

# Magnesium

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**W**orld production of primary and secondary magnesium increased in 1997 to 427 400 t, up from a revised figure of 404 900 t in 1996, and world consumption of both primary and secondary magnesium reached 416 100 t in 1997, up from 394 500 t in 1996.

In 1998, increased demand again led the way to record magnesium shipments. According to the International Magnesium Association (IMA), primary magnesium shipments for 1998 were a record 360 300 t, up 8% over the 333 700 t shipped in 1997. The main reasons for the increase were higher shipments for the die-casting (up 16% over 1997) and aluminum alloy (up 6%) markets.

Primary Western production (which excludes China, the former Soviet Union and Israel) increased by over 11% (27 900 t) to 272 100 t, beating the 1990 record of 260 800 t. Exports from Russia, China and Ukraine continued to be strong, accounting for about 30% of Western markets in the last quarter of 1998.

IMA data also indicate that year-end inventories of magnesium increased in 1998 to total 44 300 t, compared to 32 900 t at the end of 1997. This represents approximately 39 days of world consumption.

## **CANADIAN DEVELOPMENTS**

Norsk Hydro Canada Inc., a wholly owned subsidiary of Norsk Hydro ASA of Norway, produces magnesium metal at a 43 000-t/y Bécancour, Quebec, plant using an electrolytic process. The company announced in 1997 that it would increase the plant's capacity in a two-phase expansion project that was scheduled to begin in 1998. The first phase would increase capacity to 68 000 t/y and, once the first stage is operational, a second phase would further increase capacity to 86 000 t/y. Existing dehydration units will be

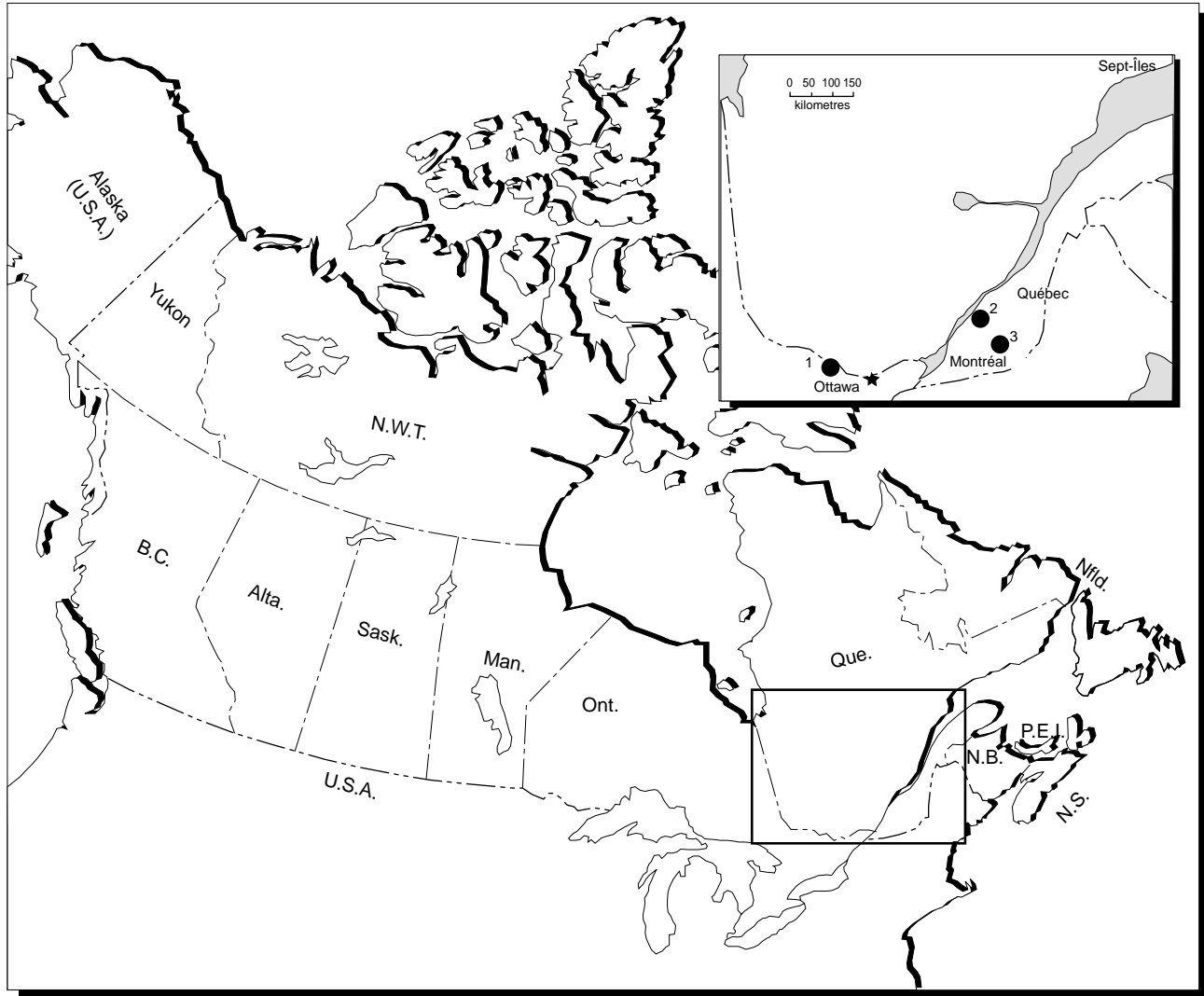
modified to accommodate the first phase. In addition, the project will include new electrolytic capacity and technological improvements that will lead to higher productivity per cell. Other planned changes would reduce energy consumption. The overall improved efficiencies and economies of scale are expected to reduce the plant's operating costs. Norsk is currently testing and qualifying each step of the proposed expansion. Norsk's board will make a final decision on the expansion in mid-1999 and, if approved, additional magnesium production from the expansion would start in 2000, reaching full capacity in 2001. (Further information can be obtained on the Internet at <http://www.hydro.com/>.)

On June 29, 1998, Norsk Hydro Produksjon a.s., another wholly owned subsidiary of Norsk Hydro ASA, and Teksid S.p.A., a wholly owned subsidiary of Fiat S.p.A. of Italy, made an offer to acquire the remaining 44% of Meridian Technologies Inc. that they did not already own. Subsequently, Meridian became a wholly owned subsidiary of Norsk and Teksid. Meridian is the world's largest magnesium die caster with plants in Strathroy (Ontario), Eaton Rapids (Michigan), and Verres (Italy), with 1997 annual sales of \$366 million. (Further information can be obtained on the Internet at <http://www.mni.ca/>.) Teksid manufactures and sells metallurgical components for the international automotive industry.

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.

In 1998, Timminco continued to implement a program to address the company's capacity limitations in its plants. The company completed expansion of its Haley extrusion plant, improvements to casting

**Figure 1  
Magnesium Smelters, 1998**



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 (proposed)	Magnola Metallurgy Inc.	63 000

capabilities, and construction of a new granulation facility. Timminco also plans to complete a new magnesium melting and alloying facility in 1999 as the final step in a multi-phased capital expenditure program that began in 1995.

After receiving approvals from Quebec's Environment Minister, Magnola Metallurgy Inc. (held 80% by Noranda Inc. and 20% by Société générale de finance-

ment du Québec) started construction on its 63 000-t/y commercial magnesium plant in Danville, Quebec. 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 production process that was developed over the last 10 years by researchers at the Noranda Technology Centre. Noranda's proprietary process allows for 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.

Construction of Magnola's \$733 million plant is proceeding on schedule with approximately 650 workers on the site since April 1998. The plant is expected to produce its first metal in June 2000 with full production in the first quarter of 2001. In addition to the construction work generated by the project, nearly 350 direct permanent jobs will be created by the operation of the plant. (For further information on Magnola, visit its web site at <http://www.magnola.com/>.)

Over the past year in Canada, as in the rest of the world, there has been an interest in the production of magnesium metal from dolomite or from previously mined asbestos deposits. The Canadian projects include Gossan Resources Ltd. at Inwood, Manitoba; Minroc Mines Inc. at Cassiar, British Columbia; and Canadian Magnesium Corporation at Baie Verte, Newfoundland.

In September 1997, Gossan Resources Ltd. announced the results of a pilot plant study by Hazen Research of Golden, Colorado. The study confirmed that dolomite at the company's Inwood, Manitoba, property (67 Mt grading 21.6% magnesium oxide) can be made into commercial-grade magnesium metal using the Magnetherm process. Gossan is awaiting completion of financing for a marketing study for the magnesium and calcium products from the property. (Further information can be obtained from Gossan's web site at <http://www.gossan.ca/>.)

Minroc Mines Inc. has announced that a preliminary assessment, carried out by Hatch & Associates, indi-

cates that the tailings from the former Cassiar mine in British Columbia have potential for the production of magnesium. The company is in the process of arranging financing for a feasibility study of the project and plans to carry out such a study on a 30 000-t/y operation in 1999. (Further information can be obtained on Minroc's web site at <http://www.minroc.com/>.)

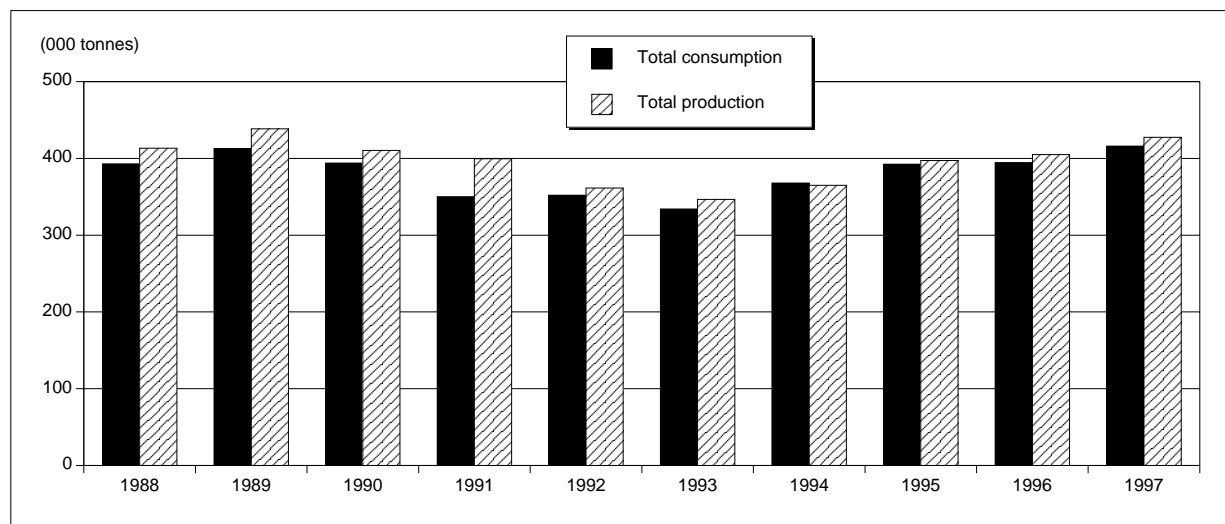
A proposal was submitted to the Government of Newfoundland by Geotech Survey on behalf of Canadian Magnesium Corporation to develop a plant to extract magnesium oxide from the tailings at the former Baie Verte asbestos mine in Newfoundland. The company has received a mineral lease and the project is undergoing feasibility studies for the development of a pilot project for the extraction of magnesium from the tailings.

## WORLD DEVELOPMENTS

Western World primary magnesium production was reported by the IMA to have increased to 272 100 t in 1998 from 244 200 t in 1997. This is a new record, surpassing the previous record of 260 800 t set in 1990. Year-end inventories of 44 300 t were 11 400 t higher than at the end of 1997.

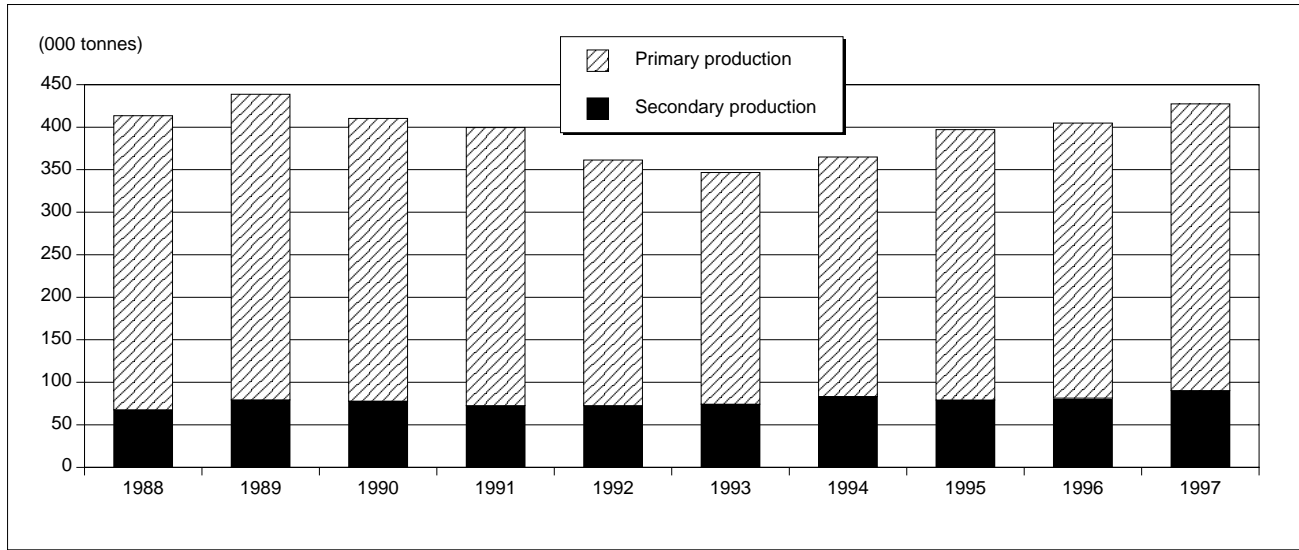
The IMA also reported that shipments in North America remained strong with 210 700 t shipped in 1998, compared to 197 700 t in 1997. This reflected the increased demand in some of magnesium's key market sectors, particularly in Western Europe and North America. (Further information can be obtained on the Internet at <http://www.intlomag.org/>.)

**Figure 2**  
World Production and Consumption of Primary and Secondary Magnesium, 1988-97



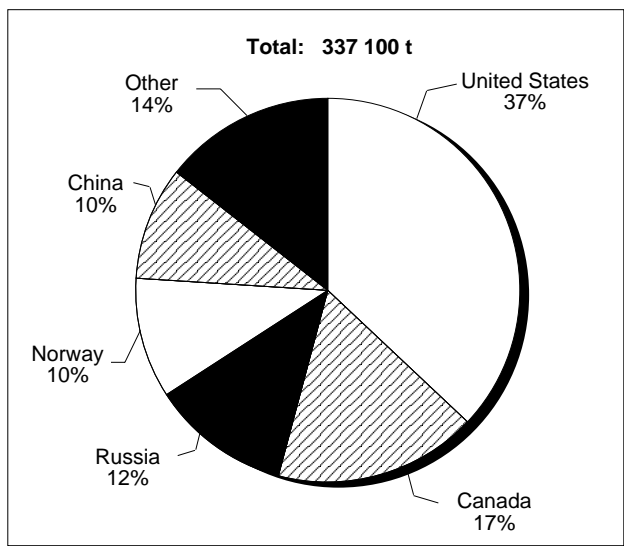
Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

**Figure 3**  
World Production of Magnesium, 1988-97



Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

**Figure 4**  
World Primary Magnesium Production, 1997



Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

## United States

At the end of 1998, the United States had two operating primary magnesium smelters. Magnesium Corporation of America (Magcorp) operates a 41 000-t/y electrolytic plant in Rowley, Utah. Magcorp, a wholly owned subsidiary of Renco Metals, Inc., continued an upgrading program that began in 1997. The com-

pany has been developing new electrolytic cell technology to improve efficiency and to comply with new environmental standards that will require reductions in chlorine emissions. It will also install a new magnesium caster to improve product quality and produce custom shapes at a lower cost. Prototype work on cell technology is expected to be completed in mid-1999, and the conversion of cells will take an additional two to three years. The caster is expected to be operational in late 1999.

Northwest Alloys, Inc., a subsidiary of Alcoa Inc., operates a 38 000-t/y magnesium plant in Addy, Washington. Northwest Alloy's plant uses the Magnetherm silicothermic process in which magnesium is produced by reducing dolomite with ferrosilicon. The bulk of Northwest Alloy's production is shipped for use by Alcoa subsidiaries.

The Dow Chemical Company, formerly the largest U.S. magnesium metal producer, operated an electrolytic plant at Freeport, Texas. The plant had a production capacity of 65 000 t/y when it was closed in November. Magnesium chloride feedstock for the plant was derived from a seawater-dolomite process. Damages resulting from storms in 1998 (Hurricane Frances, a lightning strike in June, and storms in August and September) resulted in the plant closure. The company declared *force majeure* on September 30, 1998, and, on November 20, 1998, Dow announced that it would stop producing magnesium at its Freeport, Texas operation, which had originally started producing magnesium in January 1941. The company intends to continue producing magnesium chloride and hydrochloric acid at the plant and is

licensing its magnesium technology. (Further information can be obtained on the Internet at [http://www.dow.com/pr\\_business/mag.html](http://www.dow.com/pr_business/mag.html).)

In July 1998, Timminco completed arrangements to purchase Dow Chemical Co.'s Fabricated Metals Business in Aurora, Colorado. The unit employs 82 full-time and 43 contract workers and has annual sales of about US\$40 million of fabricated extruded products.

Two separate reviews were conducted by the International Trade Administration (ITA) related to the establishment of countervailing duties and of antidumping duties on magnesium imports from Norsk Hydro Canada Inc. In a preliminary review published on May 12, 1998, covering the period August 1, 1996 to July 1997, a preliminary ruling set antidumping duties for pure and alloy magnesium at 0% *ad valorem*. This is the third time a review set antidumping duties at 0%, but the ITA has indicated it will not revoke the antidumping order. The ITA subsequently extended the time limit for the final result to March 8, 1999. In the second review, the ITA issued preliminary results of the fifth countervailing duty review for pure and alloy magnesium for 1996. As a result, for the period covering 1998, the ITA established countervailing duties at 2.78% *ad valorem* for pure and alloy magnesium from Norsk Hydro. The ITA has begun another investigation that is scheduled to be completed in 1999. (Further information can be obtained on the Internet at <http://www.usitc.gov/>, or at <http://www.ita.doc.gov/>.)

The Court of International Trade (CIT) upheld a decision that the U.S. magnesium industry is not injured by imports from Ukraine. In 1995, the International Trade Commission (ITC) imposed antidumping duties ranging from 74.87% to 104.27% on pure magnesium from Ukraine. The duties were appealed to the U.S. Court of Appeals in 1995, the case was remanded back to the CIT in 1997, and the upheld decision was a result of the appeal. As a result of the remand order, the ITC is re-opening its anti-dumping investigation. (Further information can be obtained on the Internet at <http://www.ita.doc.gov/>.)

The U.S. Department of Commerce (DOC) issued final results for a review of the antidumping duty order on sales of pure primary magnesium from China's Taiyuan Heavy Machinery Import and Export Corp. for the period May 1, 1996 to October 31, 1996. The DOC determined that sales were made below the normal value and instructed the U.S. Customs Service to assess antidumping duties based on the difference between export price and the normal value. The duties were set at 69.53%. (Further information can be obtained on the Internet at <http://www.usitc.gov/>, or at <http://www.ita.doc.gov/>.)

For additional information on magnesium production in the United States and other general information

on magnesium, visit the U.S. Geological Survey's web site at <http://minerals.er.usgs.gov>.

## Europe

The European Commission (EC) investigated imports of unwrought unalloyed magnesium imports from China following a complaint by the European Alloys Association, Euroalliages, on behalf of Pechiney SA for its wholly owned subsidiary Pechiney Électrométallurgie of France. Pechiney Électrométallurgie is the sole producer of magnesium within the European Union. The investigation, started last year, found that China had dumped magnesium, which harmed the EU-based industry and caused material injury to the European industry. As a result, European Community Council Regulation 2402/98, dated November 8, 1998, imposed an antidumping duty on imports of unwrought unalloyed magnesium originating from China.

The ruling lowered the minimum price to 2622 European Currency Units (ECU) per tonne for unwrought unalloyed magnesium from a provisional price of 2797 ECU/t established in May 1998. The final ruling includes a table of all the commonly used alloys and, if an import does not fit the table, it will be subject to duty. Alloyed magnesium was defined as magnesium containing more than 3% of intentionally added alloying elements. The duty will be 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 an *ad valorem* duty of 31.7%. (Additional information is available on the Internet at <http://europa.eu.int>.)

Icelandic Magnesium Co. conducted work on engineering and environmental studies on a proposed 50 000-t/y smelter in Iceland. The company delayed a decision, originally expected in 1998, to build the smelter to enable it to find a major shareholder and conduct further studies. During the year, Australian Magnesium Corporation (AMC) purchased 40% of the company. AMC, a wholly owned subsidiary of Australian Magnesium Investments Pty Ltd., is conducting pilot plant testing of a process that could be used for commercial production of metal. (Refer to the section on Australia below.)

The Antheus Magnesium Project Group has proposed a new magnesium plant in the Eemsmond region in Delfzijl metal park, in the northeastern Netherlands, adjacent to Hoogovens Groep BV's aluminum smelter. The Group includes Nedmag Industries Mining & Manufacturing, a producer of dead-burned magnesia; Hoogovens, which operates an aluminum smelter in Delfzijl; Northern Netherlands Development & Investment Co.; and the Netherlands' Ministry of Economic Affairs. The proposed magnesium plant would have a capacity of 40 000-60 000 t/y, and

the Group hopes that it will be operational in 2005. Feasibility studies are expected to be completed in 1999.

## Russia

Solikamsk Magnesium Works is continuing work on feasibility studies for a 25 000-t/y expansion to bring its capacity to 42 000 t/y. An investment plan was approved by the European Bank for Reconstruction and Development, but it was revised as Solikamsk coped with problems of falling prices and the unstable Russian financial climate. The plan has been studied by Daimler Benz, which pledged part of the financing for the expansion in return for magnesium supplies.

Russia's only other primary magnesium producer, Avisma Titanium-Magnesium Works, reported that the plant was operating at below its full capacity of 18 000 t/y. Production in 1998 from the plant, which is expected to be around 16 000 t, is shipped primarily to export markets in the European Union and the United States.

## Kazakhstan

Ust-Kamenogorsk Titanium-Magnesium Works, which closed in 1994, resumed magnesium production in 1998 and was reported to have produced 6000 t. The company is expected to reduce its magnesium production from this level in 1999.

## Israel

Dead Sea Magnesium Ltd. (DSM) is a joint venture of Dead Sea Works Ltd. (DSW) of Israel (65%) and Volkswagen AG of Germany (35%). DSM completed its second full year of operation at its plant at Sdom, Israel. It experienced some difficulty in bringing the plant on line and with financing, but production has now stabilized and the company has sold magnesium production beyond its commitments to Volkswagen. DSM has changed from a batch process to a continuous flow process and has removed bottlenecks in the operation. The plant is running at approximately a 25 000-t/y level, and the company has been considering construction of a die-casting plant in Dimonea, 40 km from the smelter.

Potash Corporation of Saskatchewan (PCS Inc.) purchased 9% of Israel Chemicals Ltd. in a public offering in December 1998. Early in 1999, PCS Inc. confirmed that it was negotiating to acquire an additional interest in Israel Corp., which owns 52% of Israel Chemicals Ltd., the parent company of DSW. (Additional information can be obtained on the Internet at <http://www.dsw.co.il/>, or at <http://www.potashcorp.com/>.)

## China

China's magnesium metal production capacity, in approximately 500 plants, is estimated at approximately 200 000 t/y. Its actual production is about half of that capacity due to the closure of small plants because of low prices in 1998. About 50 plants were reported to be in production at the end of 1998.

The China National Nonferrous Metals Industry Corporation's (CNNC) participation in the magnesium industry has been replaced by a new group, the State Bureau of Nonferrous Metals Industry Administration. It is reported that, unlike the CNNC, the Administration's duties are to make plans on a whole industry basis based on economic returns, and plants will be controlled at the operational level. The Administration is also reported to have instructed all operations to reduce stocks and to expand exports.

As a result of the rapid development of China's primary magnesium industry in 1994 and 1995, and the limited demand in the domestic market, China has become a major exporter of primary magnesium to the Western World in recent years. Exports of primary magnesium totalled more than 77 000 t in 1997, or approximately one quarter of world primary shipments. Since the United States imposed anti-dumping duties on China's unwrought magnesium, China's primary magnesium exports have been mainly focused on the European and Japanese markets.

As a result of duties imposed on Chinese magnesium by the United States, Europe and India, the Chinese National Magnesium Industry Association attempted to establish a floor price for exports. Late in 1998, China's new National Magnesium Products Export Coordination Committee, representing 36 producers, set minimum export prices for magnesium at US\$1950/t for October to December 1998, and set US\$2320/t as the minimum price for 1999.

The Wenxi Yinguang Magnesium Industry group has purchased a number of magnesium-producing plants in Shanxi Province and plans to acquire more. The company expects to produce 14 000 t in 1999.

Milky Way Magnesium in Hebei Province ceased production of magnesium in 1998 due to low prices, but the equipment will remain and could be restarted if prices increase. The company will continue to produce magnesium granules, powder and filings.

## Republic of the Congo (Brazzaville)

Magnesium Alloy Corp. continued work on its Kouilou project in the Republic of the Congo (Brazzaville) during 1998. The company has two 2400-km<sup>2</sup> exploration permits located in the Kouilou region. Previous exploration work for potash and oil

indicate the presence of potassium and magnesium salts, including carnallite, sylvanite and bischofite. A drill hole, completed in 1998, confirmed presence of the magnesium-bearing salt beds.

The company has negotiated a contract with the Congolese government to evaluate and, if feasible, finance to production a magnesium solution mining and extraction plant. Consulting and technology transfer agreements with Salzgitter Anlagenbau, the Russian National Aluminum and Magnesium Institute and SNC-Lavalin have focused on producing an advanced prefeasibility study to evaluate a proposed 60 000-t/y plant in Pointe-Noire to produce magnesium metal. Work on prefeasibility studies is scheduled for completion early in 1999 and, if results are positive, will be followed by a feasibility study. The company indicates that if current and subsequent work and studies are successful, magnesium production could potentially start in late 2002. (Additional information can be obtained on the Internet at <http://www.magnesiumalloy.ca/>)

## Australia

Australian Magnesium Corporation (AMC), based in Brisbane, completed construction of a 1500-t/y magnesium and metal alloy demonstration project as part of feasibility work towards a 90 000-t/y commercial metal plant. AMC is a wholly owned subsidiary of Australian Magnesium Investments Pty Ltd., which in turn is owned equally by Queensland Metals Corporation Limited and Normandy Mining. Work on the pilot project began in early 1997 after a company announcement that Ford Motor Company had committed to invest US\$30 million in the project in return for an agreement to purchase magnesium metal. Fluor Daniel is earning a 5% equity in AMC through the provision of engineering services. The magnesium will be produced from magnesite from Queensland Metals Corporation's Kunwara magnesite project using a process developed by the Commonwealth Scientific and Industrial Research Organization (CSIRO). CSIRO has worked with Queensland Metals for more than 10 years to develop a low-cost process to produce magnesium metal from magnesite. CSIRO has agreed to provide expertise to the demonstration project and contribute A\$7 million to the project, which was estimated to cost A\$110 million. As a non-equity partner, it will receive a royalty from the company.

AMC indicates that if the technology is viable, construction of a commercial plant with an estimated cost of A\$700 million could begin in mid-1999, with production of metal starting in 2002 and achievement of full production in 2004. The company assessed four sites for the smelter's location and has chosen a site at Stanwell, approximately 50 km south of the Kunwara deposit. The pilot plant had produced anhydrous magnesium oxide by year-end and metal

production was expected in early 1999. A decision on construction of the smelter is expected in late 1999. The company is also studying a second plant in Iceland with its purchase of an interest in Icelandic Magnesium. (Additional information is available on the Internet at <http://www.normandy.com.au/>)

A number of companies in Australia have shown an interest in developing resources of magnesite or magnesium-rich mineral residues to produce magnesium metal. Australian projects include: Crest Magnesium NL's property in Tasmania, Golden Triangle Resources NL's project in Tasmania, Mt. Grace Resources' project in the Northern Territory, and Samag Ltd.'s project in South Australia.

Crest Magnesium signed an agreement with Multiplex Construction Proprietary to fund drilling and a bankable feasibility study of its magnesite property in the Arthur and Lyons rivers area in northwestern Tasmania, and for financing and building a 95 000-t/y magnesium metal plant, likely near Bell Bay. A prefeasibility study was completed in mid-October by BHP Engineering Pty and Hatch Associates of Canada. The study indicated that a project could be commercially viable with operating costs of US\$0.65/lb using the company's rights to technology from the Ukrainian National Research & Design Titanium Institute and the Aluminium & Magnesium Institute (VAMI) in Russia. The company has been considering doubling the size of the proposed plant and expects to complete a feasibility study in 1999. Construction could potentially start in 2000 with completion scheduled for 2002.

Golden Triangle Resources NL is spending A\$750 000 to outline reserves of magnesite ore at its Main Creek mine in Tasmania. The company is also looking at asbestos tailings at its Woodsreef project in New South Wales. Golden Triangle has appointed Lakefield Research to begin the second phase of laboratory work towards a pilot plant program. A feasibility study is expected to be completed in 1999. (Further information can be obtained from Golden Triangle's web site at <http://www.goldentriangle.com.au/>)

Samag Ltd. (owned 80% by Pima Mining NI) is discussing joint ventures based on magnesite deposits near Leigh Creek in the Willouran Ranges region of South Australia. The company has committed to spending A\$1.5 million on a feasibility study, completion of a resource outline and metallurgical testing for a proposed 52 000-t/y smelter at Port Augusta in South Australia. The study is expected to be completed in 1999.

Mt. Grace Resources has started work on a prefeasibility study for a project at its Northern Territory Batchelor magnesium project. Drilling was reported in 1998 on the deposit, which is located 85 km south of Darwin in the Northern Territory.

## CONSUMPTION AND USES

Total world consumption of primary magnesium reached 323 600 t in 1997, compared to a revised total of 302 000 t in 1996. In Canada, reported magnesium consumption in 1997 increased by 6450 t to 34 026 t. The consumption of magnesium metal for castings and wrought products increased by almost 5600 t to 16 795 t. There was also a 3% increase in reported demand for magnesium in the production of aluminum alloys to a record 14 793 t.

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 over 60 different minerals. The principal magnesium minerals include carbonate forms in dolomite and magnesite; as a silicate in olivine and brucite; as an oxide in serpentine; and as a chloride in seawater, natural brines and evaporites. Magnesium metal is produced from three major sources: dolomite/magnesite, seawater, and brines.

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 main application of magnesium is as an alloying agent for aluminum, accounting for 43% of Western World consumption of primary magnesium in 1998. According to the IMA, Western World magnesium shipments for this application reached 154 400 t in 1998, up 6% compared to the 146 150 t shipped in 1997. Magnesium consumption for this application is forecast to increase by 2% annually.

The second largest use of magnesium is in structural applications where high-pressure die-cast products are the most important use. The IMA reported that shipments of primary magnesium in 1998 for die-cast applications increased by 16% to a total of 110 100 t from 95 300 t in 1997. During the next decade, high-pressure die casting is expected to be the fastest growing sector, particularly in the United States and Europe.

The increased interest in magnesium metal in the automotive market is largely due to weight savings of about 33% compared to aluminum. Magnesium also has good vibration-dampening characteristics. Its lower heat of solidification, which increases die-

casting production capacity by 25%, results in major process energy savings. In addition, magnesium dies are reported to have more than twice the life of aluminum dies. Furthermore, at a magnesium-to-aluminum price ratio of 1.7:1.0 or less, many magnesium metal parts can be fabricated at a lower cost than those made from aluminum.

The enforcement of stricter fuel efficiency and emissions standards is encouraging many auto manufacturers to reduce their vehicles' weight. Increased consumer demand for cars with added luxury items is also driving manufacturers to find ways to reduce automobile curb weight. Many automobile manufacturers in both the United States and Japan are looking to magnesium to help reduce total vehicle weight without sacrificing consumer demand for larger vehicles.

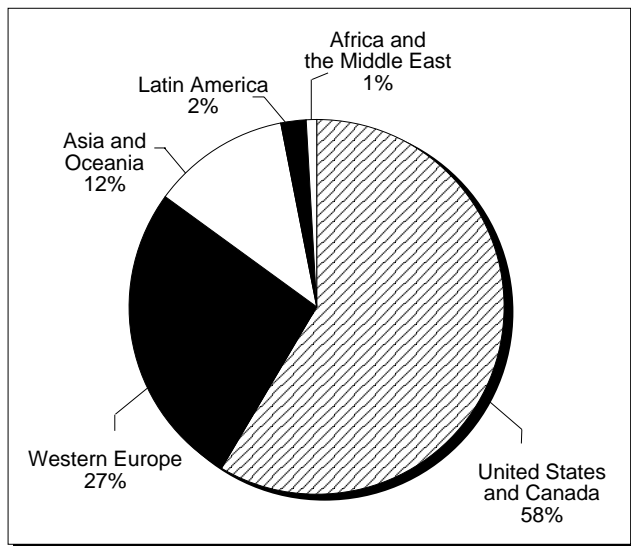
In addition to automotive applications, die-cast magnesium products are widely used in the manufacture of portable tools and sporting goods. The use of magnesium in electronics equipment, particularly computer housings and components, has grown substantially. This trend is expected to continue. Magnesium's 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. Magnesium shipments in 1998 for desulphurization, as reported by the IMA, totalled 48 200 t in 1998, an increase of about 1% from the 47 950 t shipped in 1997. This sector, which grew at an average rate of 15%/y in the late 1980s, should see a more moderate growth rate because of the rationalization that took place in the steel industry.

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 in 1998 totalled 11 300 t, down from 11 750 t in 1997. This application is expected to continue to face stiff competition as plastics increasingly penetrate the water pipe market. Magnesium is also used as a reducing agent in the production of titanium, beryllium, zirconium, hafnium and uranium. Electrochemical applications account for about 4% of magnesium consumption for use in the manufacture of batteries and in anodes for the cathodic protection of gas pipelines and water heaters. As with nodular iron, plastics in the gas pipeline market continue to penetrate this market. Chemical applications include the manufacture of pharmaceutical products, perfumes and pyrotechnics. Wrought products mainly 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.

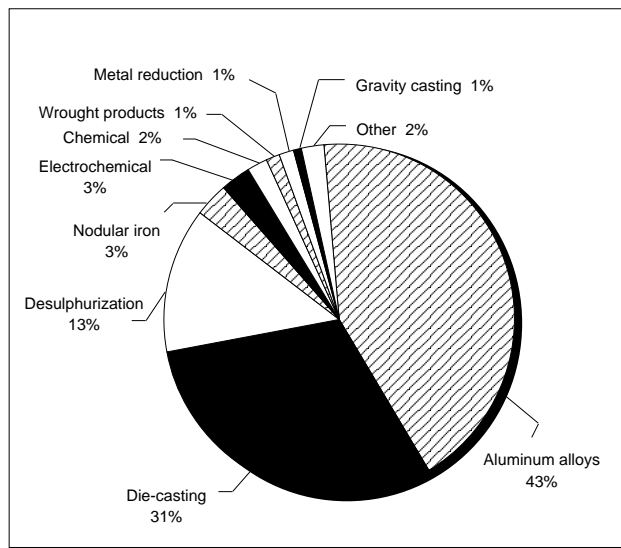


**Figure 5**  
Magnesium Shipments by World Zone, 1998<sup>e</sup>



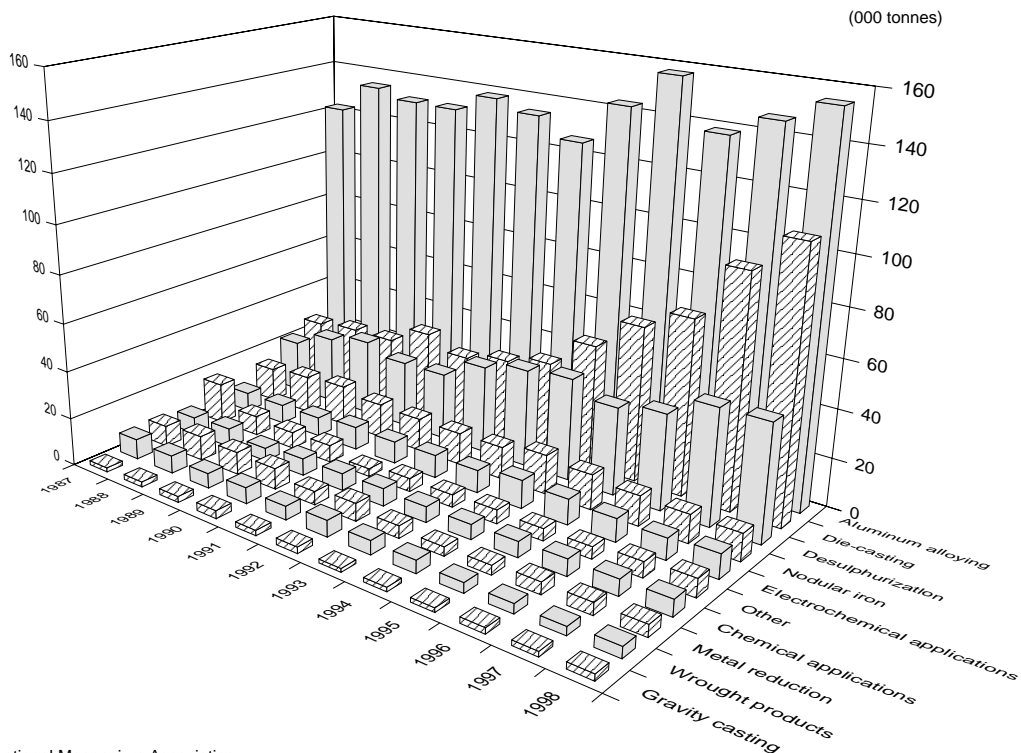
Source: International Magnesium Association.

**Figure 6**  
Magnesium Shipments by Use, 1998



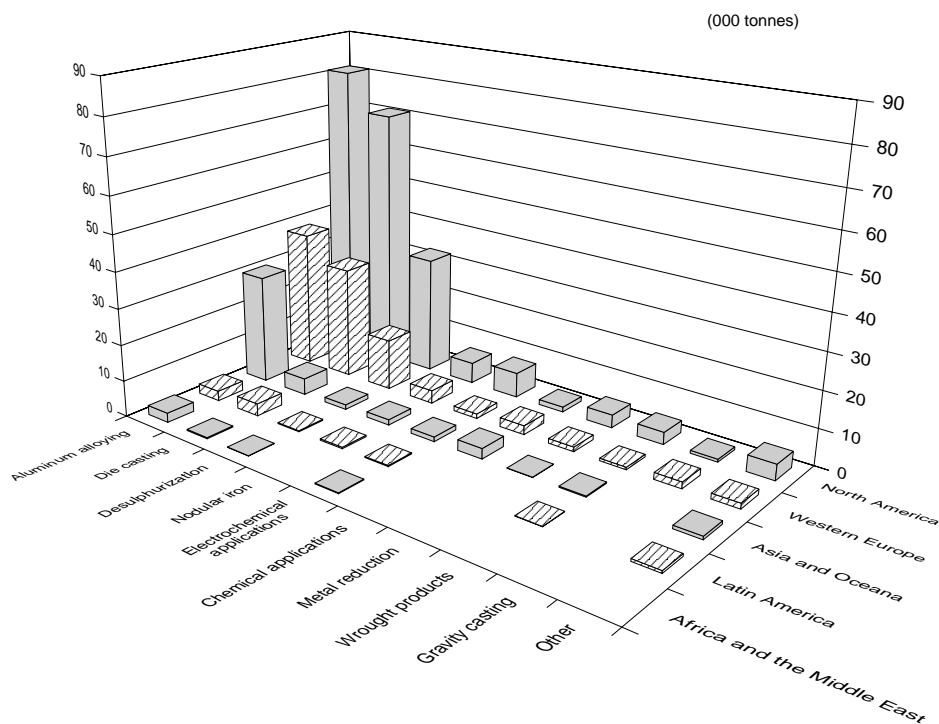
Source: International Magnesium Association.

**Figure 7**  
Primary Magnesium Shipments by Category, 1987-98



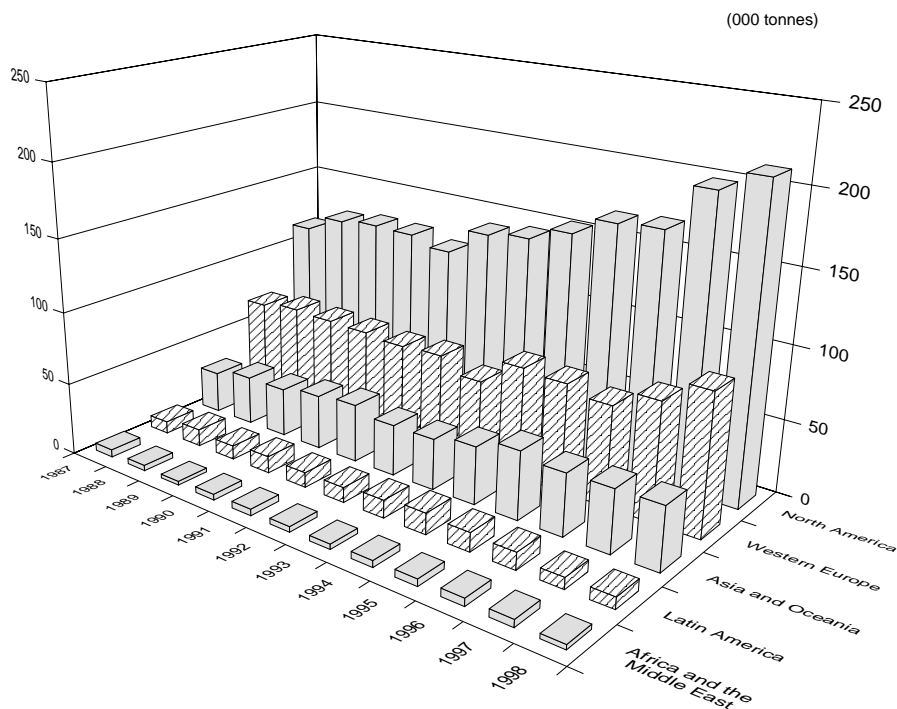
Source: International Magnesium Association.

**Figure 8**  
Primary Magnesium Shipments by Type and Area, 1998



Source: International Magnesium Association.

**Figure 9**  
Primary Magnesium Shipments by Area, 1987-98



Source: International Magnesium Association.

## RECYCLING

The anticipated growth for magnesium die-cast parts in the automotive sector should provide greater opportunities for magnesium recycling. Norsk Hydro Canada and Dow Chemical collect magnesium scrap from their clients. This source of supply is expected to increase as magnesium metal further penetrates the automotive market.

Similar to aluminum, recycled magnesium only requires about 5% of the energy required to produce primary magnesium. The recycling of magnesium is expected to increase with the anticipated growth in the use of magnesium die-cast automobile parts.

In 1998, Chrysler approved the use of 100% recycled magnesium for die-cast components from parts suppliers. Both Ford Motor Company and General Motors have used parts made from recycled magnesium for several years. The use of recycled magnesium reduces the cost of die-cast components.

## PRICES AND STOCKS

As a relatively new metal, the quantity of magnesium produced and used is less than many other metals used for industrial and structural purposes. As a result, markets for the metal are young and not well developed. Magnesium is not traded on the London Metal Exchange nor on the New York Mercantile Exchange (NYMEX) on a daily basis. In addition, due to the limited market, magnesium prices are sensitive to supply and demand in the end use markets. Many producers have direct sales contracts with large consumers, often on a long-term basis. Magnesium producers' list prices can be taken as a general guide, but prices are dependent on many factors, including the quality, purity, location, shape and amount desired by an end user.

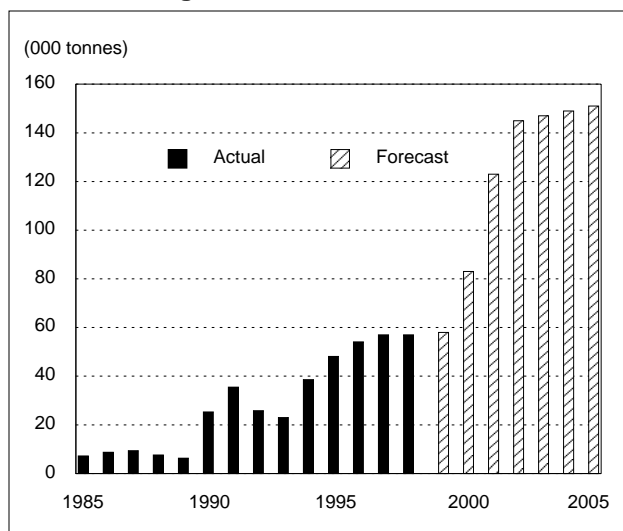
In general, prices for magnesium weakened throughout the year. *Metals Week* reported that the U.S. Spot Western mean price started the year at US\$1.60/lb, increased to US\$1.63/lb in February, but then started decreasing in May to reach US\$1.57/lb by year-end, averaging US\$1.59/lb for the year compared to US\$1.66/lb for 1997. Similarly, the U.S. Dealer Import mean price started the year at US\$1.52/lb and decreased to US\$1.31/lb by year-end, for an average of US\$1.38/lb for the year compared to the 1997 average of US\$1.44/lb.

According to the IMA, total magnesium stocks increased steadily throughout the year from 33 800 t at the end of 1997 to 44 300 t by the end of 1998. This represents approximately 39 days of world consumption.

## OUTLOOK

Canadian production of magnesium increased dramatically at the start of the decade with the opening of Norsk Hydro's 40 000-t/y Bécancour smelter in 1989. Canada's installed capacity has since remained stable, but it is set to rise again with the proposed expansion of Norsk Hydro's Bécancour plant and the addition of Magnola Metallurgy's 63 000-t/y plant at Danville, Quebec. Once completed, Canadian primary magnesium production capacity will rise to about 150 000 t/y. Canada was the second largest producer of primary magnesium in the world in 1997 after the United States. World primary magnesium production is expected to rise from 337 100 t in 1997 to 360 000 t/y by 2000 and to 500 000 t/y by 2005.

**Figure 10**  
Canadian Magnesium Production, 1985-2005



Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

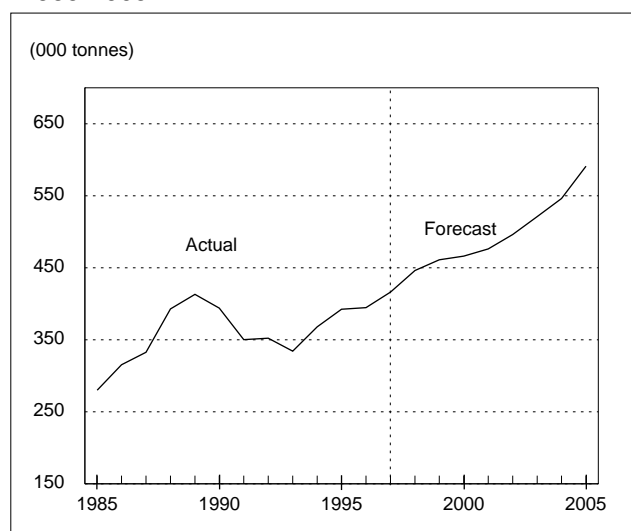
World primary magnesium consumption was 323 600 t in 1997, and is expected to increase to 375 000 t/y by 2000 and to 495 000 t/y by 2005. The Western World's primary magnesium annual growth in demand for this period is expected to reach 5% in North America, 4% in Western Europe, and 9% in the Far East. This growth will be fed primarily by a strong demand for magnesium in aluminum alloys, die-cast automotive parts and desulphurization applications in the steel industry. Magnesium continues to face stiff competition from other materials, including aluminum and plastics, in the all-important automotive parts sector. New applications and increased awareness of the advantages of magnesium in certain applications are, however, growing, particularly in the North American automotive industry.

Continued strength in prices is forecast in the short term, with North American primary ingot prices expected to remain in the US\$1.70-\$1.90/lb range for 1999. A 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 or the opening of new capacity in Canada, the Congo, Iceland, the Middle East, Australia, and possibly China. The availability of this newer, low-cost supply without a concurrent corresponding increase in

consumption may eventually cause prices to decline, in constant dollar terms, over the next decade. Over the longer term, prices are expected to remain in the US\$1.60-\$1.70/lb range in constant 1998 dollars.

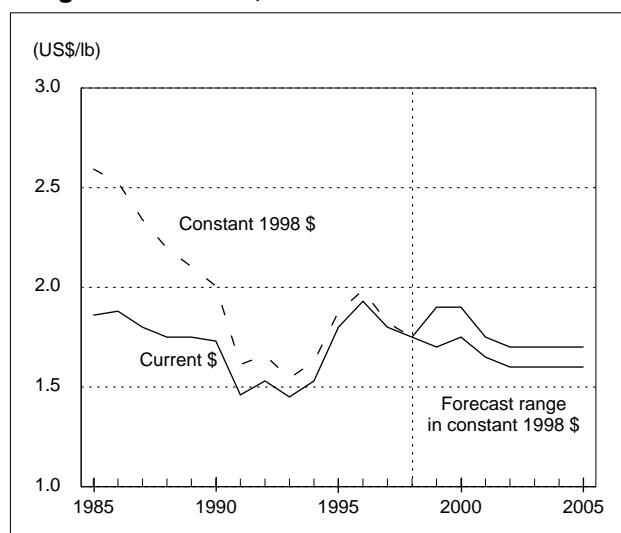
*Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 65. (2) Information in this review was current as of February 20, 1999.*

**Figure 11**  
World Primary Magnesium Consumption,  
1985-2005



Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

**Figure 12**  
Magnesium Prices, 1985-2005



Source: Natural Resources Canada.

## TARIFFS

Item No.	Description	Canada		USA	United States Canada	EU MFN	Japan <sup>1</sup> WTO
		MFN	GPT				
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium	2.5%	Free	Free	Free	5.3%	1.3-3.7%
8104.19 8104.19.10	Magnesium unwrought, other 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	4.3%	1.3-3.7%
8104.19.90	Other	2.5%	Free	Free	Free	4.3%	1.3-3.7%
8104.20	Magnesium waste and scrap	Free	Free	Free	Free	Free	2.3%
8104.30	Magnesium raspings, turnings and granules, graded according to size; powders	2.5%	Free	Free	Free	4.3%	3.8%
8104.90	Other magnesium	2.5%	Free	Free	Free	4.3%	3.8%

Sources: Customs Tariff, effective January 1999, Revenue Canada; Harmonized Tariff Schedule of the United States, 1999; Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of the European Union (38th Annual Edition: 1998); Custom Tariff Schedules of Japan, 1998.

<sup>1</sup> WTO rate is shown; lower tariff rates may apply circumstantially.

**TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITY AND COUNTRY, 1997 AND 1998**

Item No.	1997		1998P		
	(tonnes)	(\$000)	(tonnes)	(\$000)	
<b>EXPORTS</b>					
8104.11	Magnesium unwrought, containing by weight at least 99.8% magnesium				
	United States	1 213	6 882	2 324	12 392
	Germany	2 418	10 191	2 651	11 026
	Japan	1 438	7 143	2 277	10 876
	Australia	1 586	6 655	1 482	6 111
	United Kingdom	744	4 160	382	2 708
	Norway	311	1 293	544	2 095
	Netherlands	160	728	348	1 490
	France	483	2 206	264	1 193
	Other countries	1 053	5 442	483	2 239
	<b>Total</b>	<b>9 406</b>	<b>44 700</b>	<b>10 755</b>	<b>50 130</b>
8104.19	Magnesium unwrought, other				
	United States	26 471	123 950	29 789	150 494
	Australia	530	3 476	573	4 352
	Netherlands	304	2 734	371	2 689
	Italy	340	2 289	352	2 433
	South Africa	59	456	113	1 126
	Germany	92	543	167	1 033
	Other countries	260	1 597	286	1 270
	<b>Total</b>	<b>28 056</b>	<b>135 045</b>	<b>31 651</b>	<b>163 397</b>
8104.20	Magnesium waste and scrap				
	United States	2 226	6 270	2 689	6 960
	Norway	1 128	4 392	-	-
	Other countries	33	81	-	-
	<b>Total</b>	<b>3 387</b>	<b>10 743</b>	<b>2 689</b>	<b>6 960</b>
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	5 051	23 738	4 551	21 509
	Ireland	270	1 985	135	1 054
	Netherlands	111	768	96	758
	Other countries	367	2 163	123	703
	<b>Total</b>	<b>5 799</b>	<b>28 654</b>	<b>4 905</b>	<b>24 024</b>
8104.90	Magnesium and articles thereof, other				
	United States	319	2 527	80	549
	Italy	-	-	12	418
	Other countries	26	188	15	127
	<b>Total</b>	<b>345</b>	<b>2 715</b>	<b>107</b>	<b>1 094</b>
	<b>Total exports</b>	<b>46 993</b>	<b>221 857</b>	<b>50 107</b>	<b>245 605</b>
<b>IMPORTS</b>					
8104.11	Magnesium unwrought, containing by weight at least 99.8% magnesium				
	China	4 188	16 468	3 679	13 690
	Russia	375	1 399	749	3 151
	United States	2 644	13 964	525	2 316
	Other countries	391	1 377	387	1 727
	<b>Total</b>	<b>7 598</b>	<b>33 208</b>	<b>5 340</b>	<b>20 884</b>
8104.19	Magnesium unwrought, other				
	United States	2 408	10 892	4 840	22 798
	Russia	4 784	22 992	4 028	18 258
	China	1 182	4 298	3 092	11 213
	France	-	-	268	1 614
	Other countries	5 846	27 847	302	2 391
	<b>Total</b>	<b>14 220</b>	<b>66 029</b>	<b>12 530</b>	<b>56 274</b>
8104.20	Magnesium waste and scrap				
	United States	11 287	34 246	13 372	43 205
	Other countries	43	208	209	302
	<b>Total</b>	<b>11 330</b>	<b>34 454</b>	<b>13 581</b>	<b>43 507</b>
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	835	3 181	278	1 159
	United Kingdom	20	73	108	469
	Other countries	355	1 285	52	204
	<b>Total</b>	<b>1 210</b>	<b>4 539</b>	<b>438</b>	<b>1 832</b>
8104.90	Magnesium and articles thereof, other				
	United States	430	3 184	223	3 161
	Mexico	44	357	194	1 358
	Other countries	142	648	5	54
	<b>Total</b>	<b>616</b>	<b>4 189</b>	<b>422</b>	<b>4 573</b>
	<b>Total imports</b>	<b>34 974</b>	<b>142 419</b>	<b>32 311</b>	<b>127 070</b>

Source: Statistics Canada.

- Nil; p Preliminary.

Note: Numbers may not add to totals due to rounding.

**TABLE 2. CANADA, CONSUMPTION<sup>1</sup> OF MAGNESIUM, 1991-97**

	1991 <sup>a</sup>	1992 <sup>a</sup>	1993 <sup>a</sup>	1994	1995 <sup>a</sup>	1996 <sup>a</sup>	1997 <sup>p</sup>
	(tonnes)						
Castings and wrought products <sup>2</sup>	4 604	6 915	7 678	8 940	12 488	11 197	16 795
Aluminum alloys	9 215	9 203	10 174	12 389	12 323	14 022	14 793
Other uses <sup>3</sup>	1 926	2 005	2 162	2 234	2 329	2 357	2 438
<b>Total</b>	<b>15 745</b>	<b>18 123</b>	<b>20 014</b>	<b>23 563</b>	<b>27 140</b>	<b>27 576</b>	<b>34 026</b>

Source: Natural Resources Canada.

<sup>p</sup> Preliminary.<sup>a</sup> Increase in number of companies being surveyed.<sup>1</sup> Available data as reported by consumers. <sup>2</sup> Die, permanent mould and sand castings, structural shapes, tubings, forgings, sheet and plate. <sup>3</sup> Cathodic protection, reducing agents, deoxidizers and other alloys.**TABLE 3. WORLD PRODUCTION OF MAGNESIUM, 1994-97**

Country	1994	1995	1996	1997 <sup>p</sup>
	(tonnes)			
<b>PRIMARY PRODUCTION</b>				
France	12.3	14.5	14.0	14.0
Norway	27.6	28.0	37.8	34.2
Russia	35.4	37.5	35.0	39.5
Serbia & Montenegro	—	2.6	3.1 <sup>r</sup>	3.7
Ukraine	12.0	13.0	13.0	12.0
China	11.0	12.6	14.4	32.2
India	1.0	1.0	1.0	1.0
Japan	3.4	—	—	—
Kazakstan	3.0 <sup>r</sup>	9.0 <sup>r</sup>	9.0 <sup>r</sup>	9.0
Brazil	8.8	9.7	9.0	9.0
Canada	38.6	48.1	54.1 <sup>r</sup>	57.7
United States	128.5	142.1	133.1	124.8
<b>Total primary</b>	<b>281.6</b>	<b>318.1</b>	<b>323.5</b>	<b>337.1</b>
<b>SECONDARY PRODUCTION</b>				
Austria	0.1	0.1	—	—
United Kingdom	0.5	0.5	0.5	0.5
Japan	19.0	11.8	8.4	8.0
Brazil	1.6	1.6	1.6	1.6
United States	62.1	65.1	70.9	80.2
<b>Total secondary</b>	<b>83.3</b>	<b>79.1</b>	<b>81.4</b>	<b>90.3</b>
<b>Total production</b>	<b>364.9<sup>r</sup></b>	<b>397.2<sup>r</sup></b>	<b>404.9<sup>r</sup></b>	<b>427.4</b>

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

— Nil; <sup>p</sup> Preliminary; <sup>r</sup> Revised.

**TABLE 4. WORLD CONSUMPTION OF MAGNESIUM, 1994-97**

Country	1994	1995	1996	1997
(tonnes)				
<b>PRIMARY PRODUCTION</b>				
Argentina	0.4	0.4	0.4	0.4
Australia <sup>e</sup>	4.0	4.0	4.0	4.0
Austria	3.5	3.5	1.6 <sup>r</sup>	2.2
Belgium/Luxembourg	4.4	4.0	1.3	5.1
Brazil	10.5	10.0	10.0	10.0
Cameroon	0.1	0.1	0.1	0.1
Canada	23.6	27.1	27.6	34.0
China	10.0 <sup>r</sup>	22.0	22.0	22.0
Czech Republic	0.4 <sup>r</sup>	0.3 <sup>r</sup>	0.3	0.3
Denmark	0.2	0.2	0.2	0.2
Egypt <sup>e</sup>	1.0	1.2 <sup>r</sup>	1.0	1.0
Ex-Yugoslavia	0.4	0.2	0.2	0.2
France	16.1	17.0	18.7 <sup>r</sup>	20.1
Germany	19.0	19.9	19.6	21.9
Ghana	0.1	0.1	0.1	0.1
Greece	0.1 <sup>r</sup>	0.1 <sup>r</sup>	0.1 <sup>r</sup>	0.1
Hungary	0.2	0.2	0.2	0.2
India	1.8	1.8	1.8	1.8
Italy	4.7	5.4	6.2	9.3
Japan	24.5 <sup>r</sup>	27.8 <sup>r</sup>	30.9 <sup>r</sup>	30.9
Mexico	1.0	1.0	1.0	1.0
Netherlands	1.0	1.2 <sup>r</sup>	1.2 <sup>r</sup>	1.2
New Zealand <sup>e</sup>	0.4	0.4	0.4	0.4
Norway <sup>e</sup>	6.0	6.0	6.0	6.0
Poland	0.5	0.5	0.5	0.5
Romania	0.4	0.3	0.3	2.3
Russia	25.0	25.0	25.0	25.0
South Africa	0.8	0.8	0.7	0.7
South Korea	2.2	2.0	3.1 <sup>r</sup>	3.6
Spain	1.7	1.5	1.5	2.3
Sweden	2.2	2.2	1.7	1.6
Switzerland	2.6	2.1	2.4 <sup>r</sup>	3.3
Taiwan	1.5	3.0	1.7	2.9
Turkey	0.6	1.5 <sup>r</sup>	0.5	0.5
United States	112.0 <sup>r</sup>	109.0	102.0	101.0
United Kingdom	6.0	6.0	5.2 <sup>r</sup>	4.9
Venezuela	0.6	0.5	0.5	0.5
Other	1.9	2.0	2.0	2.0
Total primary	291.4	310.3	302.0	323.6
<b>SECONDARY MAGNESIUM</b>				
Japan	14.3	17.1	21.6	21.6
United States	62.1	65.0	70.9	70.9
Total secondary	76.4	82.1	92.5	92.5
Total world	367.8 <sup>r</sup>	392.4 <sup>r</sup>	394.5 <sup>r</sup>	416.1

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.

<sup>e</sup> Estimated; <sup>r</sup> Revised.

**TABLE 5. WORLD PRIMARY MAGNESIUM SMELTER CAPACITY, 1998**

Country	Smelter Location	Company/Plant	Capacity (t/y)
Brazil	Bocaiuva	Rima Industrial S.A.	12 000
Canada	Bécancour	Norsk Hydro Canada Inc.	43 000
	Haley Station	Timminco Metals	6 000
China	Baotou	Baotou 202 Factory	3 500
	Dancheng	Dancheng Ferroalloy Factory	1 000
	Fushun	Fushun Aluminium Smelter (CNNC)	5 400
	Guigang	Guangxi Magnesium Smelter	3 000
	Hebei	Fuda Magnesium Plant	3 500
	Henan	Huaqi Magnesium Industry Co.	6 000
	Hengyang	Hunan Magnesium Smelter	3 400
	Huinong	Huinong Xian Smelter	1 400
	Jinzhou	Xinmei Co. Ltd.	3 000
	Liaoning	Chaoyang Rich Magnesium Co.	4 000
	Minhe Xian	Minhe Magnesium Smelter (CNNC)	5 000
	Nanjing Shi	Nanjing Ube Magnesium Co. (CNNC)	14 000
	Ningxia Hui	Silver River Corporation	1 000
	Ningxia	Shizoushan Ferroalloy Plant	4 000
	Shanxi	Min Xian Magnesium Plant	3 000
	Shanxi	Wen Xi Yin Guang Magnesium Industry Group	9 600
	Shanxi	Yinguang Magnesium Group Co.	3 000
	Taiyuan	Taiyuan East United Smelt Magnesium Co. Ltd.	10 000
	Taiyuan	Zhaojiabao Group Co.	4 000
	Tongxin Xian	Tongxin Xian Magnesium Factory	1 700
Yinchuan Shi	Yinchuan Smelter	1 000	
		Guanghua Chemical Industry Co.	3 500
		Linjiang Magnesium Industry Group	7 000
		Yubu Magnesium Industry Co.	4 000
France	Maringnac	Pechiney	18 000
India	Hyderabad	Southern Magnesium and Chemicals	1 000
Israel	Sdom	Dead Sea Magnesium Ltd.	25 000
Kazakstan	Ust Kamenogorsk	Ust Kamenogorsk Works	40 000
Norway	Porsgrunn	Norsk Hydro ASA	55 000
Russia	Solikamsk	Solikamsk Works	20 000
	Berezniki	Avisma Titanium-Magnesium Works	25 000
Ukraine	Kaluzh	Kaluzh Works	24 000
	Zaporozhyre	Zaporozhyre Works	45 000
United States	Freeport	The Dow Chemical Company <sup>1</sup>	65 000
	Addy	Northwest Alloys Inc.	38 000
	Rowley	Magnesium Corp. of America	41 000
Former Yugoslavia	Bela Stena	Magnohrom	9 000
Total			572 000

Source: Natural Resources Canada.

CNNC China National Nonferrous Metals Industry Corporation (now the State Nonferrous Metals Industry Association).

<sup>1</sup> Closed in late 1998.**NOTE TO READERS**

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