Magnesium

Patrick Chevalier

The author is with the Mining Sector,
Natural Resources Canada.
Telephone: (613) 992-4401
Internet: pchevali@nrcan.gc.ca

According to the International Magnesium Association (IMA), Western World primary magnesium production totalled 161 900 t for the first three quarters of 1994, compared to 167 600 t during the same period in 1993. As a result of lower production and increased consumer demand, primary magnesium stocks fell to 23 600 t by the end of the third quarter of 1994, compared to 42 400 t at the end of 1993.

Primary magnesium exports to the West from the former Soviet Union (FSU) and the People's Republic of China reached 20% of the total Western World market share in 1993. Combined imports from the FSU and China increased to 50 100 t in 1993, up from 15 000 t in 1992. According to IMA figures, magnesium imports remained strong until the third quarter of this year. Before the political break-up of the FSU in 1990, all primary magnesium production was consumed internally. Since then, most of the magnesium imports from the FSU and China targeted the aluminum alloying, nodular iron, and desulphurization markets.

CANADIAN DEVELOPMENTS

The Canadian magnesium industry increased production in 1994 after several difficult years that included weak market activity in the world's major economies and trade action against magnesium imports from Canada by the United States. In 1993, Canadian magnesium consumption increased by 2400 t to 20 600 t. The increase was mainly the result of increased consumption for castings and wrought products, which increased 16% to 8219 t. Demand for magnesium used in aluminum alloys also increased 9.5% to 10 200 t.

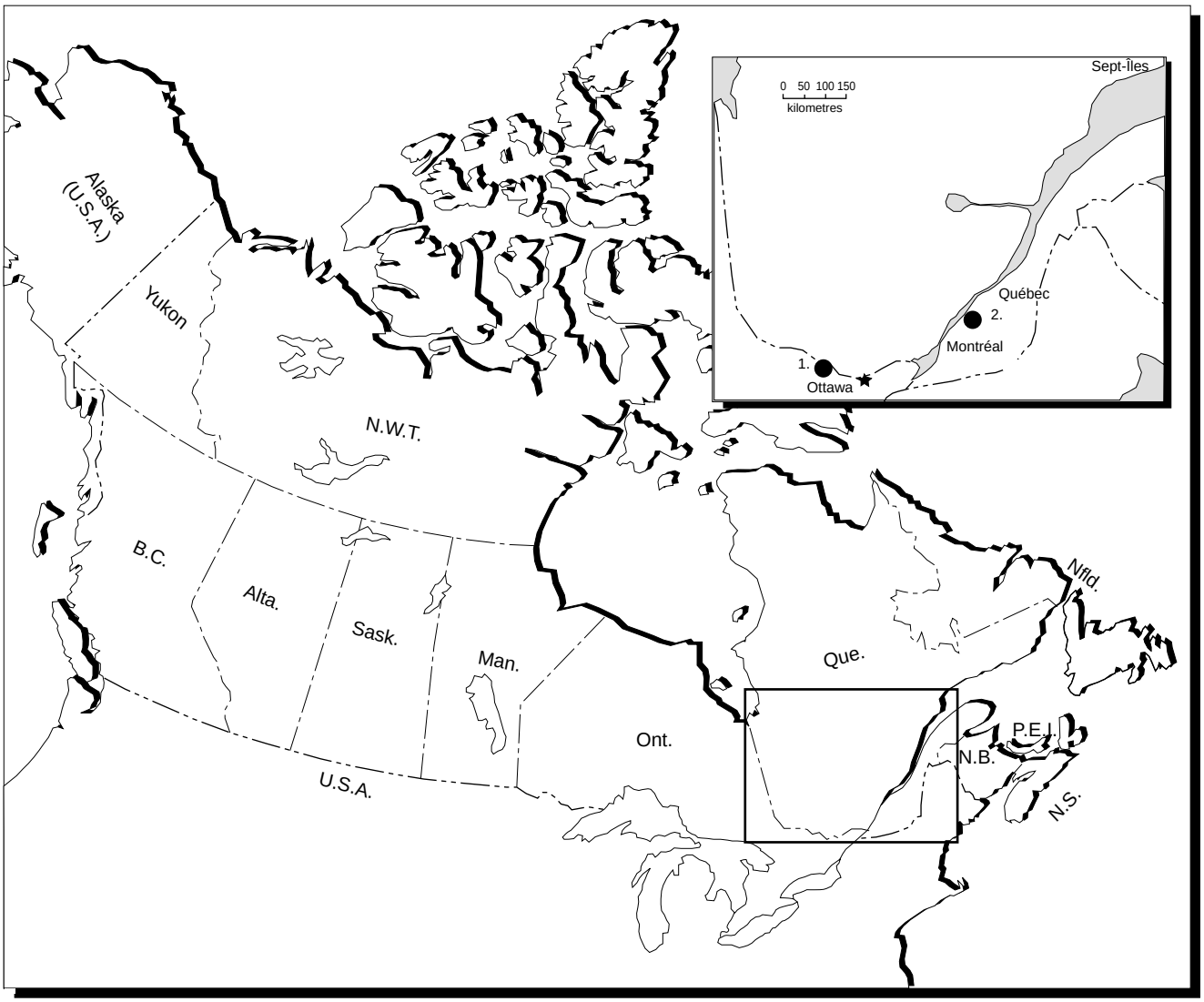
Production at Norsk Hydro Canada Inc.'s 40 000-t/y Bécancour smelter continued to be affected by the imposition of anti-dumping and countervailing duties on magnesium imports to the United States. In 1991, Magnesium Corporation of America (Magcorp) filed a petition requesting the imposition of anti-dumping and countervailing duties on magnesium imports from Canada. The United States subsequently imposed a 7.6% countervailing duty against magnesium imports from Norsk Hydro. Canada's only other magnesium producer, Timminco Limited, was not subject to the duty. In addition to the countervailing duties, the United States issued a 32.7% anti-dumping duty against pure magnesium from Norsk Hydro Canada. The dumping margin for Timminco was zero.

Three separate panels were established in 1993 under the dispute settlement provisions of the Canada-U.S. Free Trade Agreement to examine the cases for dumping, subsidy and material injury. The panel review on dumping maintained the anti-dumping duty on pure magnesium exports to the United States, but at a lower rate of 21%. The second panel accepted the decision to impose a 7.6% countervailing duty against both pure and alloy magnesium. The third panel, set up to decide whether the exports had caused material injury to U.S. producers, upheld the other two panels' decisions. The dumping duties are expected to remain in effect until at least 1998.

Norsk Hydro's Bécancour smelter started production in December 1989 and continued to produce at less than the plant's 40 000-t/y capacity in 1994 because of the trade action. The smelter's 10 000-t/y re-smelting capacity operated at close to full capacity in 1994. In July, Norsk Hydro started to increase output at the smelter to cover the growing demand from both domestic and overseas clients and to compensate for the continuing reduction in stocks.

The process technology used at Bécancour involves leaching magnesite imported from China with hydrochloric acid to produce a brine of magnesium chloride ($MgCl_2$), and then reducing the $MgCl_2$ granules in electrolytic cells to produce metallic magnesium. This year, Norsk Hydro became the first magnesium producer in the world to receive ISO 9001 certification. The smelter at Bécancour received its certificate in June, while the company's plant in Norway received certification in January. The Bécancour smelter also received the 1994 Mercure prize as the best large enterprise in Quebec with regard to environmental protection and management.

Figure 1
Magnesium Smelters, 1994



SMELTER	COMPANY	CAPACITY (t/y)
1. Haley Station, Ontario	Timminco	6 000
2. Bécancour, Quebec	Norsk Hydro	40 000

Timminco Metals, a division of Timminco Limited, produces high-purity metal (up to 99.99% pure) for specialized market applications at its 4000-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 can be used for a variety of applications such as an alloying agent for aluminum and calcium, 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.

Haley Industries Ltd. of Haley Station, Ontario, and Amcan Castings Ltd. of Hamilton signed a letter of intent to form a joint venture to manufacture magnesium die castings for the automotive industry. The operation, initially employing two 800-t die-casting machines, will be located in Haley Station and is scheduled for start-up in mid-1995.

Noranda Minerals Inc. announced its intention to enter the magnesium market by the year 2000. In

1992, Noranda acquired sole ownership of the Magnola magnesium project. The project involves the development of a 58 000-t/y magnesium smelter using a unique proprietary process based on the tailings from a local asbestos mine (containing 25% magnesium) near Thetford Mines, Quebec, to serve as the plant's feedstock. In 1995, Noranda will build a $33 million pilot plant at its research centre in Pointe-Claire, Quebec. Noranda plans to have the first phase of the new smelter operational by the third quarter of 1997 and the entire plant completed by 2000.

In December, the province of Alberta announced that it was abandoning efforts to sell the Magnesium Company of Canada (Magcan) facility near High River, Alberta, as an operational plant. Alberta placed the plant up for sale to any bidder and will liquidate the equipment and dismantle the site if the Magcan smelter is not sold by the end of March 1995. Alberta Natural Gas Company Ltd. and Magnesium International Canada Ltd. formed Magcan in 1986. The province of Alberta guaranteed a loan for $103 million to build the first phase of the $370 million smelter, which was completed in July 1990. The smelter was closed in 1991 after one of the partners refused to invest more money. An engineering firm was retained to maintain the facility for sale. Costs to the province increased as efforts to find a buyer failed. Combining the loan guarantee, interest costs and property maintenance since 1991, losses to the province totalled more than $169 million. Complicating the prospects for a sale was the dispute over ownership of the technology licence to operate the smelter.

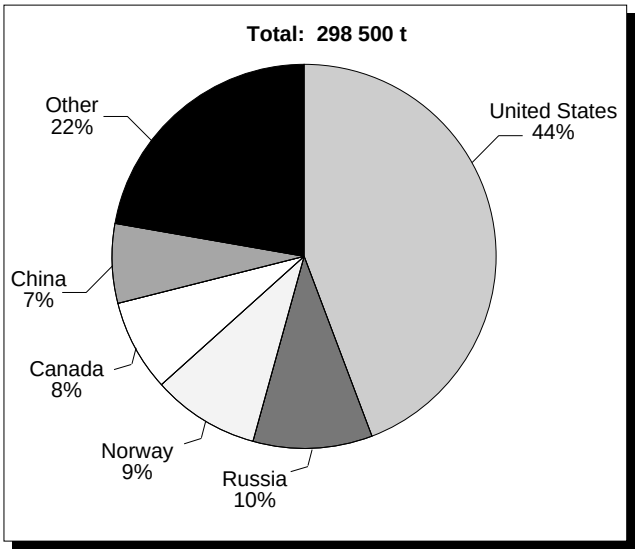
Meridian Technologies Inc. of Toronto won a contract worth $35 million annually to supply magnesium instrument panels for General Motors Corp. (GM) trucks. Deliveries will begin in the 1998 model year and continue over a 10-year period. The contract represents the single largest magnesium contract awarded to a supplier in North America. Meridian also announced that it received a letter of intent to supply magnesium transfer cases for all of GM's light trucks beginning in 1997. As a result of increased demand, Meridian plans to build a third die-casting plant in North America. The company currently operates plants in Strathoy, Ontario, and Eaton Rapids, Michigan. The new plant will be located either in Ontario or Michigan.

WORLD DEVELOPMENTS

Western World primary production totalled 161 900 t in the first three quarters of 1994, compared to 167 600 t in 1993. Lower production and increased demand, particularly in North America and the Far East, helped push prices to higher levels by year-end. Total magnesium shipments for the first nine months increased 28% to 215 000 t compared to 154 000 t for the same period in 1993. Magnesium exports from the republics of the FSU and China remained strong in the first half of 1994 and led to the initiation of trade action investigations in the United States, Europe and Brazil.

Inventories continued to decline during the year in response to increased consumer demand and reduced production in 1993. Total inventories, as reported by the IMA, fell to 23 600 t by the end of September 1994, down from 45 000 t in September 1993. By year-end, inventories were expected to be below 25 000 t.

Figure 2
World Primary Magnesium Production, 1993



Source: Natural Resources Canada.

United States

The United States, the world's largest magnesium producer, has three primary magnesium smelters. The Dow Chemical Company, the largest U.S. producer, operates a 95 000-t/y electrolytic magnesium plant at Freeport, Texas. Magnesium chloride feedstock for the plant is derived from a seawater-dolomite process. Dow is generally considered one of the world's lowest-cost producers of magnesium.

In December, Dow announced that it was permanently closing its 30 000-t/y Plant B at the Freeport complex and will gradually expand capacity at Plant A. Dow completed the shut-down of the facility in the first quarter of 1994. Plant A has a production capacity of about 60 000 t/y. Dow continued to work on the installation of a new proprietary cell technology that is expected to significantly increase capacity within the existing Plant A infrastructure.

Magcorp operates a 36 000-t/y electrolytic plant in Rowley, Utah. The magnesium chloride for the plant

is normally derived from the natural brines of Great Salt Lake. However, high water levels on the lake in 1986 caused US$20 million in damage to the solar ponding system. In 1989, the company began drawing brine from a new pond system in the West Desert. Magcorp estimates that the new ponds have a 10- to 15-year supply of brine. In February 1994, Magcorp announced that it had carried out a significant reduction in magnesium production because of increased imports from Russia and China. While not specifying the amount of production that was affected, more than 50 people were laid off from a total work force of 550 employees.

Northwest Alloys Inc., a subsidiary of the Aluminum Company of America (Alcoa), operates a 33 000-t/y magnesium plant in Addy, Washington. The plant uses the Magnetherm silicothermic process by which magnesium is produced by reducing dolomite with ferrosilicon. The bulk of Northwest's production is shipped for use by subsidiaries of Alcoa.

The U.S. International Trade Commission ruled there was reasonable indication of material injury to U.S. magnesium producers due to imports from China, Russia and Ukraine. The decision was the first step in an anti-dumping case brought by Magcorp and Dow Chemical. In April, the U.S. Trade Representatives' office announced that Russia would lose its Generalized System of Preferences (GSP) zero tariff trade status into the United States effective July 1. Importers are now required to pay the general 8% tariff that applies to magnesium imports from countries without the GSP status. Russia lost its status because it exceeded the GSP limits of not more than 50% of total U.S. imports.

Brazil

Brazil ordered an inquiry into charges that the United States, Ukraine and Russia are dumping magnesium. A Ministry of Industry and Commerce order called for an investigation of magnesium imports from January 1993 to June 1994. The investigation was requested by Rima Industrial SA, Brazil's only primary magnesium producer. Russia and Ukraine were reportedly selling magnesium to Brazilian customers at 36% below the cost of production, while the United States was reportedly selling at 25% below the cost of production. Brazilian imports have risen from an annual average of 790 t in the period covering 1990-92 to 1120 t in 1993.

Europe

Norsk Hydro AS operates a 55 000-t/y primary magnesium smelter at Porsgrunn, Norway. The plant produces magnesium by the electrolysis of magnesium chloride derived from a seawater-dolomite process and from magnesium chloride brine imported from Germany. The smelter received ISO 9001 certification in January.

In September 1993, the European metals federation Euroalliages filed an anti-dumping suit for the only European producer, Pechiney Électrométallurgie, against magnesium imports from the FSU. The European Commission (EC) subsequently announced in January 1994 that it had opened an anti-dumping inquiry into imports of unwrought magnesium from Russia, Ukraine and Kazakhstan. In its presentation, Euroalliages alleged that imports from the three countries had risen from 2300 t in 1991 to 8000 t in 1992, and that the three countries' combined European Union market share rose from 5% to 17%. The EC can impose duties on imports if it deems them to be unfairly undercutting European industry prices.

Australia

Mount Isa Mines Ltd. (a wholly owned subsidiary of MIM Holdings Ltd.) and Ube Magnesium (Australia) Pty. Ltd. (a subsidiary of Ube Industries Ltd.) withdrew from the Australian Magnesium Research Development Project. Mount Isa and Ube each had a 24.5% interest in funding the A$50 million project, along with the Commonwealth Scientific and Industrial Research Organization (CSIRO) (50%) and Queensland Metals Corp. Ltd. (QMC) (1%). MIM had committed a total of A$18 million to the project as of May, when Mount Isa and Ube withdrew from the project. The partners had planned to build a 60 000-t/y magnesium smelter next to QMC's magnesite deposit in Kunwarara. The project will now be restructured with CSIRO and QMC each taking a 50% share. QMC supplies about 7% of the world's high-grade refractory-brick magnesia.

Japan

Japan's last magnesium producer, Ube Industries Ltd., stopped producing magnesium this year at its 8500-t/y plant, citing the appreciation of the yen and cheap supplies from China and Russia as the main reasons for the closure. The high cost of electricity in Japan also affected Ube's competitiveness. The 17-year-old plant used the Pidgeon silicothermic process to produce magnesium. Ube will import magnesium from Timminco of Canada and Norsk Hydro of Norway to continue supplying its customers.

Middle East

Israel's Dead Sea Works announced that the company was negotiating with Volkswagen to become a joint-venture partner in the new 25 000-t/y magnesium smelter project currently under construction in Sdom. Work started on the new smelter in the summer of 1993 and it is expected to start production in early 1996 using Russian magnesium smelter technology. Should this phase of the project prove successful, construction on a second 25 000-t/y phase will begin in 1998.

Russian Federation

Magnesium production in the former Soviet Union was expected to fall to between 41 000 t and 43 000 t in 1994 from 50 000 t in 1993. Exports were also expected to fall between 10% and 12%, according to the Solikamsk Magnesium Works. Increased costs for electricity were cited as part of the reason for the fall in production. Solikamsk Magnesium Works, Russia's largest magnesium producer, started producing die-cast magnesium alloy parts, including wheels, for Lada cars. Earlier this year, Lada awarded Solikamsk with a contract to produce 100 000 magnesium wheels annually. Solikamsk operates a 17 000-t/y magnesium smelter in the Ural region of central Russia.

Berezniki Magnesium and Titanium Works changed its name to Avisma. Avisma is the world's largest producer of titanium sponge, but is studying the possibility of doubling its magnesium output over the next couple of years from the current 10 000 t/y.

China

Japan's Liberty World Corporation and the government of China's Henan province will set up a joint-venture operation to produce magnesium in Hebi, China. Hebi Four Seasons Metal Industry Corp. will refine 1500 t/y of magnesium starting in April 1995. Output is expected to increase to 3500 t/y by 1997. The magnesium will be sold mainly in China, where demand is increasing, but will also be exported to Japan.

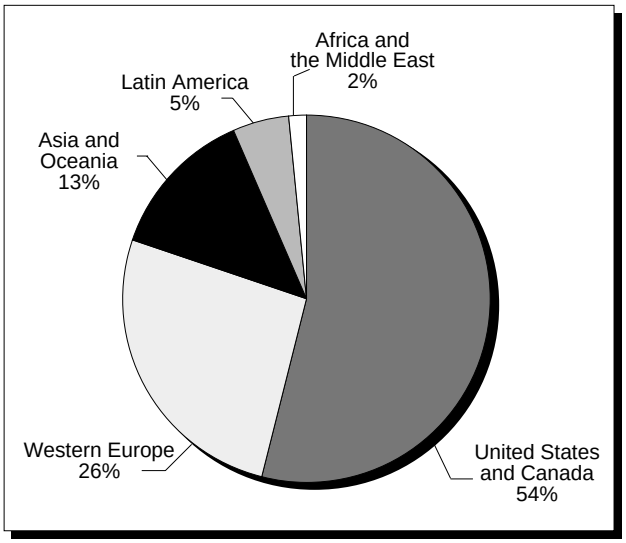
CONSUMPTION AND USES

Total world consumption of primary magnesium was 252 000 t in 1993. Total reported Canadian primary magnesium consumption at the first processing stage was 20 600 t in 1993, compared to 18 100 t in 1992.

Magnesium is the eighth most abundant element in the earth's crust, comprising over 2% of the total. It is the third most abundant element dissolved in seawater with a concentration averaging 0.14%. Unlike many major elements, magnesium does not occur in its native state, but is found in over 60 different minerals. The principal sources of magnesium are as a carbonate in dolomite and magnesite, as a silicate in olivine and brucite, and as a chloride in seawater, natural brines and evaporites, and salt deposits. Magnesium metal is currently produced from three major sources: dolomite/magnesite, seawater, and brines and bitterns.

Magnesium 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 several other elements including aluminum, lithium, manganese, rare-earth metals, silver, thorium, zinc and zirconium. When alloyed with one or a number of these elements, the resultant alloys can have unusually high strength-to-weight ratios. Magnesium-aluminum alloys are the most common and are principally used in die-cast applications.

Figure 3
Magnesium Shipments by World Zone, 1994[e]



Source: International Magnesium Association.
[e] Estimated.

The main application of magnesium is as an alloying agent for aluminum, accounting for close to 57% of Western World consumption in 1993. According to the IMA, Western World magnesium shipments for this application reached 105 700 t in the first nine months of 1994, compared to 82 200 t for the same period in 1993. Magnesium consumption for this application is forecast to increase by 3%/y, despite increased recycling of aluminum beverage cans and a reduction in their thickness.

The second largest use of magnesium is in structural applications, of which pressure die-cast products is the most important use. The IMA reported that shipments of magnesium in the first nine months of 1994 for die-cast applications totalled 37 800 t. Total consumption of magnesium for this application is expected to exceed 55 000 t/y within the next five years. During the next decade, pressure die casting is expected to be the fastest growing sector, particularly in the United States and Japan.

The increased interest in magnesium metal in the automotive market is largely due to weight savings of about 33% compared to the weight of 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 twice the life of aluminum dies. Parts requiring several castings when made from aluminum can be produced with a single casting when made from magnesium. Furthermore, at a magnesium-aluminum price ratio of 1.7:1.0, some magnesium metal parts can be fabricated at the same cost as 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.

The Japanese government introduced nitrous oxide regulations requiring the average automobile weight to decrease by 35% over the next 10 years. The goal of the Japanese legislation, as with the U.S. Corporate Average Fuel Economy (CAFE) requirement, is to reduce both fuel consumption and automobile emissions of carbon dioxide, sulphur dioxide and nitrous oxide. The Japanese Automotive Manufacturers Association expects magnesium use per Japanese car to grow from 1 kg in 1989 to 5 kg in 1995 and to 40 kg by the year 2000. In anticipation of this market growth, Norsk Hydro has established a market development centre in Japan. Norsk Hydro and Dow currently operate market development centres in the United States and Europe.

Several automobile manufacturers announced plans to increase magnesium use beyond the average of 2-3 kg per American car. Chrysler Corp.'s Dodge Viper high-performance sports car, introduced in 1992, incorporates about 5 kg of magnesium components in its engine as well as magnesium castings in valve covers and accessory brackets. General Motors' North-Star V-8 Cadillac engine contains about 7 kg of magnesium for use in the induction system, valve covers, and oil filter adapters.

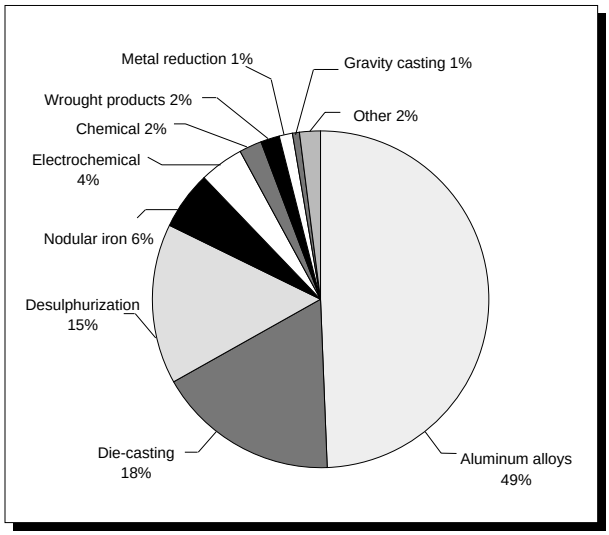
New applications in European luxury cars should also translate into further applications for magnesium. Mercedez Benz started to use an 8.5-kg magnesium one-piece seat frame on some of its models. Audi uses a 4.2-kg magnesium component in the dashboard bulkhead on its V-8 sedan. The company anticipates using this part on other models. Volvo is evaluating magnesium and aluminum doors for one of its models. Magnesium and aluminum doors can provide a weight reduction of around 13 kg. Such an application could also be used for electric cars in which weight limitations are very important.

Besides 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, good heat dissipation, electromagnetic field containment, and radio frequency interference dissipation.

The third largest use of magnesium is as a deoxidizing and desulphurizing agent in the ferrous industry. Magnesium shipments in the first nine months of 1994 for desulphurization, as reported by the IMA, totalled 33 300 t. 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. An increase in steel scrap recovery is also expected to create more markets for magnesium in this application.

Nodular iron production is used primarily for ductile iron pipes and die-cast parts for use in automobiles and farm equipment. Shipments in the first nine months of 1994 totalled 12 100 t. This application is not expected to grow 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 anodes for 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 with other materials.

Figure 4
Magnesium Shipments by Use, First Nine Months, 1994



Source: International Magnesium Association.

RECYCLING

Anticipated growth of 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 trend is expected to continue as magnesium metal further penetrates the automobile market.

The International Magnesium Association unveiled a new magnesium recycling logo in 1992. The logo comprises the chemical symbol for magnesium (Mg) surrounded by a hexagonal-shaped mobius loop. It was designed to educate end users about a magnesium component's metal content and its ability to be recycled. Like aluminum, recycled magnesium only requires about 5% of the energy required to manufacture primary magnesium. Currently, the magnesium contained in aluminum alloys (primarily beverage cans) accounts for approximately 75% of the magnesium recycled throughout the world. Recycling of magnesium is expected to increase with the expected growth in the use of magnesium die-cast automobile parts.

Norsk Hydro A/S received final approval for construction of a 10 000-t/y magnesium recycling plant at its Porsgrunn smelter in Norway. The plant is scheduled to start production by the second half of 1995. The plant will handle all types of scrap and produce material suitable for die casting, including high-purity magnesium alloys. Norsk Hydro already operates a 10 000-t/y recycling facility at its Bécancour smelter in Canada.

MSI Magnesium Services (US) Inc. announced that it plans to build a 10 000-t/y magnesium scrap refining and alloy production facility in the mid-western United States by late 1996. The plant will take in scrap from die casters and producers and recycle it into a form of high-purity alloy ingots for die casting. There are currently three companies that recycle magnesium scrap in the United States: Garfield Alloys Inc. (10 000-t/y capacity), IMCO Recycling Inc. and Halaco.

PRICES AND STOCKS

According to the IMA, total Western World magnesium stocks decreased from 42 400 t in December 1993 to 22 600 t in September 1994, the lowest level recorded since December of 1983.

The increased availability of magnesium from the FSU and China, including oxidized metal offered at a discount, and the general weakness in the European and Japanese economies, forced producers to reduce output in 1993 as prices fell. By the second quarter of 1994, however, renewed economic activity, particularly in the North American and Far East markets, led to increased demand, decreased stocks, and much higher spot prices by the end of the year.

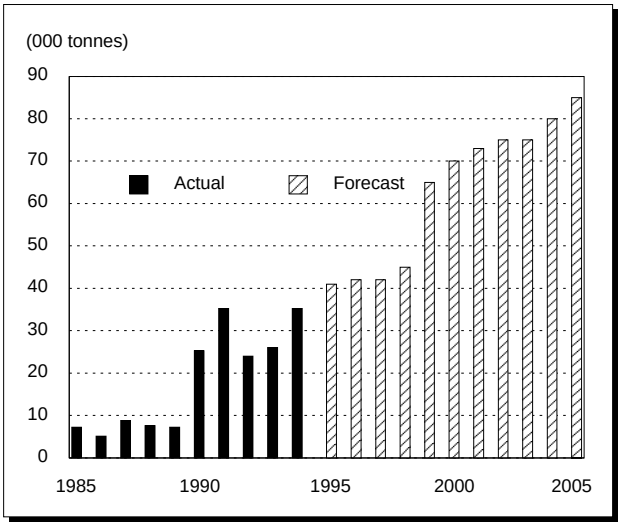
Quoted primary magnesium prices increased significantly in the second quarter of 1994 and again toward the end of the year. In November, Norsk Hydro increased its European producer price for pure magnesium to DM5.60/kg (US$1.65/lb) from DM5.45/kg. By year-end, European free-market prices reached US$3050-$3150/t.

In North America, Norsk Hydro increased its North American spot price to US$1.63/lb from $1.53/lb. The *Metals Week* U.S. Spot Western price for pure magnesium reflected the physical tightness in the North American market and increased from US$1.45/lb in January to $1.62/lb by year-end. Over the same period, the U.S. dealer-import mean price rose from US$1.20/lb to $1.57/lb. Prices for magnesium die-cast alloy AZ91D remained unchanged at US$1.46/lb.

OUTLOOK

Canadian production increased dramatically at the start of the decade with the opening of Norsk Hydro's 40 000-t/y Bécancour smelter in 1989. Production subsequently dropped in 1993 with the closing of Magcan and U.S. trade action against Norsk Hydro's exports. Production is, however, expected to increase in 1995 to meet increasing demand. In the longer term, Noranda's new 58 000-t/y magnesium smelter at Thetford Mines will increase Canadian magnesium production by the end of the decade, for a total magnesium production capacity of close to 105 000 t/y. World magnesium production is expected to reach 360 000 t in 2000 and to increase further to 500 000 t by 2005.

Figure 5
Canadian Magnesium Production, 1985-2005



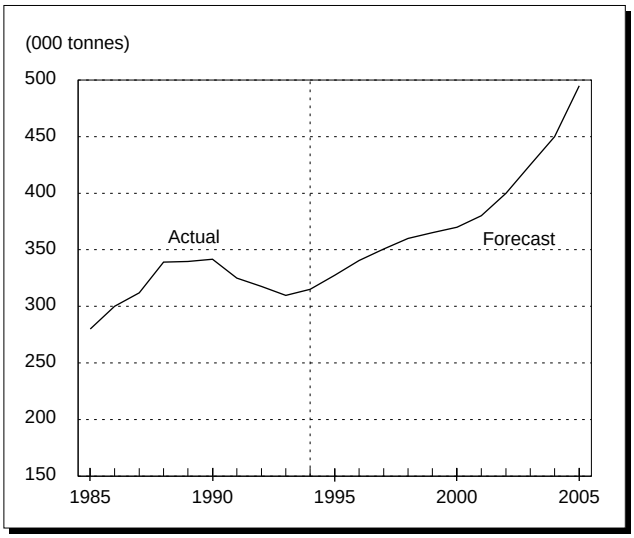
Source: Natural Resources Canada.

World primary magnesium consumption is forecast to increase to 375 000 t by the end of the decade and to 495 000 t by 2005. Western World primary magnesium annual growth in demand for this period is forecast to reach 5% in North America, 4% in Western Europe, and 9% in the Far East. Growth will be primarily fed by 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 growing, particularly in the North American automotive industry.

A major factor that will affect magnesium prices over the next decade will be the growth in supply from expansions or new capacity in Canada, the Middle East, Australia, and possibly China. This new, low-cost supply is forecast to eventually cause prices to decline slightly, in constant dollar terms, over the next decade. Prices, in constant 1994 dollars, are forecast to average US$1.55/lb in 1995, and to gradually decline to the $1.25-$1.35/lb range in the longer term.

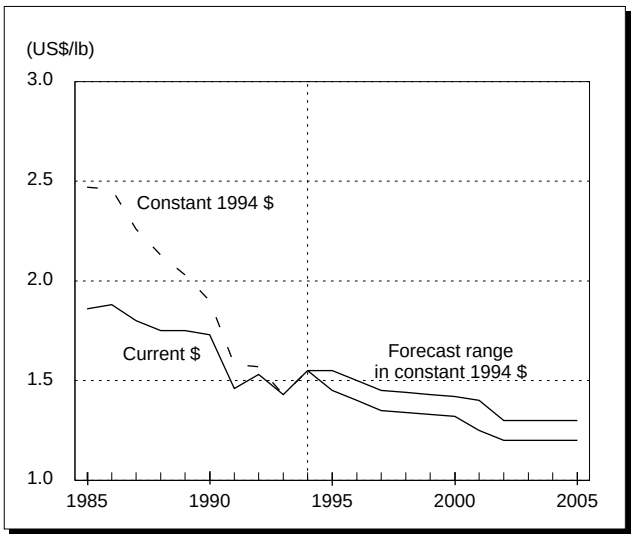
Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 60. (2) Information in this review was current as of January 25, 1995.

Figure 6
World Primary Magnesium Consumption, 1985-2005



Source: Natural Resources Canada.

Figure 7
Magnesium Prices, 1985-2005



Source: Natural Resources Canada.

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada	E.U. MFN	Japan[1] GATT
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium	3.7%	2.5%	1.2%	2.4%	5.3%	6.5%
8104.19	Magnesium unwrought, n.e.s.	3.7%	Free	1.2%	1.9%	5.3%	6.5%
8104.20	Magnesium waste and scrap	Free	Free	Free	Free	Free	3.2%
8104.30	Magnesium raspings, turnings and granules, graded according to size; powders						
8104.30.10.00	Raspings, turnings and granules; powders, alloyed	8.8%	6.5%	3%	1.9%	5.3%	7.2%
8104.30.20.00	Powders, not alloyed	3.7%	2.5%	1.2%	1.9%	5.3%	7.2%
8104.90	Other magnesium						
8104.90.10	Bars, rods, plates, sheets, strip, foil, tubes and pipes, alloyed	3.7%	Free	1.2%	[a]	5.3%	7.2%
8104.90.90	Other	8.8%	6.5%	3%	[a]	5.3%	7.2%

Sources: Customs Tariff, effective January 1995, Revenue Canada; Harmonized Tariff Schedule of the United States 1995; The "Bulletin International des Douanes," Journal Number 14 (16th Edition), European Economic Community, 1992-1993, "Conventional" column; 1st Supplement fo Journal Number 14 (16th Edition), European Economic Community, 1993-94, "Conventional" column; Customs Tariff Schedules of Japan, 1994.
n.e.s. Not elsewhere specified.
[a] 4.4¢/kg on magnesium content plus 1%.
[1] GATT rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITIES AND COUNTRIES, 1993 AND 1994

Item No.		1993		1994p	
		(tonnes)	($000)	(tonnes)	($000)
EXPORTS					
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium				
	Japan	2 102	7 490	3 037	11 545
	Norway	758	1 838	1 776	6 307
	Germany	216	602	1 737	5 722
	United States	1 939	7 684	1 210	4 975
	Australia	548	1 485	949	3 464
	United Kingdom	428	2 244	596	3 255
	Luxembourg	–	–	430	1 228
	Other countries	1 242	7 086	2 104	7 724
	Total	7 233	28 438	11 838	44 230
8104.19	Magnesium unwrought, n.e.s.				
	United States	5 635	22 872	8 591	35 881
	Australia	290	1 629	279	1 728
	Germany	10	80	348	1 437
	Mexico	77	460	192	1 203
	Italy	39	221	134	773
	Norway	16	38	79	291
	Other countries	505	2 762	272	1 618
	Total	6 572	28 069	9 895	42 939
8104.20	Magnesium waste and scrap				
	United States	517	984	442	1 118
	Total	517	984	442	1 118
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	341	1 861	460	2 708
	Ireland	129	789	108	665
	Netherlands	27	116	25	150
	Switzerland	–	–	19	77
	Other countries	26	114	–	–
	Total	523	2 880	611	3 601
8104.90	Magnesium and articles thereof, n.e.s.				
	United States	144	669	935	4 258
	Netherlands	57	478	156	1 295
	Switzerland	19	74	14	126
	Japan	1	18	17	66
	Other countries	25	141	57	350
	Total	246	1 380	1 179	6 100
	Total exports	15 091	61 751	23 965	97 988
IMPORTS					
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium				
	United States	5 490	19 068	2 485	8 885
	Norway	–	–	159	610
	Russia	73	259	133	527
	France	40	160	40	153
	Other countries	17	58	1	4
	Total	5 620	19 548	2 818	10 182
8104.19	Magnesium unwrought, n.e.s.				
	United States	1 093	4 173	4 483	15 327
	Norway	1 405	4 859	409	1 544
	Brazil	149	455	211	921
	Other countries	59	419	470	2 208
	Total	2 705	9 909	5 573	20 005
8104.20	Magnesium waste and scrap				
	United States	2 024	5 683	1 920	5 707
	Germany	386	400	133	388
	Other countries	337	1 039	108	380
	Total	2 746	7 123	2 161	6 477
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	52	224	125	548
	Other countries	25	76	4	12
	Total	77	301	129	562
8104.90	Magnesium and articles thereof, n.e.s.				
	United States	732	4 140	714	3 576
	United Kingdom	–	–	. . .	1
	Total	732	4 140	714	3 577
	Total imports	11 880	41 021	11 395	40 803

Source: Statistics Canada.
– Nil; . . . Amount too small to be expressed; n.e.s. Not elsewhere specified; p Preliminary.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, CONSUMPTION[1] OF MAGNESIUM, 1987-93

	1987	1988[a]	1989[a]	1990	1991[a]	1992[a]	1993[a]
				(tonnes)			
Castings and wrought products[2]	3 837	5 067	5 661	5 849	4 604	6 915	8 219
Aluminum alloys	4 508	7 810	7 761	7 672	9 215	9 203	10 174[r]
Other uses[3]	1 124	1 189	1 985	1 603	1 926	2 005	2 162
Total	9 469	14 066	15 407	15 125	15 745	18 123	20 555[r]

Source: Natural Resources Canada.
r Revised.
a Increase in number of companies being surveyed.
1 Available data as reported by consumers. 2 Die, permanent mould and sand castings, structural shapes, tubings, forgings, sheet and plate. 3 Cathodic protection, reducing agents, deoxidizers and other alloys.

TABLE 3. WORLD MAGNESIUM PRODUCTION, 1990-93

Country	1990	1991	1992	1993[p]
		(tonnes)		
Australia (secondary)	100	100	100[e]	100
Brazil	8 700	7 800	7 300	9 700
Brazil (secondary)	1 600[e]	1 600[e]	1 600	1 600
Canada	25 300	35 500	25 800[e]	23 000[e]
China[e]	16 000	15 500	20 000	20 000
France	14 600	14 000	13 700	10 900
Italy	5 900	3 900	1 200	–
India	1 000	1 000[e]	1 000[e]	1 000
Japan	12 800	11 600	7 100	7 500
Japan (secondary)	20 400	17 200	13 000	17 300
Kazakhstan[e]	n.a.	n.a.	20 000	20 000
Norway	48 200	44 300	30 400	27 300
Russia[e]	n.a.	n.a.	40 000	30 000
Serbia	n.a.	n.a.	4 000[e]	3 000
Ukraine	n.a.	n.a.	10 000	9 000
U.S.S.R.	88 000[e]	80 000[e]	n.a.	n.a.
U.S.S.R. (secondary)	7 500[e]	7 000[e]	6 500	6 000
United Kingdom (secondary)	1 000[e]	1 000	1 000[e]	1 000
United States	139 300	131 200	136 900	132 100
United States (secondary)	54 800	50 500	57 000	58 900
Yugoslavia	5 788	4 000	n.a.	n.a.
Total (primary)	365 600	348 800	317 400	298 500
Total (secondary)	85 400	77 400	79 200	84 900
Total	451 000	426 200	396 600	383 400

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.
– Nil; e Estimated; n.a. Not applicable; p Preliminary.

TABLE 4. WORLD CONSUMPTION OF MAGNESIUM, 1990-93

Country	1990	1991	1992	1993p
		(tonnes)		
Argentina	500	800	400	400
Australia	3 500	3 500	3 500	4 000
Austria	1 900	3 200	4 300	3 500
Belgium/Luxembourg	2 300	2 400	2 600	2 000e
Brazil	9 300e	8 100	8 500	10 700
Cameroon	100	100	200	100e
Canada	15 100	15 700	18 100	20 500
Chinae	16 000	15 500	17 000	17 000
Czechoslovakia	1 500	1 300	n.a.	n.a.
Denmark	100	100	200	200
Egypte	1 000	1 000	1 000	1 000
France	12 400	12 600	13 800	12 000
Germany	25 400	20 600	21 300	14 900
Germany, Democratic Republic of	1 000	n.a.	n.a.	n.a.
Ghana	1 800	500e	100	100e
Greece	700	1 000	600	1 000
Hungarye	600	500	n.a.	200
Italy	5 800	4 800	5 500	3 800
India	1 500	1 800	1 600	1 800e
Japan (primary)	25 000	27 200	27 000	27 000
Japan (secondary)	26 000	17 200	13 000	11 200
Mexico	700	900	1 300	1 000e
Netherlands	1 200	1 000	1 000	1 000
New Zealande	300	300	400	400
Norwaye	8 000	6 000	8 000	5 800
Polande	300	200	300	700
Romaniae	1 000	700	500	500
Slovakiae	n.a.	n.a.	n.a.	1 000
South Africa	n.a.	800	600	500
South Korea	1 500	1 700	1 800	2 100
Spain	1 400	1 800	1 500	1 500e
Sweden	2 000	1 300	1 700	1 800
Switzerland	2 700	2 100	2 600	1 800
Taiwan	1 000	1 700	1 700	1 600
Turkey	n.a.	600	500	600
Ex-U.S.S.R.e	87 000	85 000	67 000	60 000
United Kingdom	4 200	3 200	5 800	6 300
United States (primary)	96 100	91 900	93 800	100 600
United States (secondary)	50 300	52 900	51 200	54 400
Venezuela	2 000	400	700	500e
Ex-Yugoslavia	1 800	1 500	1 000e	500
Othere	4 800	3 200	1 800	1 900
Total (primary)	341 500	325 000	317 700	309 600
Total (secondary)	76 300	70 100	64 200	65 600
Total	417 800	395 100	381 900	375 200

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.
e Estimated; n.a. Not applicable; p Preliminary.

TABLE 5. WORLD PRIMARY MAGNESIUM SMELTER CAPACITY, 1994

Country	Smelter Location	Company	Capacity
			(t/y)
Brazil	Bocaiuva	Rima Industrial S.A.	12 000
Canada	Bécancour	Norsk Hydro	40 000
	Haley Station	Timminco	6 000
China	Baotou	CNNC	3 500
	Dancheng	CNNC	1 000
	Fushun	CNNC	5 000
	Guigang	CNNC	1 000
	Hengyang	CNNC	3 000
	Huinong	CNNC	1 000
	Jinzhou	CNNC	1 000
	Minhe	CNNC	4 000
	Tongxin	CNNC	1 700
	Yinchuan	CNNC	1 000
France	Maringnac	Pechiney	18 000
India	Valinokkam	Tamil Nadu	600
	Hyderabad	Southern Magnesium	1 000
Kazakhstan	Ust Kamenogorsk	Ust Kamenogorsk Works	40 000
Norway	Porsgrunn	Norsk Hydro	55 000
Russia	Solikamsk	Solikamsk Magnesium Works	25 000
	Berezniki	Avisma	10 000
Serbia	Bela Stena	Magnohrom	9 000
Ukraine	Kaluzh	Kaluzh Works	24 000
	Zaporozhyre	Zaporozhyre Works	45 000
United States	Freeport	Dow Chemical	90 000
	Addy	Northwest Alloys	35 000
	Rowley	Magcorp	35 000
Total			467 800

Source: Natural Resources Canada.
CNNC China National Nonferrous Metals Industry Corporation.

TABLE 6. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE, 1984-94

Period	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 COMECON C.I.S. & PRC	Total
				(000 tonnes)			
1984	110.1	8.0	66.8	1.6	29.5	–	216.0
1985	102.4	9.4	72.2	2.4	38.4	–	224.8
1986	103.3	11.3	73.6	3.2	35.0	–	226.4
1987	113.7	8.3	66.9	5.2	28.7	13.2	236.0
1988	125.0	11.7	70.6	3.8	33.8	6.2	251.2
1989	127.9	9.4	69.5	2.6	33.7	4.1	246.2
1990	127.3	11.6	68.7	4.0	37.6	2.8	252.0
1991	121.3	10.3	66.6	4.5	40.1	0.7	243.5
1992	139.5	10.3	67.9	3.8	35.0	0.8	257.3
1993	143.1	12.3	58.1	3.6	35.0	–	252.1
1994e	154.0	14.2	75.0	4.4	38.0	–	285.6

Source: International Magnesium Association.
– Nil; e Estimated.

TABLE 7. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE AND CATEGORY, 1994 (JANUARY TO SEPTEMBER)

Use	Area 1 United States and Canada	Area 2 Latin America	Area 3 Western Europe	Area 4 Africa and Middle East	Area 5 Asia and Oceania	Area 6 Other	Total
				(000 tonnes)			
Aluminum alloying	54.2	1.9	25.5	2.6	21.5	–	105.7
Die casting	22.6	6.5	7.2	–	1.5	–	37.8
Desulphurization	21.3	–	11.0	0.4	0.6	–	33.3
Nodular iron	5.4	0.6	4.2	–	1.9	–	12.1
Electrochemical applications	5.0	1.1	2.2	0.1	0.7	–	9.1
Chemical applications	1.3	–	2.1	–	1.3	–	4.7
Wrought products	3.1	–	0.6	–	0.1	–	3.8
Metal reduction	1.8	–	0.8	–	0.2	–	2.8
Gravity casting	0.4	–	0.1	–	–	–	1.4
Other	0.7	0.6	1.9	0.2	0.9	–	4.3
Total	115.8	10.7	56.5	3.3	28.7	–	215.0

Source: International Magnesium Association.
– Nil.

TABLE 8. PRIMARY MAGNESIUM SHIPMENTS BY CATEGORY, 1984-94

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994[e]
						(000 tonnes)					
Aluminum alloying	113.5	121.0	122.1	122.1	134.3	130.8	130.6	137.9	133.8	126.0	140.9
Die casting	30.4	29.7	26.8	26.6	28.5	28.6	36.3	30.7	34.5	38.6	50.0
Desulphurization	17.4	19.1	20.3	21.9	28.6	32.3	28.0	28.1	36.6	40.6	44.0
Nodular iron	9.8	11.3	12.3	14.2	15.8	16.9	14.4	13.7	13.3	13.4	16.0
Electrochemical applications	7.7	9.1	8.3	8.0	8.0	8.1	9.6	9.2	9.5	9.4	12.1
Chemical applications	7.8	8.0	8.0	7.2	8.1	5.5	7.1	7.1	7.3	6.5	6.2
Wrought products	6.6	4.8	5.4	8.4	7.4	6.2	6.7	5.7	6.8	5.8	5.1
Metal reduction	12.2	10.3	9.6	8.8	10.2	9.4	8.8	5.6	7.4	5.1	3.7
Gravity casting	1.3	1.2	1.6	1.8	2.1	2.5	3.3	2.2	2.6	1.5	1.9
Other	9.3	10.3	10.0	17.0	8.2	6.9	7.2	3.3	5.5	5.2	5.7
Total	216.0	224.8	226.4	236.0	251.2	247.2	252.0	243.5	257.3	252.1	285.6

Source: International Magnesium Association.
[e] Estimated.