0.1	0.1	0.1	0.1	0.1	. .
Other Europe	39	0.1	0.1	0.1	0.1	0.1	. .
Denmark	40	0.2	0.2	0.2	0.2	0.1	. .
Total primary		402.7[r]	406.7[r]	426.3[r]	419.2	423.8	. .
% Change from previous year		9.4%	1.0%	4.8%	-1.7%	1.1%	. .

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.
. . Not available at time of writing; [e] Estimated; [r] Revised.