Magnesium

Wayne Wagner

The author is with the Minerals and Metals Sector, Natural Resources Canada.
Telephone: (613) 996-5951
E-mail: wwagner @ nrcan.gc.ca (text-based e-mail only with appropriate subject heading)

	2000	2001	2002	2003	2004
			($000)		
Exports (1)	204 713	176 224	266 717	288 055	164 187
Imports (1)	138 637	122 672	114 385	110 335	151 794

(1) Exports and imports given here include those classified as HS Code 8104.

	2000	2001	2002	2003	2004
			(tonnes)		
Primary metal production capacity (1,e)	50 500	59 500	70 000	56 000	57 000
Exports (HS 8104) (r)	47 182	43 295	71 244	58 632	47 859
Imports (HS 8104) (r)	33 851	32 870	34 895	37 937	52 869

(e) Estimated; (r) Revised.
(1) Canadian magnesium production data are confidential due to the limited number of companies reporting. This number is based on published capacity for primary metal. Note that other published estimates of Canadian magnesium production include quantities of recycled material.

CANADIAN DEVELOPMENTS

Producers

Norsk Hydro Canada Inc., a wholly owned subsidiary of Norsk Hydro ASA of Norway (www.magnesium.hydro.com), has produced primary magnesium metal at its Bécancour, Quebec, plant using an electrolytic process since 1989. Norsk Hydro announced in January 2005 that it was expanding the capacity of the plant by 7000 t to 58 000 t/y over the next 18 months.[1] The plant also recycles magnesium scrap produced by its customers and has a recycling capacity of 22 000 t/y.[1] The company is the leader in the production and provision of pure and alloyed magnesium. It has a global service network offering assistance in metal management and logistics, recycling, technical support, and application development.

Timminco Limited (www.timminco.com) operates a silicothermic reduction facility producing high-purity metal (up to 99.98% pure) for specialized markets at its 6000-t/y magnesium plant in Haley Station, Ontario. The operation includes a dolomitic limestone deposit and facilities for calcination, feed preparation, reduction, refining, and the casting of magnesium ingots and billets. Processing facilities include an extrusion and anode fabrication and assembly plant, as well as magnesium billet and slab processing facilities. The company also produces highly corrosion-resistant magnesium die-casting alloys and extruded anode rods for hot-water heaters. The casting facility at Haley provides magnesium billets for Timminco's extrusion facilities at Haley Station, Ontario, and Aurora, Colorado.

Timminco intends, on a longer-term basis, to broaden its activity. In line with this goal, it announced in March 2004 that it had acquired 24% of the equity in Fundamus, an aluminum wheel manufacturer based in Hoyanger, Norway. In September 2004, the company announced that it had completed the acquisition of Bécancour Silicon Inc., a Quebec-based producer of high-quality chemical and electronics-grade silicon metal and specialty ferrosilicon.

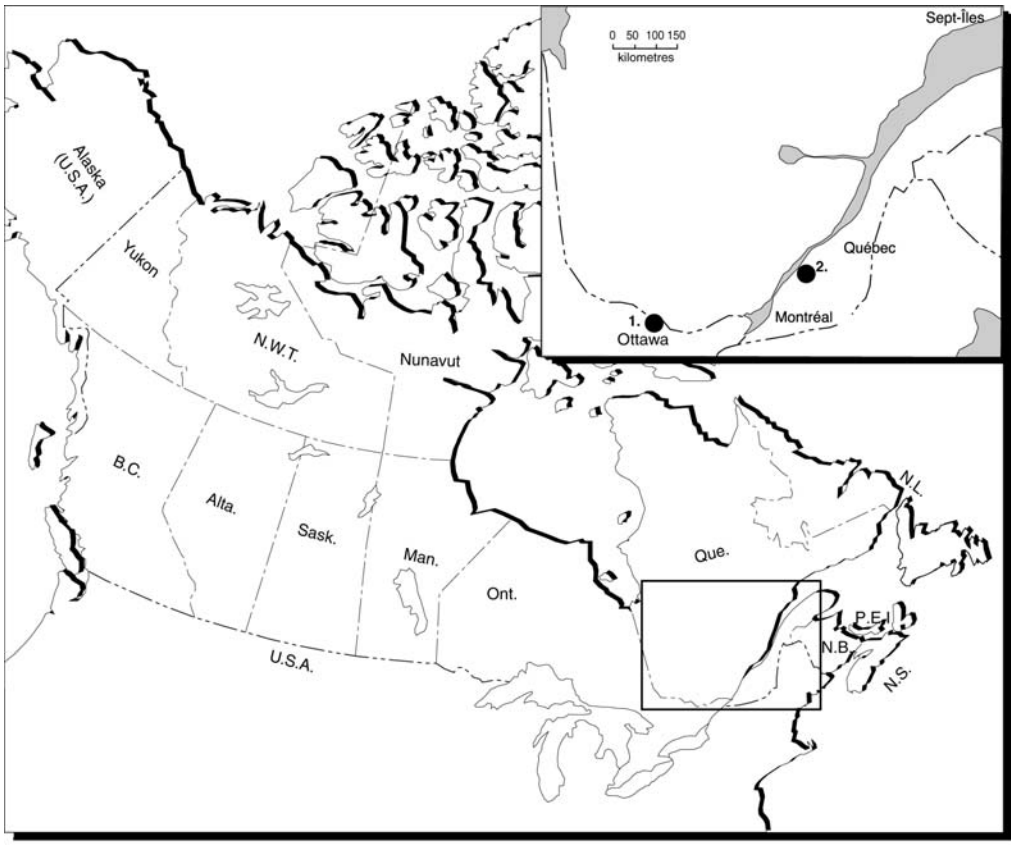
Potential Projects

Magnola Metallurgy Inc., owned 80% by Falconbridge Limited (formerly Noranda Inc.) and 20% by Société générale de financement du Québec, closed the 58 000-t/y magnesium metal smelter at Danville, Quebec, in April 2003. Noranda had indicated that prices would have to increase from current levels before it would re-open the smelter.

Active Canadian projects currently include: Globex Mining Enterprises Inc., a magnesite-talc project at Timmins, Ontario; Leader Mining International Inc., a silicate-based project near Hope, British Columbia; Gossan Resources Ltd., a dolomite project at Inwood, Manitoba; and an asbestos-based project at Thetford Mines, Quebec.

Globex continued work on its magnesium-talc deposit 13 km south of Timmins, Ontario. Previous work has indicated the potential for production of both magnesium

Figure 1
Magnesium Smelters, 2004



SMELTER	COMPANY	CAPACITY (t/y)
1. Haley Station, Ontario	Timminco Limited	6 000
2. Bécancour, Quebec	Norsk Hydro Canada Inc.	51 000

metal and high-quality talc from the deposit. Results of a 2001 scoping study were positive and indicated a good economic potential using available technology. The project would include a mine-mill complex located near Timmins, Ontario, and a 95 000-t/y smelter located west of Rouyn-Noranda, Quebec, and has the advantages of ready access to competitive power prices; large consumer markets; a stable, high-calibre work force; excellent infrastructure, including highways and railways; and a high-quality talc by-product to provide additional revenue.

During 2004, mineralogical test work was undertaken by Globex on samples from four cross-sectional drill holes. The company is seeking a financial and/or technical partner on the project to conduct a bankable feasibility study with an expected cost of US$12 million and to complete the project with a US$1.0 billion construction cost.

Gossan Resources Ltd. holds a dolomite deposit at Inwood, Manitoba, on which the company is conducting studies towards a metal project. The company's high-purity dolomite resource is estimated at 67 Mt grading 21.6% magnesium oxide with additional inferred resources. In 2003, a five-hole drill program was completed and Mintek Engineering of South Africa tested a 75-kg bulk sample of Inwood dolomite. Mintek determined that dolomite from the deposit was suitable for a new silicothermic process for the extraction of magnesium. In March 2004, the company entered into an agreement with Hatch Associates for the first in a series of studies for a preliminary feasibility study. Environmental studies on the property were also conducted. An initial economic assessment of using Mintek's atmospheric silicothermic magnesium extraction process was under way in 2004 and the company has indicated that it may send a bulk sample to Mintek for further testing in 2005.

The timing of this latter work depends on progress on the new process. (Additional information is available on the Internet at www.gossan.ca and www.mintek.ac.za.)

Leader Mining International Inc. continued work on its Cogburn ultramafic intrusive near Hope, British Columbia, which contains magnesium-bearing silicates. Pilot-scale testing was carried out in 2002 on core samples with positive results. Other activities have included work on environmental permitting, infrastructure studies, and bench-scale testing on composite samples, as well as agreements for construction, mining, power and water. In May 2003, the company reported that Hatch Associates had delivered a positive project feasibility study for a mine and a 120 000-t/y smelter project. The new management of the company reported that all work is now being carried out by a wholly owned subsidiary, North Pacific Alloys Limited, and it was looking for an experienced company with the capability and capacity to become the operator and/or major owner of the project.

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

Canadian Production and Use

Canadian production capacity for magnesium (reported capacity in published public reports) fell to approximately 56 000 t/y in 2003 with the closure of Magnola. With the expansion at Norsk Hydro currently under way, Canadian production capacity will rise to approximately 64 000 t/y in mid-2006.

In Canada, the reported use of magnesium increased from 54 100 t in 2002 to 56 175 t in 2003. In both years, 35 companies were surveyed on their use of magnesium.

GLOBAL CONTEXT

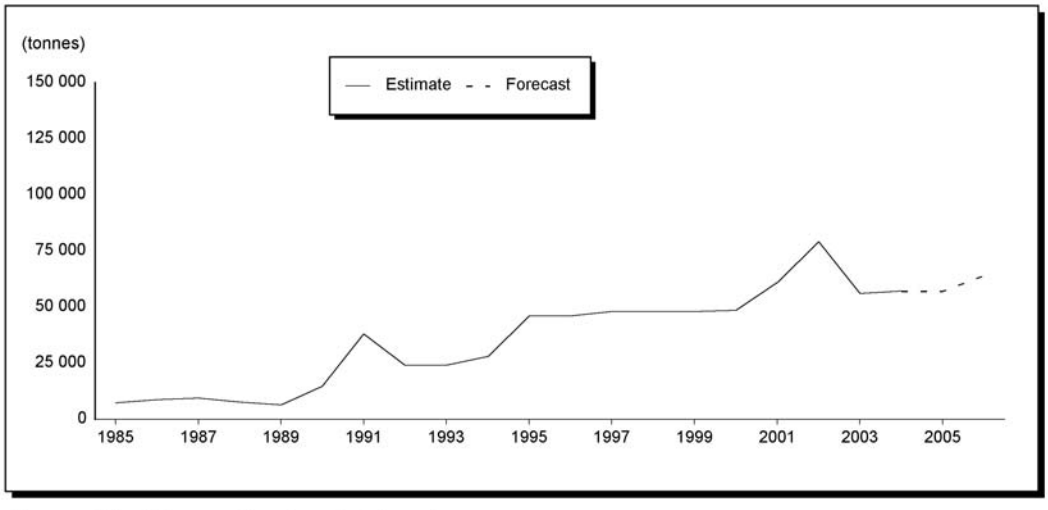
World primary magnesium production surpassed 600 000 t in 2004. With recycled magnesium, the total reached approximately 690 000 t. This represents a 40% increase in total magnesium production over the past decade.

China is by far the largest producer of primary magnesium in the world. The Chinese Statistics Bureau reported that magnesium production increased by about 20% in 2004 to 423 000 t. Approximately 354 000 t were produced in 2003. This follows a 50% increase in 2003 and a 16% increase in 2002 (see Table 3).

Approximately 228 000 t of unwrought pure magnesium and 80 000 t of alloy magnesium were reported exported from China in 2004. Alloy production and export have grown in the past several years and export growth in that area, as well as in semi-fabricated forms and parts, is expected in the coming years.

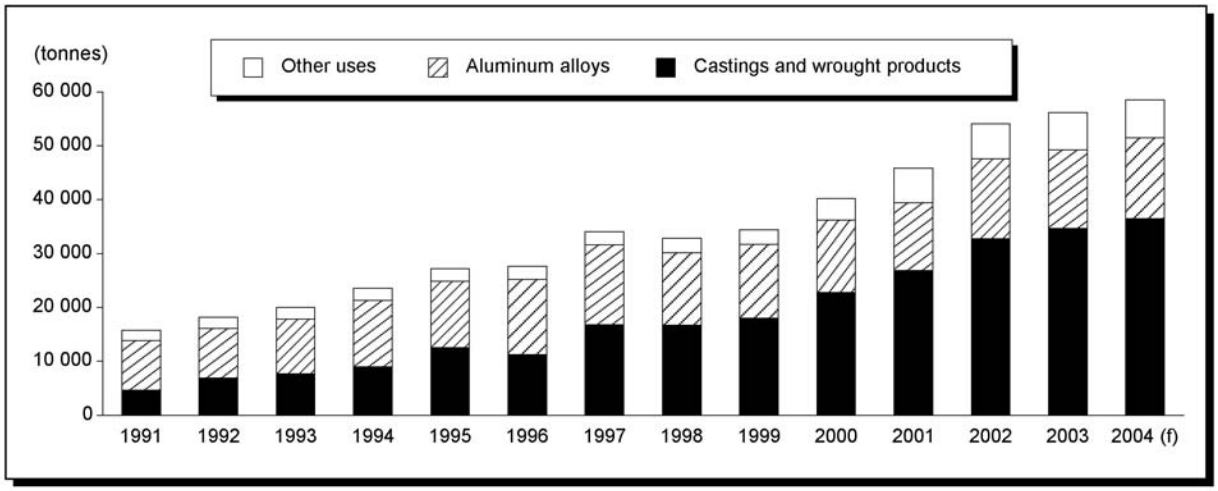
China continues to focus on improvements in the industry to increase the size and efficiency of smaller operations as well as more value-added operations. Given present

Figure 2
Canadian Primary Magnesium Production Capacity, 1985-2006



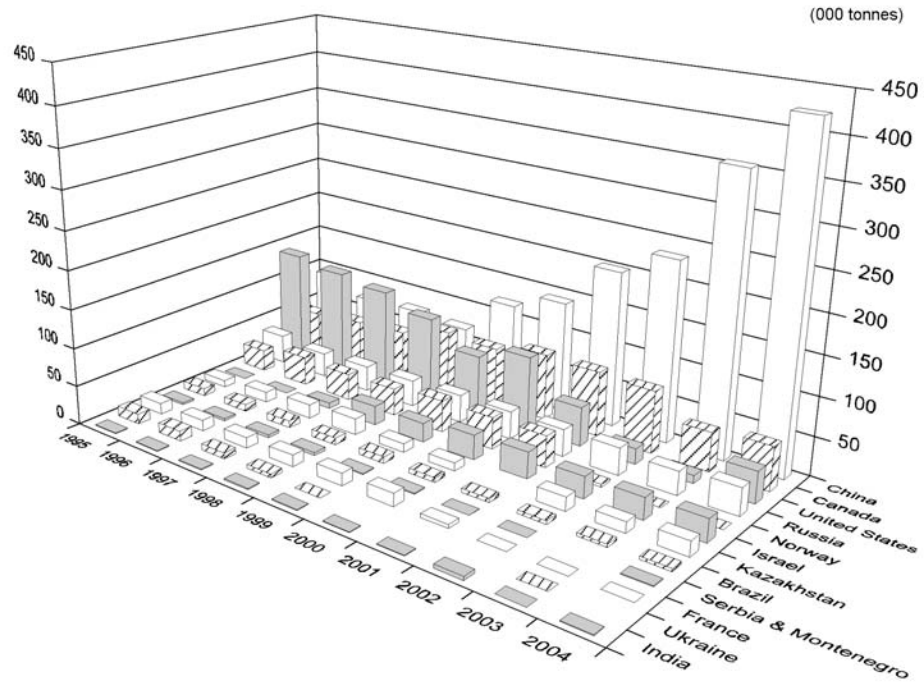
Sources: Natural Resources Canada; published reports.
Note: Canadian production data are confidential due to the limited number of producers. This is the primary capacity or production of plants in Canada reported from credible published sources.

Figure 3
Canadian Use of Magnesium, 1991-2004



Source: Natural Resources Canada survey of 35 Canadian users of magnesium.
(f) Forecast.

Figure 4
World Primary Magnesium Production, 1995-2004
Estimated total in 2004 = 630 000 t



Sources: International Consultative Group on Nonferrous Metal Statistics; reports in various journals (also see notes on the accompanying production table).

growth rates, unless production from small plants is totally curtailed, production capacity is likely to continue to expand. In addition, increasing focus is being placed on the production of more processed material to increase revenues to producers, including the production of alloys and semi-finished and finished products instead of pure magnesium ingot.

Government Activities

Brazil

Brazil's Department of Development Industry and Commerce investigated the dumping of metallic magnesium from China based on a complaint from Rima Industrial SA, Brazil's only magnesium producer. A decision was announced in October 2004 that a duty of US$1.18/kg was applied to pure magnesium. (Additional information is available on the Internet at www.desenvolvimento.gov.br.)

United States

U.S. Magnesium LLC and U.S. workers filed an anti-dumping suit against China and Russia in February 2004. The U.S. International Trade Commission (ITC) later determined that there is a reasonable indication that the U.S. industry was materially injured by reason of imports of pure magnesium from Russia and alloy magnesium from China and Russia that are allegedly sold in the United States at less than fair value. At the time, existing duties on Chinese magnesium ranged up to 305.56%; however, previous rulings on Russian material have determined a 0% margin with no duty applied. In March 2005, amended final anti-dumping margin rulings were published in the Federal Register on pure and alloy magnesium from Russia at 18.65% for Solikamsk and 21.71% for JSC AVISMA, with an all other's rate of 21.01%. Final rulings on a China-wide rate for alloy magnesium determined margins at 141.49%. A rate of 91.31% for two producers was later amended to 49.66% (www.gpoaccess.gov).

In April 2004, the Department of Commerce (DOC) announced preliminary results of the review for pure magnesium from Canada for the period August 1, 2002, through July 31, 2003, that the rate for Norsk Hydro is 0.01%, de minimis. As Magnola did not ship magnesium in this period, no rate was determined for Magnola.

In September 2004, the DOC announced the final results of the countervailing duty administrative reviews for 2002 for pure and alloy magnesium from Canada and that it had determined rates of 1.07% for Norsk Hydro and 1.84% for Magnola.

In December, the DOC published a Federal Register notice that it had revoked the anti-dumping duty order on pure magnesium from Canada effective August 1, 2000, as the result of a NAFTA binational review panel review.

India

The Indian government reduced import duties on magnesium from 20% to 15% (indiabudget.nic.in/ub2004-05/mem/mem2.pdf).

Producer and Project Developer Activities

Congo

Magnesium Alloy Corporation (MagAlloy) continued work on developing its Kouilou project in The Republic of Congo (Brazzaville).

Shareholders approved a name change to MagIndustries Inc. in early 2005 (www.magindustries.com). The company has been active on the corporate front and has expanded and restructured operations into several business segments: MagMetals Inc., to develop its metal smelter project; MagEnergy Inc., to rehabilitate the Inga Hydro power station and to construct transmission facilities and a gas-fired power plant; MagEnergy International Inc., which trades in oil products; MagMinerals Inc., to develop and produce agricultural-grade fertilizers and food-grade salt; MagForestry, to manage a eucalyptus plantation; and MagAlloy Congo SA, jointly held by MagIndustries (90%) and the Government of The Republic of Congo, to develop and operate a salt brine extraction facility for feedstock to its other subsidiaries.

MagIndustries signed a fiscal agreement in August with the government to allow company operations in a free trade zone. The brine extraction facility will be owned 90% by MagIndustries with the other 10% owned by the government. The proposed 60 000-t/y smelter will be owned solely by the company. The company also signed a Technology Access Agreement with VAMI (Russian National Aluminum and Magnesium Institute), STI (State Titanium Research and Design Institute), and Al Al (Aluminum Alloys & Metallurgical Process LLC). The Agreement gives MagIndustries regionally exclusive rights for magnesium extraction technologies and knowledge transfer.

China

Quay Magnesium is building a 15 000-t/y alloy plant near Nanjing, China, using magnesium from other Chinese smelters to produce alloy. The company reduced the size of the plant as funds were not sufficient to construct the originally planned 30 000-t/y facility (www.quaymagnesium.com).

Australia

Latrobe Magnesium Limited, in Victoria State, continued initial studies on the production of magnesium from fly

ash. Upon successful completion of these studies, a bankable feasibility study may be undertaken in 2005. This study was expected to take two years to complete (latrobemagnesium.com).

Egypt

Magnesium International Ltd. planned to conduct a bankable feasibility study in 2005 of an 88 000-t/y (43 000-t/y in the first phase) smelter in Egypt at Sokhna on the Gulf of Suez. If positive, the smelter would be owned and operated by Egyptian Magnesium Company SAE (EMAG), which was expected to be held 60% by Magnesium International, 20% by Egyptian partners, and 20% by European development agencies (www.mgil.com.au).

Russia

Interfax reported that the Government of the Sverdlovsk Region in Russia, JSC Uralasbest, and Minmet Financing Co., part owner of the Solikamsk magnesium plant in Russia (www.minmet.ch), have continued working on a project to produce metal from asbestos mining residues. Feasibility studies were under way in 2004 for a 60 000-t/y smelter and a decision on construction was expected in 2005.

Magnesium.com reported that Russian Aluminum and the Volograd District in Russia announced a feasibility study on the construction of a 40 000-t/y smelter in the Volograd region. As with other magnesium smelters, magnesium salts would be used as the feed source for the smelter.

Ukraine

Kalush Magniy, which owns a 25 000-t/y smelter in the western Ukraine (closed in 1999), started reconstruction of its facilities in January 2004. Magnesium production restarted in January 2005 and the company planned to produce 6000 t of magnesium in 2005. The company plans to increase its production to 10 000 t in 2006 and to 20 000 t in 2007 (www.kalush-mg.com).

United States

US Magnesium LLC announced on September 23, 2004, that it had completed studies on expansion of its 43 000-t/y plant to a capacity of 73 000 t/y. It also indicated that its capacity will increase to 51 000 t/y in June 2005. As the sole magnesium producer in the United States, this company receives all duties collected by the U.S. government on magnesium imports to the country (www.usmagnesium.com).

RECYCLING UPDATES

Hydro Magnesium (www.magnesium.hydro.com) doubled its recycling capacity in Bottrop, Germany, to 15 000 t/y in 2004 due to increased recycling demand, particularly from the automotive industry.

Hydro Magnesium also increased its remelt/recycling capacity in Xi'an, China, to 15 000 t/y from its initial capacity of 10 000 t/y due to increased demand in Asia.

Aleris International, Inc. expected to open its magnesium recycling plant in Germany in the first quarter of 2005. BMW Group has contracted the company's VAW-IMCO subsidiary to recycle a new magnesium engine block. Initial production of 5000 t/y will rise to 15 000 t/y as the company obtains scrap from other customers. Aleris International, Inc. resulted from the merger of Commonwealth Industries, Inc. and IMCO Recycling Inc. (www.aleris.com and www.imcorecycling.com).

In 2003, Advanced Magnesium Alloys Corp. (AMACOR) purchased the magnesium recycling plant at Anderson, Indiana, from Xstrata Plc. and increased its capacity to approximately 30 000 t/y. In January 2005, a fire destroyed its scrap warehouse and operations were shut down. The company expected to resume production in mid-2005 (www.amacor.us).

PRICES

Prices published by *Metals Week* for magnesium moved upwards, peaking in September, after which they began to show some weakness. The U.S. Spot Western Mean started the year at about US$1.10/lb, increased to US$1.74/lb in September, and subsequently fell to US$1.60/lb in December, and has continued to decline to $1.54/lb in early 2005. The mean U.S. dealer import prices have increased from US$1.07/lb early in the year to US$1.51/lb at the end of the year. The *Metal Bulletin*'s World Free Market Price for minimum 99.8% magnesium metal started the year at US$1850-$1950/t, increased to US$2200-$2300/t in April and May, and subsequently drifted lower to end the year at US$1890-$1940/t.

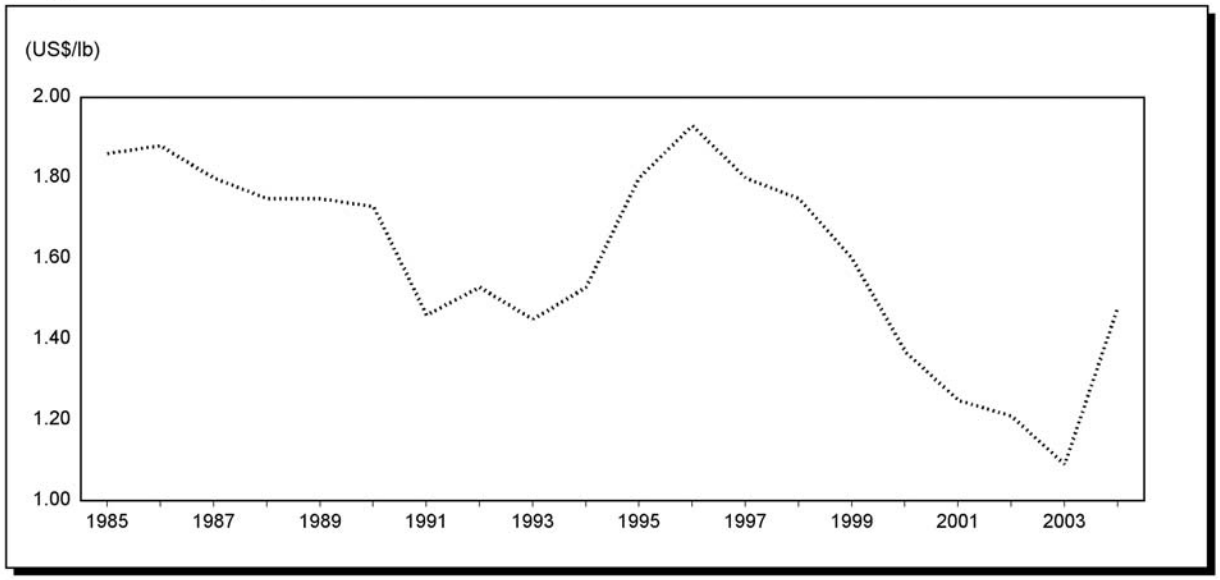
Reported prices of Chinese magnesium on a spot basis f.o.b. China started the year at approximately US$1650-$1750/t and increased until April, reaching US$2200-$2300/t, and then subsequently weakened to end the year around US$1700-$1740/t. Prices were reported slightly lower in early 2005.

ANNUAL AVERAGE PRICES, METALS WEEK (U.S. SPOT WESTERN MEAN)

1998	1999	2000	2001	2002	2003	2004
			(US$/lb)			
1.59	1.55	1.37	1.25	1.21	1.09	1.48

Source: Calculated from data published in *Platts Metals Week.*

Figure 5
Magnesium Prices, 1985-2004



Sources: Natural Resources Canada; *Metals Week* (U.S. Spot Western Mean).

Hydro Magnesium announced that it had decreased its European producer price for magnesium alloy from 2.75/kg to 2.55/kg on February 18, 2005. The previous price was set on March 15, 2004.

GENERAL INFORMATION

For recent statistics and events in the Canadian and global industry, see:

- Previous editions of the magnesium chapter of the *Canadian Minerals Yearbook* at www.nrcan.gc.ca/mms/cmy/com_e.html;
- the *Nonferrous Metals Outlook* at www.nrcan.gc.ca/mms/pubs/nfo_e.htm;
- the web site of the International Magnesium Association at www.intlmag.org;
- Magnesium.com on-line resource at www.magnesium.com/w3/; and
- the U.S. Geological Survey web site at http://minerals.usgs.gov/minerals/pubs/commodity/magnesium.

Canadian magnesium metal producers have web sites located at:

- Hydro Magnesium: www.magnesium.hydro.com
- Timminco Limited: www.timminco.com

Canadian companies with an interest in producing magnesium metal[2] have web sites located at:

- Falconbridge Limited (Noranda Magnesium Inc.): www.falconbridge.com
- Globex Mining Enterprises Inc.: www.globexmining.com
- Gossan Resources Ltd.: www.gossan.ca
- Hatch Associates of Canada: www.hatch.ca
- Lakefield Research of Canada Limited: www.lakefield.com
- Leader Mining International Inc.: www.leadermining.com
- MagIndustries Inc.: www.magindustries.com

Occurrence

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

Technology

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

Research has taken place to refine, modernize and replace existing production processes. Although production improvements have been made in existing operations, other options exist. The results of work to date have not been successfully adapted to large-scale production, although some changes in material supply and feedstock production and preparation have been implemented by existing producers.

Magnesium Production in Canada

In 1939, Dr. Lloyd Pidgeon and a research team in the National Research Council Canada's (NRC) Division of Chemistry developed a method of producing pure solid metallic magnesium in a process that combined ferrosilicon and dolomite. The first magnesium produced by this method to be used in aircraft came from the NRC's Sussex Drive laboratories in Ottawa, Ontario. A pilot plant built with funding from mining companies became Dominion Magnesium Company after the war.

Canada is now the second largest producer of magnesium in the world. In 2004, there were two operating magnesium smelters in Canada.

Timminco Limited was established in 1934 and produces high-purity metal (up to 99.98% pure) for specialized market applications at its 6000-t/y magnesium plant at Haley Station, Ontario. Timminco uses the Pidgeon magnesium process in which calcined dolomite is reduced by ferrosilicon in a vacuum retort in controlled batches of known and consistent chemistry. As a result, the company produces the highest-purity commercial magnesium in the world. Timminco mines the dolomite at the plant site, but purchases the ferrosilicon feed on the open market. 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. (For further information, see Timminco's web site at www.timminco.com.)

Norsk Hydro Canada Inc., a wholly owned subsidiary of Norsk Hydro ASA of Norway, produces magnesium metal at a 51 000-t/y[1] Bécancour, Quebec, plant using an electrolytic process and purchased magnesite. The plant opened in 1989 with a capacity of 40 000 t/y and has subsequently increased production through debottlenecking of the original plant. It also recycles magnesium scrap produced by its customers and has a remelt capacity of 20 000 t/y. This plant is one of the most efficient in the world and is the lowest-cost Western producer of magnesium metal. The company offers a global service network, including metal management and logistics, recycling, technical support, and application development. (For further information, see Norsk Hydro's web site at www.magnesium.hydro.com.)

In early 2001, Magnola Metallurgy Inc. (owned 80% by Falconbridge Limited and 20% by Société générale de financement du Québec) completed construction of its 58 000-t/y magnesium metal plant in Danville, Quebec. Magnola was to use asbestos mine tailings as a feedstock to a proprietary process developed by the Noranda Technology Centre of Noranda Inc. to produce the magnesium chloride needed for electrolysis. The plant started producing magnesium metal in October 2000 in a plant based on electrolysis of magnesium chloride from the serpentine feedstock. Although the company faced some start-up problems, it expected to reach commercial production levels in 2002 but, in early 2003, closed the plant. The shut-down is for an indefinite period of time until market conditions allow for a viable operation of the plant. (For further information, see the company's web site at www.falconbridge.com.)

Use

Although magnesium is consumed in some applications (such as in flares or pyrotechnics, or when magnesium is used in chemical reactions in the production of other

metals), most use in industrial and consumer products is generally non-destructive and the metal can be recycled and re-used. The energy inherent in the metal remains and the process of recycling the metal recovers that energy in a repeating and sustainable manner. Discussions on metals taking place in a number of fora indicate that usage of the word "consumption" in reports should be modified to more appropriately reflect the actual use of the metal.

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

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

The use of die-cast magnesium parts can help automobile manufacturers reduce total vehicle weight while meeting the consumer demand for larger vehicles. The interest in magnesium metal in the automotive market is largely due to weight savings of more than 30% compared to aluminum and to a desire to increase fuel efficiency through weight reduction.

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

The primary use of magnesium metal is as an alloying agent for aluminum where it imparts strength and rigidity to alloys used in various applications, including aluminum sheet, such as that used in the manufacture of aluminum beverage containers. These alloys allow the use of less material, producing thinner walls and lighter containers than would normally otherwise be possible.

The next most important use for magnesium metal is for die-cast products. These castings can be used in structural applications such as instrument panel beams of automobiles or as equipment cases for electronic equipment such as cameras, cell phones, computers, portable tools and sporting goods. 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 deoxidizing and desulphurizing agent in the ferrous industry where it is consumed in the production of steel and cast iron. 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.

Other uses are much smaller in comparison to those above. These include:

- Chemical uses: in pharmaceutical and chemical products, perfumes and pyrotechnics;
- Electrochemical applications: in batteries and in anodes for the cathodic protection of gas pipelines and water heaters;
- Wrought products: in extruded products, sheets and plates; and
- Magnesium metal is also used to produce other metals such as titanium, beryllium, zirconium, hafnium and uranium.

The biggest potential for growth in the use of magnesium lies in the aluminum alloy and automotive markets sectors. However, growth will be dependent upon prices and price stability as magnesium continues to face stiff competition from other materials, including aluminum, steel and plastics.

Recycling

The production of recycled magnesium from metallic scrap requires about 5% of the energy required to produce primary magnesium. The recycling of old or post-

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

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

Prices

Magnesium metal does not trade on the London Metal Exchange or the New York Mercantile Exchange Inc. Producers and metal traders deal directly with users as the volumes of metal are not large enough for inclusion in an organized market. Producer and dealer pure and alloy magnesium metal price quotes can be found in various metal publications such as *Metal Bulletin*, *American Metal Markets*, or other similar papers and journals with metals news. It should be noted that duties and other taxes can significantly change prices within regional areas and published data may not apply to all markets.

REFERENCES

1 www.magnesium.hydro.com.

2 If you are a Canadian company with an interest in producing magnesium metal and are not listed here and wish to be included, please contact the author by e-mail at wwagner @ nrcan.gc.ca.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 64. (2) Information in this review was current as of March 30, 2005. (3) Some differences are noted in some production data from independent sources. Readers are cautioned to confirm data from all sources. (4) Lorraine Ralph and others in the Minerals and Metals Statistics Division created Tables 1 and 2 and provided input into other tables and figures (contact Lorraine Ralph or Julie Simon, tel.: 613-947-6777). (5) This and other reviews, including previous editions, are available on the Internet at www.nrcan.gc.ca/mms/cmy/com_e.html.

NOTE TO READERS

TARIFFS (1)

Item No.	Description	Canada			United States	EU	Japan
		MFN	GPT	USA	Canada	Conventional Rate (2)	WTO (3)
3824.90.90.42	Granular metallic magnesium coated with inorganic salts, mixed with lime	6.5%	3%	Free	Free	6.5%	Free-3.9%
3824.90.90.43	Other granular metallic magnesium coated with inorganic salts	6.5%	3%	Free	Free	6.5%	Free-3.9%
8104.11	Magnesium and articles thereof, unwrought; containing by weight at least 99.8% of magnesium	2.5%	Free	Free	Free	5.3%	Free-3%
8104.19	Magnesium unwrought, other						
8104.19.10	Magnesium-rare earth, magnesium-didymium, magnesium-thorium, magnesium-zirconium and magnesium-thorium-neodymium-rare earth for use in the manufacture of magnesium castings	Free	Free	Free	Free	4%	Free-3%
8104.19.90	Other	2.5%	Free	Free	Free	4%	Free-3%
8104.20	Magnesium waste and scrap	Free	Free	Free	Free	Free	2.1%
8104.30	Magnesium raspings, turnings and granules, graded according to size;	2.5%	Free	Free	Free	4%	3%
8104.90	Other magnesium	2.5%	Free	Free	Free	4%	3%

Sources: Canadian *Customs Tariff*, effective January 2005, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States,* 2005; *Official Journal of the European Union* (October 30, 2004 Edition); *Customs Tariff Schedules of Japan, 2004.*
(1) Does not include countervail or anti-dumping duties, which may be applied to material of certain origin. (2) The customs duties applicable to imported goods originating in countries that are Contracting Parties to the General Agreement on Tariffs and Trade or with which the European Community has concluded agreements containing the most-favoured-nation tariff clause shall be the conventional duties shown in column 3 of the Schedule of Duties. (3) WTO rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, MAGNESIUM EXPORTS AND IMPORTS BY COMMODITY, 2002-04

Item No.		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS							
2519.10	Natural magnesium carbonate (magnesite)	20	9	2 462	251	6 176	575
2519.90	Other magnesium oxide	56 618	20 167	52 051	15 339	62 445	16 170
2816.10	Hydroxide and peroxide of magnesium	–	–	1	4	259	512
2827.31	Other chlorides: Of magnesium	262	235	483	248	338	74
8104.11	Magnesium unwrought, containing by weight at least 99.8% magnesium	20 614	65 916	15 927	41 385	10 239	31 893
8104.19	Magnesium unwrought, other	35 993	146 132	30 775	109 774	25 250	94 788
8104.20	Magnesium waste and scrap	10 266	24 788	10 134	20 529	10 047	20 512
8104.30	Magnesium raspings, turnings or granules, graded according to size, and powders	1 847	8 234	711	3 062	1 378	6 925
8104.90	Magnesium and articles thereof, other	2 523	21 645	1 082	13 303	946	10 064
	Total exports	140 407	289 812	125 572	206 498	127 057	184 086
IMPORTS							
2519.10	Natural magnesium carbonate (magnesite)	238 864	16 882	176 041	9 417	202 524	10 671
2519.90	Other magnesium oxide	101 013	38 840	100 180	39 551	78 056	37 088
2816.10	Hydroxide and peroxide of magnesium	9 089	4 471	8 090	5 230	8 444	4 820
2827.31	Other chlorides: Of magnesium	7 970	3 995	16 947	7 419	29 076	4 900
2833.21	Other sulphates: Of magnesium	10 297	4 687	18 116	4 373	20 634	4 659
2836.99.10.40	Magnesium carbonates	48	105	46	110	22	44
2836.99.90.30	Other: Magnesium carbonates	93	186	91	181	63	124
3824.90.90.42	Granular metallic magnesium coated with inorganic salts, mixed with lime	33	34	73	71	32	27
8104.11	Magnesium unwrought, containing by weight at least 99.8% magnesium	16 782	39 397	18 736	43 953	36 087	92 825
8104.19	Magnesium unwrought, other	8 940	40 281	10 427	36 640	9 459	33 939
8104.20	Magnesium waste and scrap	6 911	22 766	6 334	17 384	5 759	14 901
8104.30	Magnesium raspings, turnings or granules, graded according to size and powders	972	3 985	572	1 950	804	3 098
8104.90	Magnesium and articles thereof, other	1 289	7 955	1 865	10 365	1 060	7 029
	Total imports	402 301	183 584	357 518	176 644	392 020	214 125

Sources: Natural Resources Canada; Statistics Canada.
– Nil.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, MAGNESIUM USE, (1) **1993-2003**

	1993 (a)	1994	1995 (a)	1996	1997	1998 (a)	1999 (a)	2000 (a)	2001 (a,r)	2002 (r)	2003
						(tonnes)					
Castings and wrought products (2)	7 678	8 940	12 488	11 197	16 795	16 687	17 951	22 728	26 818	32 770	34 655
Aluminum alloys	10 174	12 389	12 323	14 022	14 793	13 417	13 741	13 466	12 562	14 857	14 537
Other uses (3)	2 162	2 234	2 329	2 357	2 438	2 685	2 727	3 960	6 460	6 472	6 983
Total	20 014	23 563	27 140	27 576	34 026	32 790	34 419	40 154	(r) 45 840	54 100	56 175

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

TABLE 3. WORLD PRODUCTION (1) **OF MAGNESIUM, 1995-2004**

Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004 (f)
					(000 tonnes)					
PRIMARY PRODUCTION										
China (1)	93.6	73.2	76	70.5	120.7	142.1	199.7	231.7	354.0	423
Canada (2)	48.1	54.0	57.7	77.1	73.7	85.7	83.4	80.0	78.0	79
United States	10.0	133.1	124.8	106.1	75.0	94.0	50.0	20.0	10.0	40
Russia	37.5	31.5	33.0	34.1	35.2	35.5	35.0	35.0	30.0	35
Israel	–	0.1	7.4	24.5	24.3	31.7	34.0	28.0	28.0	29
Kazakhstan	9.0	13.4	17.9	20.9	11.0	10.4	16.5	(r) 17.9	14.2	19
Brazil	9.7	9.0	9.0	9.0	8.0	5.7	5.5	4.5	4.0	4
India	1.0	1.0	1.0	1.5	1.0	0.5	0.5	0.5	0.2	1
Serbia and Montenegro	2.6	3.1	3.9	4.0	1.2	1.3	0.2	–	0.5	1
Norway	28.0	37.8	34.2	35.4	40.8	41.4	(r) 40.7	(r) 3.1	–	–
France	14.5	14.0	13.8	14.7	16.2	16.5	4.8	–	–	–
Ukraine	13.0	12.9	7.7	5.0	–	–	–	–	–	–
Total primary	399.1	383.1	386.4	402.8	407.1	464.8	470.3	420.7	518.9	630
RECYCLED PRODUCTION (3)										
Austria	0.1	–	–	–	–	–	–	–	–	–
Brazil	1.6	1.6	1.6	–	–	–	–	–	–	–
Japan	11.8	21.2	22.8	–	–	–	–	–	–	–
United States	65.1	71.2	77.6	77.1	86.1	82.3	65.8	73.7	75.0	75
United Kingdom	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.7	0.7	1
Total recycled	79.1	94.5	102.5	77.6	86.6	82.8	66.3	74.4	75.7	60
Total primary and recycled	478.2	477.6	488.9	480.4	493.7	547.6	536.6	495.1	594.6	690

Sources: International Consultative Group on Nonferrous Metals Statistics; China Magnesium Association, as reported in various journals.
– Nil; (f) Forecast; (r) Revised.
(1) Numbers used in table are from the International Consultative Group on Nonferrous Metal Statistics. As reported in various journals, Chinese Magnesium Association reported higher numbers for Chinese production: 1994 - 25 000 t; 1997 - 92 000 t; 1998 - 120 000 t; 1999 - 157 000 t; 2000 - 194 000 t; 2001 - 268 000 t; 2002 - 268 000 t; 2003 - 356 000 t; and 2004 - 450 000 t. (2) Canadian data are confidential. The numbers shown are an estimate provided by the U.S. Geological Survey to the International Consultative Group on Non-Ferrous Metal Statistics and include recycled magnesium for some years. Data for 2003 and 2004 are the published capacity for the production of primary magnesium in currently operating facilities plus the capacity for recycling magnesium. (3) Recycled magnesium facilities exist in other locations, including Canada, that have not reported separate production figures for recycled magnesium due to confidentiality and other reasons.