

# Magnesium

---

## **Patrick Chevalier**

*The author is with the Minerals and Metals Sector, Natural Resources Canada.  
Telephone: (613) 992-4401  
E-mail: pchevali@nrcan.gc.ca*

**I**ncreased demand in magnesium die-casting markets led the way to record magnesium shipments and lower inventories in 1997. According to the International Magnesium Association (IMA), year-end inventories totalled 32 900 t, compared to 38 400 t at the end of 1996. IMA data also indicated that primary magnesium shipments for 1997 were a record 333 700 t, up 13% over the 295 400 t shipped in 1996. The main reason for the increases was increased shipments to die-casting (up 32% over 1996), desulphurization (up 21%) and aluminum alloy (up 6%) markets. Primary production (excluding China, the former Soviet Union and Israel) decreased by 4100 t to 244 200 t, primarily as the result of decreased production in the United States. Exports from Russia, China and Ukraine continued to be strong and now account for roughly 25% of the Western markets, up from 23% in 1996.

## **CANADIAN DEVELOPMENTS**

Norsk Hydro Canada Inc., a wholly owned subsidiary of Norsk Hydro ASA of Norway, announced that it will increase capacity at its 43 000-t/y Bécancour plant in a two-phase expansion project that is set to begin in 1998. The first phase will increase capacity to 68 000 t/y and start producing at that level in 2000. Construction of the second phase to further increase capacity to 86 000 t/y will follow once the first stage is operational. 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 changes are expected to reduce energy consumption. By the time the project is complete, the overall improved efficiencies and economies of scale are expected to reduce the plant's operating costs.

In April, Norsk Hydro Produksjon a.s., another wholly owned subsidiary of Norsk Hydro ASA,

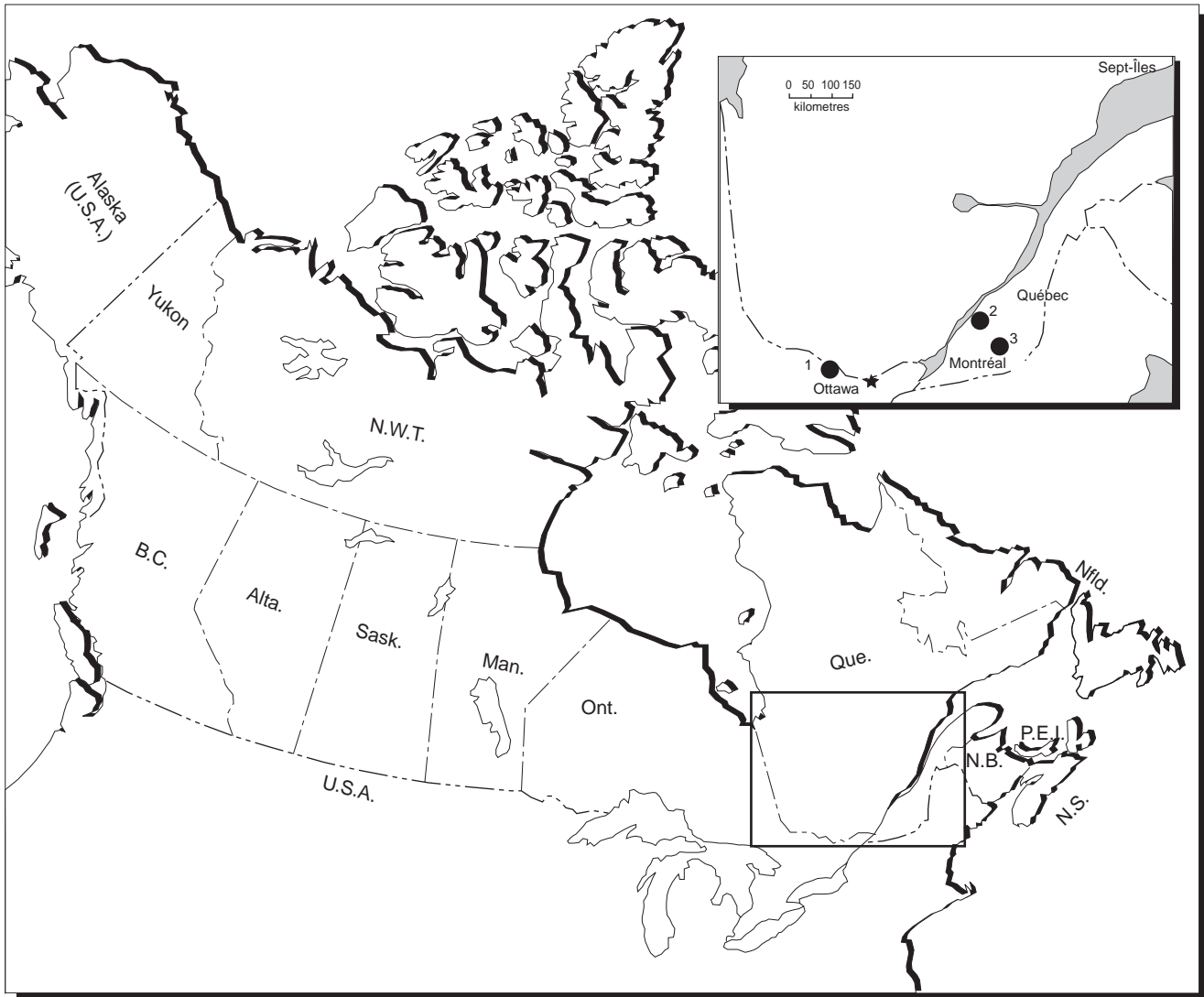
announced that it had acquired 693 500 common shares of Meridian Technologies Inc. As a result of the acquisition, Norsk Hydro owns approximately 26.6% of the outstanding shares of Meridian Technologies Inc. Meridian Technologies is a Canadian company that supplies manufactured magnesium parts and components to the automotive and service industries. In a separate announcement in May, Teksid S.p.A., a wholly owned subsidiary of Fiat S.p.A. of Italy, announced that it had acquired 692 600 common shares of Meridian Technologies as well. Teksid, who now owns approximately 32.5% of the outstanding common shares of Meridian Technologies, manufactures and sells metallurgical components for the international automotive industry.

Timminco Metals, a division of 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 an alloying agent 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 1997, Timminco continued to implement its capital program directed at its secondary processing operations, which continued to operate at or near capacity. Early this year, Timminco commissioned a new ingot casting conveyor at its Haley facility. The company is also nearing completion of its program to upgrade the two extrusion presses and to expand its magnesium extrusion facility which, when completed early in 1998, will result in added capacity and improved quality and productivity. Engineering is almost complete for a capital program, scheduled to start in early 1998, to address several remaining bottlenecks in the facility's production process.

Magnola Metallurgy Inc. cast its first magnesium ingot at its pilot plant in Salaberry-de-Valleyfield, Quebec, in March. 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.

**Figure 1**  
**Magnesium Smelters, 1997**



SMELTER	COMPANY	CAPACITY (t/y)
1. Haley Station, Ontario	Timminco Metals	6 000
2. Bécancour, Quebec	Norsk Hydro Canada Inc.	43 000
3. Asbestos, Quebec (proposed)	Magnola Metallurgy Inc.	58 000

Magnola's proprietary process allows for the production of magnesium metal from the mining residues of local asbestos mines. In November, the company announced that it will proceed with construction of a 58 000-t/y commercial plant. The \$750 million plant is expected to start production by mid-2000 and to create nearly 350 direct jobs near the town of Asbestos, Quebec. In November, SNC Lavalin Inc. was awarded the contract to build the new plant; construction is scheduled to begin in April 1998.

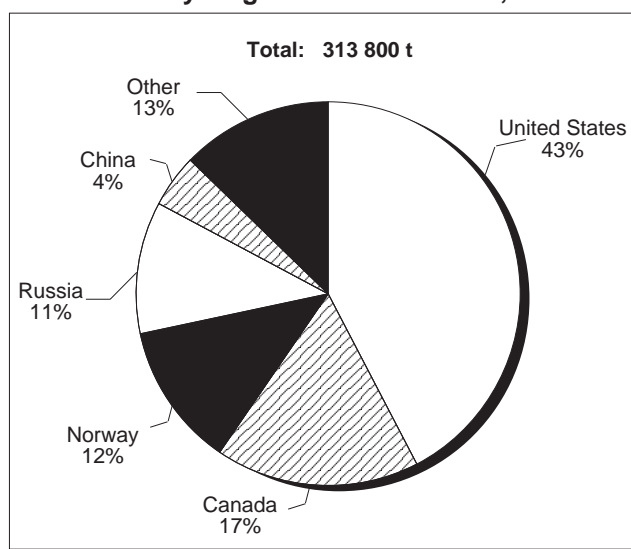
In September, Gossan Resources Ltd. announced the results of a pilot-plant study by Hazen Research of Golden, Colorado, which confirmed that dolomite at the company's Inwood, Manitoba property can be made into commercial-grade magnesium metal using the Magnetherm process. Preliminary results from a prefeasibility study conducted by Hatch and Associates confirmed previously released cost estimates with a positive post-tax internal rate of return. Gossan's Board of Directors will now consider

whether to conduct a full-scale feasibility study to evaluate the possibility of building a 50 000-t/y plant.

## WORLD DEVELOPMENTS

Western World primary magnesium production (not including Israel) decreased to 244 200 t in 1997 compared to 248 300 t in 1996. The decreased production, coupled with increased demand, lower inventories and an estimated 2% rise in exports from Russia and China totalling 80 300 t, helped to increase the market tightness and prices by year-end. Shipments in North America remained strong with 146 550 t shipped for the first three quarters of 1997 compared with 124 600 t shipped during the same period in 1996. The higher shipments overall reflected the increased demand in some of magnesium's key market sectors, with the exception of Latin America where shipments were significantly lower.

**Figure 2**  
World Primary Magnesium Production, 1996



Source: Natural Resources Canada.

### United States

The United States, which is the world's largest magnesium producer, has three primary magnesium smelters. The Dow Chemical Company, the largest U.S. producer, operates a 65 000-t/y electrolytic magnesium plant at Freeport, Texas. Magnesium chloride feedstock for the plant is derived from a seawater-dolomite process. Magnesium Corporation of America (Magcorp) operates a 38 000-t/y electrolytic plant in Rowley, Utah. Northwest Alloys, Inc., a subsidiary of the Aluminum Company of America (Alcoa), operates a 38 000-t/y magnesium plant in Addy, Washington. The plant uses the Magnetherm silicothermic process in which magnesium is produced by reducing dolomite with ferro-

silicon. The bulk of Northwest Alloy's production is shipped for use by subsidiaries of Alcoa.

Two separate administrative reviews were conducted by the International Trade Administration (ITA) related to the establishment of countervailing duties on magnesium imports from Norsk Hydro Canada Inc. In the first review, covering 1993, countervailing duties for pure and alloy magnesium were determined to be 7.34% *ad valorem*. In the second review, covering 1995, the ITA established countervailing duties at 3.18% *ad valorem* for pure and alloy magnesium. The anti-dumping rate for pure magnesium was established at 0% *ad valorem* in August. This is the second anti-dumping review to set the rate at zero; a third review would remove the duty order completely. Two more administrative reviews will be conducted for the period August 1, 1996 to July 31, 1997 for the anti-dumping duty, and from January 1, 1996 to December 31, 1996 for the countervailing duty. The review results are expected in August 1998.

In the third quarter of 1997, The Dow Chemical Company was reportedly considering the sale of its magnesium business. The sale of the division was considered to be only one of a number of options the company is evaluating for its magnesium division. A final decision is expected sometime in 1998.

### Europe

The European Commission (EC) initiated anti-dumping proceedings on magnesium imports from China following a complaint by the European alloys association, Euroalligages, on behalf of Pechiney. Pechiney, through its wholly owned subsidiary Pechiney Électrométallurgie, is the sole producer of magnesium within the European Union.

A feasibility study by Icelandic Magnesium Co. has confirmed the technical viability of a 50 000-t/y primary magnesium smelter in Iceland. Work on engineering and environmental studies is continuing so that permitting and construction of the plant can begin as soon as a decision is made to build the plant.

### Russian Federation

In April, Solikamsk Magnesium Works commissioned a new 2000-t/y magnesium granule plant. The plant will operate as a joint venture between Solikamsk and the German powder producer Almamet GmbH. Sollkamskly Zavod Dsulfurativ will supply the domestic steel desulphurization market; it was built with the capacity for future expansions to 6000 t/y and 8000 t/y depending on market conditions. In a separate announcement, the company stated that it had begun shipments of magnesium alloys to General Motors Corporation under a five-year US\$90 million contract that was signed at the end of 1996.

Russia's only other primary magnesium producer, Avisma Titanium-Magnesium Works, reported that

production was stable in 1997 with the plant operating at its full capacity of 18 000 t/y. Production from the plant is shipped primarily for export markets in the European Union and the United States.

## Kazakstan

Ust-Kamenogorsk Titanium-Magnesium Works announced plans to resume magnesium production at the end of the year. Magnesium metal was last produced in 1994; however, the company did continue to produce titanium by recycling magnesium chloride. It also announced plans to complete the construction of a carnallite processing plant by the end of the third quarter of 1997 and to produce magnesium metal at a rate of between 5000 and 10 000 t/y by the end of the fourth quarter.

## Israel

Dead Sea Magnesium Ltd. (DSM) completed its first year of full operation at Sdom, Israel. The first phase of the project reached an annual production rate of 33 000 t. Production at the plant started at the end of 1996 and is based on an innovative system that produces magnesium metal from the waters of the Dead Sea. The company is reportedly examining the timetable for the second phase of the project, which is expected to increase capacity to 52 000 t/y. DSM is a joint venture between Dead Sea Works Ltd. of Israel (65%) and Volkswagen AG of Germany (35%).

## China

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 43 380 t in the first nine months of 1997, up over 77% compared with the same period in 1996. Since the United States imposed anti-dumping duties on China's unwrought magnesium, China's primary magnesium exports have been mainly focused on the Japanese and European markets.

In November, the National Magnesium Industry Association was officially established in Zhengzhou, Henan Province. The association comprises 73 members that account for over 70% of China's magnesium producers. The Secretariat for the association is located in the China National Nonferrous Metals Industry Corporation's Information Centre.

A new silicothermic plant is planned for Xushui County in the Heibei Province of China. The proposed project includes plans to use local dolomite ore (20% magnesium oxide) with a plant capacity of 4000 t/y.

Plans to expand the Minhe magnesium plant from 7000 t/y to 10 000 t/y were announced during the

third quarter of the year. The US\$12 million investment is expected to be completed in early 1999. The plant recently completed a 3000-t/y expansion that began operating in July 1997.

## Congo

In June, the Republic of the Congo (Brazzaville) announced that it had granted two exploration permits to a private Canadian firm, Congo Minerals Inc. The permits, covering 2400 km<sup>2</sup> each, are for areas located in the Kouilou region that reportedly contain substantial quantities of potassium and magnesium salts, including carnallite, sylvanite and bischollite. Congo Minerals negotiated a contract with the Congolese government to evaluate and, if feasible, finance and bring into production a 50 000- to 100 000-t/y magnesium plant. Assorted by-products would include potash, table salt, calcium chloride and chlorine. In October, Congo Minerals Inc. and Clavos Enterprises Inc. merged to form a new company, Magnesium Alloy Corporation (Amalco). The newly formed company is continuing to work on the project and expects to begin prefeasibility and on-site studies in early 1998.

## Australia

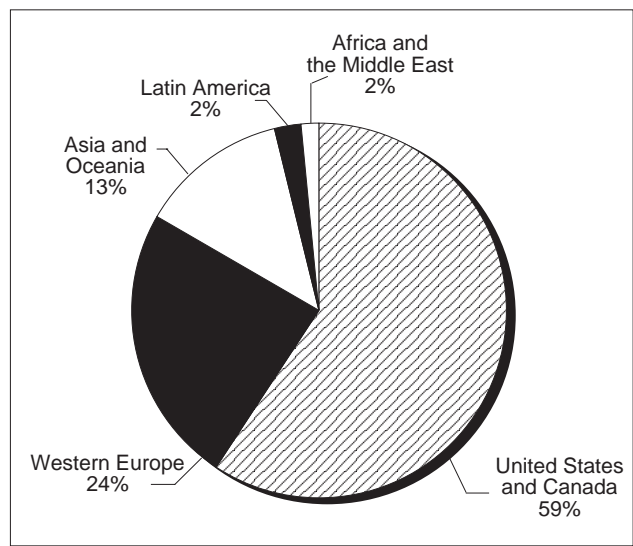
Normandy Mining Ltd. and Queensland Metals Corp. (QMC) formed a joint venture to develop a plant to produce magnesium alloys at Gladstone, Queensland. The first phase involves the construction of a 1000-t/y pilot plant and a two-year feasibility study for a 90 000-t/y smelter. Funding will be provided by the partners, together with the Australian government and Ford Motor Company, which has entered into a long-term agreement with the joint-venture partners to purchase magnesium alloys. Site work for the pilot plant has already started and it is expected to begin operating by the middle of 1998.

## CONSUMPTION AND USES

Total world consumption of primary magnesium reached 297 500 t in 1996, compared to 310 700 t in 1995. In Canada, reported magnesium consumption in 1996 increased by 436 t to 27 576 t. Consumption for castings and wrought products decreased by 1291 t to 11 197 t. This decrease was offset by a 1699-t increase in demand for magnesium in the production of aluminum alloys to a record 14 022 t.

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% by weight. 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; as an oxide in serpentine; and as a chloride in seawater, natural brines and evaporites, and salt deposits. Magnesium metal is currently

**Figure 3**  
**Magnesium Shipments by World Zone, 1997**



Source: International Magnesium Association.

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, manganese, rare-earth metals, silver, thorium, zinc and zirconium. When alloyed with one or a number 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 44% of Western World consumption in 1997. According to the IMA, Western World magnesium shipments for this application reached 146 150 t in 1997, up 6% compared to the 138 200 t shipped in 1996. 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 magnesium in 1997 for die-cast applications increased by 32% for a total of 95 300 t. Total consumption of magnesium for this application is expected to exceed 100 000 t/y within the next five years. 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, 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.

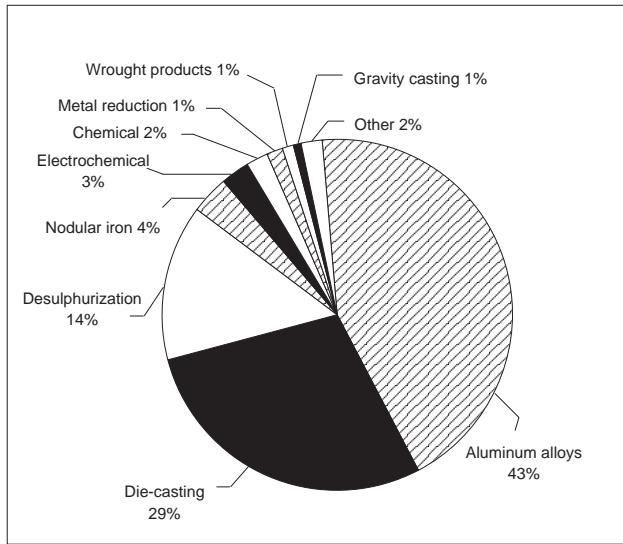
Besides automotive applications, die-cast magnesium products are widely used in the manufacture of portable tools and sporting goods. The use of magnesium in electronics equipment, particularly computer housings and components, has grown substantially. This trend is expected to continue. Magnesium's advantages for these applications are its good strength-to-weight ratio, 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 1997 for desulphurization, as reported by the IMA, totalled 47 950 t, an increase of 21% from the 39 600 t shipped in 1996. 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 1997 totalled 11 800 t, down from 12 500 t in 1996. 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 4**  
**Magnesium Shipments by Use, 1997**



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 automobile market.

Like 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.

## PRICES AND STOCKS

According to the IMA, total magnesium stocks decreased steadily throughout the year, falling from 42 100 t at the end of 1996 to 34 000 t by June of 1997, and again to 32 900 t by year-end.

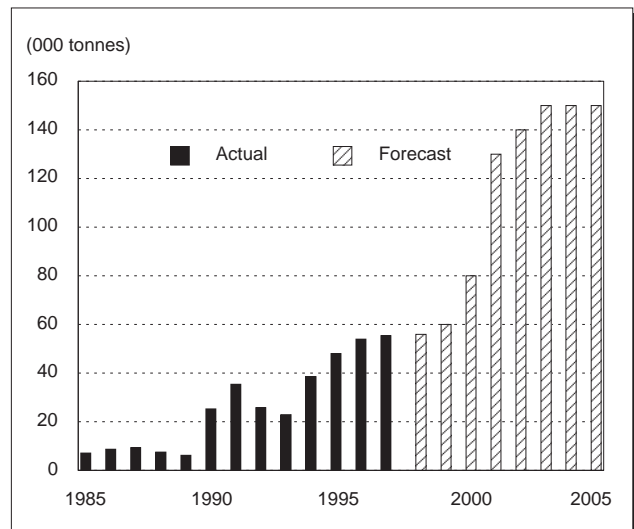
Prices for primary magnesium remained fairly stable for the first three quarters of the year as the markets continued to be balanced. As the fourth quarter approached, increased shipments, lower production and reduced inventories helped push prices up by year-end. Prices for U.S. die-cast alloy and primary ingot remained stable at US\$1.65/lb and \$1.80/lb respectively, while spot prices eased somewhat after starting the year in the US\$1.70-\$1.80/lb range, only to rise again to end the year at \$1.60-\$1.70/lb. In

January, Norsk Hydro cut its European producer price for pure magnesium to DM5.40/kg from DM5.95/kg set in November 1996, only to increase it again to DM5.75/kg in June; it ended the year at DM6.10/kg. European free market prices also ended the year higher at US\$2750-\$2850/t. Imports from China were seen as the significant influencing factor on European prices in 1997; however, as supplies of both Russian and Chinese magnesium grew tighter, prices strengthened.

## 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. Installed capacity has since remained stable, but it is set to rise again with the expansion of Norsk Hydro's Bécancour plant and the addition of Magnola Metallurgy's 58 000-t/y plant at Asbestos, 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 1996 after the United States. World primary magnesium production is expected to rise from 313 800 t in 1996 to 360 000 t/y by 2000 and to 500 000 t/y by 2005.

**Figure 5**  
**Canadian Magnesium Production, 1985-2005**



Source: Natural Resources Canada.

World primary magnesium consumption was 297 500 t in 1996, 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

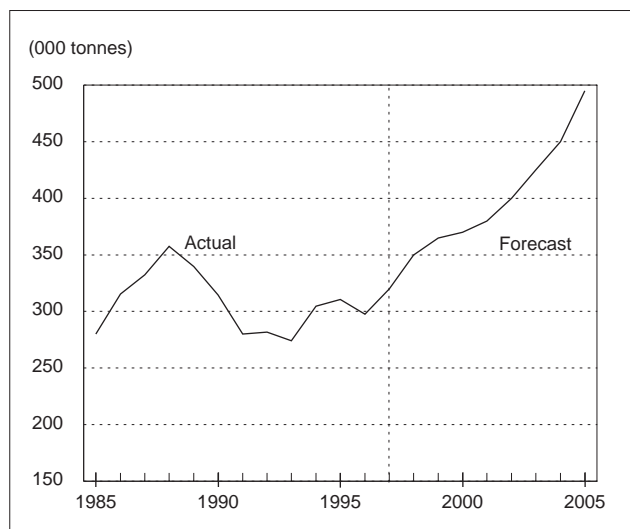
will be fed primarily by a strong demand for magnesium in aluminum alloys, die-cast automotive parts and desulphurization applications in the steel industry. Magnesium continues to face stiff competition from other materials, including aluminum and plastics, in the all-important automotive parts sector. 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-\$1.80/lb range for 1998. 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 Middle East, Australia, and possibly China. The availability of this newer, low-cost supply will eventually cause prices to decline slightly, in constant dollar terms, over the next decade. Over the longer term, prices are expected to remain in the US\$1.50-\$1.60/lb range in constant 1996 dollars.

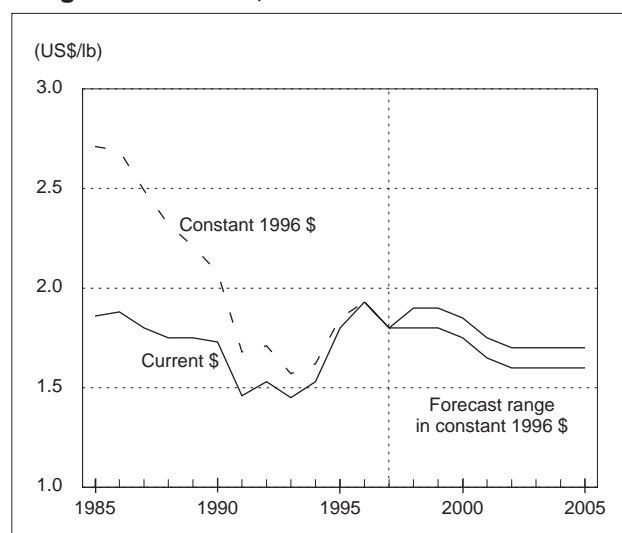
*Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 65. (2) Information in this review was current as of March 6, 1998.*

**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			United States	EU	Japan <sup>1</sup>
		MFN	GPT	USA	Canada	MFN	WTO
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium	2.5%	Free	Free	Free	5.3%	2.6-4.4%
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	4.5%	2.6-4.4%
8104.19.90	Other	2.5%	Free	Free	Free	4.5%	2.6-4.4%
8104.20	Magnesium waste and scrap	Free	Free	Free	Free	Free	2.5%
8104.30	Magnesium raspings, turnings and granules, graded according to size; powders	2.5%	Free	Free	Free	4.5%	4.7%
8104.90	Other magnesium	2.5%	Free	Free	Free	4.5%	4.7%

Sources: Customs Tariff, effective January 1998, Revenue Canada; Harmonized Tariff Schedule of the United States 1998; Worldtariff Guidebook on Customs Tariff Schedules of Import Duties of the European Union (37th Annual Edition: 1997); Custom Tariff Schedules of Japan, 1997.

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

**TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITY AND COUNTRY, 1996 AND 1997**

Item No.		1996		1997P	
		(tonnes)	(\$000)	(tonnes)	(\$000)
<b>EXPORTS</b>					
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium				
	Germany	1 913	9 805	2 418	10 191
	Japan	2 226 <sup>r</sup>	12 260 <sup>r</sup>	1 438	7 143
	United States	1 265 <sup>r</sup>	7 404 <sup>r</sup>	1 213	6 882
	Australia	182	872	1 468	6 141
	United Kingdom	762 <sup>r</sup>	4 904 <sup>r</sup>	725	4 038
	France	325	1 689	483	2 206
	Brazil	245 <sup>r</sup>	1 225 <sup>r</sup>	316	1 685
	Switzerland	404	2 066	313	1 568
	Venezuela	207	1 218	282	1 301
	Other countries	1 339 <sup>r</sup>	4 269 <sup>r</sup>	613	2 909
	Total	8 868 <sup>r</sup>	45 712 <sup>r</sup>	9 269	44 064
8104.19	Magnesium unwrought, other				
	United States	19 986	91 081	26 471	123 950
	Australia	558	3 278	511	3 356
	Netherlands	165	1 402	304	2 734
	Italy	288	2 057	340	2 289
	Venezuela	47	209	180	793
	Other countries	276 <sup>r</sup>	2 519 <sup>r</sup>	210	1 689
	Total	21 320 <sup>r</sup>	100 546 <sup>r</sup>	28 016	134 811
8104.20	Magnesium waste and scrap				
	United States	1 458	4 454	2 217	6 235
	Norway	3 847 <sup>r</sup>	15 796 <sup>r</sup>	1 062	4 124
	Other countries	6	19	33	81
	Total	5 311 <sup>r</sup>	20 269 <sup>r</sup>	3 312	10 440
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	2 377	11 228	5 051	23 738
	Ireland	348 <sup>r</sup>	2 488 <sup>r</sup>	270	1 985
	South Korea	265	1 541	317	1 885
	Other countries	155	949	161	1 046
	Total	3 145 <sup>r</sup>	16 206 <sup>r</sup>	5 799	28 654
8104.90	Magnesium and articles thereof, other				
	United States	1 092	7 457	319	2 527
	Argentina	7	61	26	185
	Other countries	195 <sup>r</sup>	509 <sup>r</sup>	. . .	3
	Total	1 294 <sup>r</sup>	8 027 <sup>r</sup>	345	2 715
	Total exports	39 938 <sup>r</sup>	190 760 <sup>r</sup>	46 741	220 684
<b>IMPORTS</b>					
8104.11	Magnesium unwrought, containing by weight at least 99.8% of magnesium				
	China	2 121	9 240	4 188	16 503
	United States	26	117	481	2 313
	Russia	5	11	375	1 399
	Other countries	109	461	391	1 377
	Total	2 261	9 829	5 435	21 592
8104.19	Magnesium unwrought, other				
	Norway	3 888	18 451	5 736	26 963
	United States	4 565 <sup>r</sup>	21 795	4 654	23 281
	Russia	1 305	6 014	4 770	22 795
	China	250	1 104	1 182	4 298
	Other countries	562	3 046	110	884
	Total	10 570 <sup>r</sup>	50 410	16 452	78 221
8104.20	Magnesium waste and scrap				
	United States	8 589 <sup>r</sup>	26 875 <sup>r</sup>	11 233	34 078
	Australia	—	—	7	108
	Other countries	365	1 350	36	100
	Total	8 954 <sup>r</sup>	28 224 <sup>r</sup>	11 276	34 286
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders				
	United States	287	1 266	835	3 181
	Russia	—	—	174	665
	Other countries	7	39	201	693
	Total	294	1 305	1 210	4 539
8104.90	Magnesium and articles thereof, other				
	United States	821 <sup>r</sup>	6 090 <sup>r</sup>	606	4 286
	United Kingdom	. . .	2	126	499
	Mexico	28	197	44	357
	China	31	184	13	136
	Other countries	22	190	3	12
	Total	902 <sup>r</sup>	6 664 <sup>r</sup>	792	5 290
	Total imports	22 981 <sup>r</sup>	96 432 <sup>r</sup>	35 165	143 928

Source: Statistics Canada.

— Nil; . . . Amount too small to be expressed; P Preliminary; <sup>r</sup> Revised.

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



**TABLE 2. CANADA, CONSUMPTION<sup>1</sup> OF MAGNESIUM, 1990-96**

	1990	1991 <sup>a</sup>	1992 <sup>a</sup>	1993 <sup>a</sup>	1994	1995 <sup>a</sup>	1996 <sup>p</sup>
	(tonnes)						
Aluminum alloys	7 672	9 215	9 203	10 174	12 389	12 323	14 022
Castings and wrought products <sup>2</sup>	5 849	4 604	6 915	7 678	8 940	12 488	11 197
Other uses <sup>3</sup>	1 603	1 926	2 005	2 162	2 234	2 329	2 357
<b>Total</b>	<b>15 125</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>

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 MAGNESIUM PRODUCTION, 1993-96**

Country	1993	1994	1995	1996 <sup>p</sup>
	(tonnes)			
Austria (secondary)	100	100	100	—
Brazil	9 600	8 800	9 700	9 000
Brazil (secondary)	1 600	1 600	1 600	1 600
Canada <sup>e</sup>	23 000	38 600	48 100	54 000
China <sup>e</sup>	11 800	11 000	12 600	14 400
France	11 000	12 300	14 500	14 000
India	1 000	1 000	1 000	1 000
Japan	7 500	3 400	—	—
Japan (secondary)	13 200	19 000	11 800	8 400
Kazakstane	2 000	—	—	—
Norway	27 300	27 600	28 000	37 800
Russia <sup>e</sup>	32 200	35 400	37 500	35 000
Ukraine <sup>e</sup>	14 900	12 000	13 000	13 000
United Kingdom (secondary)	500	500	500	500
United States	132 100	128 500	142 100	133 100
United States (secondary)	58 900	62 100	65 100	70 900
Yugoslavia, Former	—	—	2 600	2 500
Other	60 900	58 400	63 100	62 400
<b>Total (primary)</b>	<b>272 400</b>	<b>278 600</b>	<b>309 100</b>	<b>313 800</b>
<b>Total (secondary)</b>	<b>74 300</b>	<b>83 300</b>	<b>79 100</b>	<b>81 400</b>
<b>Total</b>	<b>346 700</b>	<b>361 900</b>	<b>388 200</b>	<b>395 200</b>

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

— Nil; <sup>e</sup> Estimated; <sup>p</sup> Preliminary.

**TABLE 4. WORLD CONSUMPTION OF MAGNESIUM, 1993-96**

Country	1993	1994	1995	1996 <sup>p</sup>
	(tonnes)			
Argentina	400	400	400	400
Australia	4 000	4 000	4 000	4 000
Austria	3 500	3 500	3 500	3 500
Belgium/Luxembourg	2 200	4 400	4 000	1 300
Brazil	10 000	10 500	10 000	10 000
Cameroon	100	100	100	100
Canada	20 000	23 600	27 100	27 600
China <sup>e</sup>	18 000	20 000	22 000	22 000
Denmark	200	200	200	200
Egypt <sup>e</sup>	1 000	1 000	1 000	1 000
France	12 000	16 100	17 000	15 000
Germany	14 900	19 000	19 900	19 600
Ghana	100	100	100	100
Greece	1 000	1 000	1 000	1 000
Hungary <sup>e</sup>	200	200	200	200
Italy	3 800	4 700	5 400	6 200
India	1 800	1 800	1 800	1 800
Japan (primary)	25 100	27 500	28 600	28 300
Japan (secondary)	13 100	14 300	17 100	21 600
Korea, Republic of	2 100	2 200	2 000	2 000
Mexico	1 000	1 000	1 000	1 000
Netherlands	1 000	1 000	1 000	1 000
New Zealand <sup>e</sup>	400	400	400	400
Norway <sup>e</sup>	5 800	6 000	6 000	6 000
Poland <sup>e</sup>	700	500	500	500
Romania <sup>e</sup>	500	400	300	300
Slovak Republic <sup>e</sup>	1 000	—	—	—
South Africa	500	800	800	700
Spain	1 500	1 700	1 500	1 500
Sweden	1 800	2 200	2 200	1 700
Switzerland	1 800	2 600	2 100	1 900
Taiwan	1 600	1 500	3 000	1 700
Turkey	600	600	500	500
U.S.S.R., Former <sup>e</sup>	25 000	25 000	25 000	25 000
United Kingdom	6 300	6 000	6 000	6 000
United States (primary)	101 100	111 800	109 000	102 000
United States (secondary)	58 900	62 100	65 000	70 900
Venezuela	600	600	500	500
Yugoslavia, Former	500	400	200	200
Other <sup>e</sup>	1 900	1 900	2 000	2 000
Total (primary)	274 000	304 700	310 700	297 500
Total (secondary)	72 000	76 400	82 100	92 500
Total	346 000	381 100	392 800	390 000

Sources: Natural Resources Canada; International Consultative Group on Nonferrous Metals Statistics.  
 — Nil; <sup>e</sup> Estimated; <sup>p</sup> Preliminary.

**TABLE 5. WORLD PRIMARY MAGNESIUM SMELTER CAPACITY, 1997**

Country	Smelter Location	Company/Plant	Capacity (t/y)
Brazil	Bocaiuva	Rima Industrial S.A.	12 000
Canada	Bécancour Haley Station	Norsk Hydro Canada Inc. Timminco Metals	43 000 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	3 000
	Jinzhou	Xinmei Co. Ltd.	3 000
	Minhe Xian	Minhe Magnesium Smelter (CNNC)	4 000
	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	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 Berezniki	Solikamsk Works Avisma Titanium-Magnesium Works	20 000 25 000
Ukraine	Kaluzh Zaporozhyre	Kaluzh Works Zaporozhyre Works	24 000 45 000
United States	Freeport Addy Rowley	The Dow Chemical Company Northwest Alloys Inc. Magnesium Corp. of America	65 000 38 000 38 000
Yugoslavia	Bela Stena	Magnohrom	9 000
Total			556 000

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

**TABLE 6. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE, 1987-97**

Year	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)							
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
1994	152.7	14.5	76.0	4.6	39.6	—	287.4
1995	165.4	12.9	74.0	4.9	46.8	—	304.0
1996	167.6	11.7	68.4	5.3	42.4	—	295.4
1997	197.7	7.7	80.4	5.1	42.8	—	333.7

Source: International Magnesium Association.  
— Nil.

**TABLE 7. PRIMARY MAGNESIUM SHIPMENTS BY WORLD ZONE AND CATEGORY, 1997**

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	72.8	3.1	35.0	4.1	31.2	—	146.2
Die casting	68.6	3.2	19.8	0.2	3.5	—	95.3
Desulphurization	31.3	0.4	15.3	0.2	1.0	—	48.0
Nodular iron	6.5	0.4	2.7	—	2.2	—	11.8
Electrochemical applications	5.4	0.4	1.5	0.6	1.0	—	8.9
Chemical applications	1.3	—	2.7	—	2.7	—	6.7
Metal reduction	3.8	—	1.1	—	0.1	—	5.0
Wrought products	3.3	—	0.1	—	0.1	—	3.5
Gravity casting	0.7	—	1.4	—	—	—	2.1
Other	4.3	0.2	0.8	—	1.1	—	6.4
Total	197.7	7.7	80.4	5.1	42.8	—	333.7

Source: International Magnesium Association.  
— Nil.

**TABLE 8. PRIMARY MAGNESIUM SHIPMENTS BY CATEGORY, 1987-97**

Use	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
(000 tonnes)											
Aluminum alloying	122.1	134.3	130.8	130.6	137.9	133.8	126.0	143.0	157.1	138.2	146.2
Die casting	26.6	28.5	28.6	36.3	30.7	34.5	38.6	51.2	64.1	72.3	95.3
Desulphurization	21.9	28.6	32.3	28.0	28.1	36.6	40.6	42.5	36.3	39.6	48.0
Nodular iron	14.2	15.8	16.9	14.4	13.7	13.3	13.4	16.2	14.5	12.5	11.8
Electrochemical applications	8.0	8.0	8.1	9.6	9.2	9.5	9.4	11.7	10.6	9.6	8.9
Chemical applications	7.2	8.1	5.5	7.1	7.1	7.3	6.5	6.2	6.5	6.9	6.7
Metal reduction	8.8	10.2	9.4	8.8	5.6	7.4	5.1	3.8	3.9	5.0	5.0
Wrought products	8.4	7.4	6.2	6.7	5.7	6.8	5.8	5.3	4.2	4.0	3.5
Gravity casting	1.8	2.1	2.5	3.3	2.2	2.6	1.5	1.8	1.8	2.4	2.1
Other	17.0	8.2	6.9	7.2	3.3	5.5	5.2	5.7	5.0	4.9	6.4
Total	236.0	251.2	247.2	252.0	243.5	257.3	252.1	287.4	304.0	295.4	333.7

Source: International Magnesium Association.