

MAGNESIUM

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The year 2001 saw many new and unusual things happen in the magnesium industry. Total production fell and several Western plants were permanently closed due to low market prices. World wide magnesium selling prices continued to be dominated by the Chinese magnesium industry.

Total production slumped slightly and the annual increase of magnesium used in automobiles stopped. Many problems were apparent in the industry during the year, but the tragedy of September 11, 2001 also negatively affected the use of magnesium in the US. Alcoa shutdown its Northwest Alloys 45,000 t/y primary magnesium production plant in Addy, Washington. Alcoa cited the fact that it was cheaper to buy the magnesium delivered to its plants than it was to make it itself. Pechiney shut down its 20,000 t/y magnesium production plant in Marginac, France, but will continue to melt scrap and magnesium from other sources. Norsk Hydro announced that it would shut down its 45,000 t/y magnesium production in Porsgrunn, Norway. Hydro Magnesium did say that the plant would continue to recycle magnesium scrap and produce alloy from other magnesium sources. Magnesium Corp. of America (MagCorp) installed new cells of its own design in one of its four cell buildings at the Great Salt Lake plant near Rowley, Utah. One cell building was shut down owing to power shortages. The company declared Chapter 11 bankruptcy and was operating at 30,000 t/y for most of the year.

The shocking statistic in all of this is the price of magnesium. Approximately 185,000 t/y of Western magnesium production was closed permanently or taken off line between November 1999 and December 2001. The total world production of magnesium is about 470,000 t/y. In spite of all the plant closings,

the price of magnesium was lower during 2001 than it was in 2000. Shortfalls in the world market were made up by increases in low-priced imports from the CIS and China.

Noranda's 63,000 t/y Magnola magnesium plant in Danville, Quebec, that started to produce metal in September 2000, continues to struggle. The plant is having major problems in getting all the cells operating at full capacity. At the end of 2000, there were 10 cells of a total of 24 running. At the end of 2001, there were 16 cells running. However, the cells are still not able to be run at full current design input because of problems producing sufficient high-quality anhydrous magnesium chloride. Cells that were designed for 180,000 amps are running below that number. It was reported at the end of 2001 that there were 16 cells running at 65% capacity.

The plant cost was reported to have escalated from the initial C\$720 million to over C\$920 million with the latest modifications being allowed for. The plant uses the latest Alcan EX2 electrolytic cells that are producing good quality magnesium in spite of being operated under non-ideal conditions. Total plant production in 2001 was about 10,000 t.

There was pressure on the pricing of magnesium due to increased quantities of Chinese magnesium being available in Western markets including Europe and North America. Magnesium shipments from China and from the CIS have reached approximately 43% of all shipments of magnesium. The Western world 2001 year-end inventory was down slightly to 45,180 t (representing 45-days supply). Inventory data do not include PRC/CIS stocks, stocks of secondary ingot or stocks of scrap.

The US International Trade Commission (ITC) established the following antidumping duties

Table 1. Representative Magnesium Prices in 2001 (Pure Mg-98%+)

Period covered	US Western US\$/lb	Eur Free Mkt US\$/t	Met Bull Free Mkt US\$/t	Chinese Free Mkt US\$/t
1st Quarter end	1.21 - 1.30	1,800 - 2,300	1,800 - 2,000	1,250 - 1,390
2nd Quarter end	1.22 - 1.29	1,700 - 1,900	1,750 - 1,900	1,260 - 1,280
3rd Quarter end	1.21 - 1.28	1,700 - 1,900	1,700 - 1,800	1,250 - 1,260
4th Quarter end	1.21 - 1.28	1,700 - 1,900	1,775 - 1,875	1,230 - 1,250

Table source: USGS

for pure magnesium: 1) China (24.67% to 305.56% *ad valorem*, depending on exporter); 2) Israel 0%; 3) Russia, 0%. The latest determination on Chinese magnesium included a decision that pure granular magnesium would be included.

Prices

Representative magnesium price ranges for the year 2001 are shown. *Metal Bulletin*, has tracked magnesium prices by quarters for many years. MB started tracking the Chinese free market price in the third quarter of 1999 and it has dropped every quarter since the first report.

The overall prices of magnesium continued to drop during 2001 as they did during 2000. Exports from China continued to be priced at very low prices. The antidumping duty in Europe of 63.4% *ad valorem* slowed down some of the import of Chinese magnesium. The planned closure of the Pechiney magnesium plant in Marginac, France and the Norsk Hydro plant at Porsgrunn, Norway, will leave the European Union and Europe itself with no magnesium production. It is anticipated that the antidumping duties and controls against pure magnesium from China and CIS will be dropped in 2002.

Magnesium Production

Total magnesium production experienced a decrease for the first time in over seven years. The total drop in production was nearly 7%.

Statistics on magnesium production in major market areas are basically gathered from Western producers and, in some cases, primary and secondary magnesium are lumped together. Since the methods have been the same for many years, there are good

industry trends that can be identified through the use of these numbers. In the gathering of Western statistics by the International Magnesium Association, the magnesium that is recycled is not being reported in the production numbers as it was for many years. Not to confuse the big picture by showing some drastically changed numbers, recycled magnesium from companies such as Norsk Hydro, remain in Table 2.

Table 2. Magnesium Production (Mt)

COUNTRY	1997	1998	1999	2000	2001
US (2)	140	117*	85	74 ^e	43
Brazil (1)	9	9	7	9	9
Canada (3)	54	57	54	55 ^e	65 ^e
PR of China(85 ^e)	92	120	157	195	195 ^e
France (1)	16	15	17	17	7
Israel (1)	7	25	25	25 ^e	30
Kazakhstan (1)	15 ^r	15 ^r	15	10 ^e	10
Norway(1)	52	49	52	50 ^e	35
Russia (2)	51 ^r	53 ^r	56 ^e	40 ^e	50
Ukraine (2)	7 ^r	6 ^r	6 ^e	2 ^e	2 ^e
Serbia (1)	3	3	1 ^e	2 ^e	2 ^e
India (1)	1	1.5	1	0.5	0.5
Total	447	470.5	476	479.5	448.5

Source: USGS, IMA, CMA. Author Estimates

^e estimate; ^r revision

Magnesium Consumption and Use

Magnesium consumption decreased also in 2001. The total usage was down by nearly 10% according to a review of the major market usage (shown in Table 3). This was the first decrease in five consecutive years of increases. The largest major area affected was the use of magnesium for aluminum

alloying and magnesium for die-casting usage. Desulphurisation was affected, but that use has experienced major fluctuations over the past five years.

NORTH AMERICA US

Magnesium production in the US decreased again in 2001 to an estimated 43,000 t. Northwest Alloys (Alcoa) closed its 45,000 t/y magnesium plant at Addy, Washington in October 2001. High production costs and unfavourable market conditions were cited as the reason for closing the plant.

Magnesium Corp. of America (Magcorp) installed some new electrolytic cells which started up in April 2001. Production was cut back during the replacement of the old cells in Building One (of four). The MagCorp research group developed the cells. The company has also continued to run its T-Bar caster in order to produce both T-Bars and round billets.

Xstrata AG, the Swiss-based diversified natural resource group, started up its new recycling plant in Anderson, Indiana in Oct 2001. The plant is operating one line of a planned two-line, 25,000 t/y facility which will initially recycle Class 1 die-casting scrap.

Spectrulite continues to operate both recycling operations and fabricating operations at its plant in Madison, Illinois. It produces extruded products and rolled sheet and plate. Sheet continues to be supplied to the Japanese who are making stamped cases for the Sony Walkman. Spectrulite is supplying rolled AZ31 sheet that is approximately 2 mm thick. Sony is using a hot press forging method to produce the small cases. The production lines are being automated and the number of parts that can be made in one hour is very large. By carefully controlled design of the press forging process, The average thickness of the parts has been reduced to 0.6-0.7 mm, with some parts as thin as 0.4 mm. The strengths of these parts are also superior to those of similar die-cast parts.

Spectrulite is also supplying rolled magnesium materials to the automotive industry for testing programmes to develop fabricated magnesium parts for automobiles. Spectrulite is also supplying magnesium plate for other rolling mills in the world to use for rolling experiments on either aluminum or steel rolling mills.

In 2001, recycled magnesium alloy produced by Spectrulite Consortium, Inc. was approved for use in automotive applications. The company said that its class 1 scrap-derived

Table 3. Major Markets (Mt)

Market Segment	1997	1998	1999	2000	2001
Aluminum Alloying	146,100	154,400	159,800	165,100	142,810
Die Casting	95,300	110,100	133,400	154,700*	150,000*
Desulphurisation	47,950	48,200	41,700	51,600	41,940
Sub Totals	289,350	312,700	334,900	371,400	334,750
Minor Markets:					
Electrochemical	8,900	10,000	11,200	7,500	7,500
Chemical Uses	6,700	6,800	5,200	6,000	6,000
Metal Reduction	5,600	4,900	2,400	3,600	3,400
Gravity Casting	2,100	2,600	2,000	2,200	(with other)
Wrought Products	3,900	4,500	4,100	3,400	3,200
Nodular Iron	11,300	11,750	8,900	8,800	8,400
Other Uses	6,350	7,500	6,800	8,000	10,400
Sub Totals	44,850	47,550	40,600	39,500	38,900
Totals	334,200	360,250	375,500	410,900	373,650

*Includes estimated recycled magnesium usage

alloys - AM60B, AM50A, and AZ91D - were approved by GM and Daimler Chrysler.

Garfield Alloys, MagReTech, Halaco and Remag of Alabama continue to operate independent magnesium recycling operations. However, more and more recycling of class 1 die-casting scrap is being done at the die-casting plants by the die-casting companies.

Remacor, a pioneer in development of mixtures and technology for the desulphurisation of iron and steel with magnesium powder, was forced into Chapter 11 bankruptcy. Rossborough, another pioneer desulphurisation company, purchased the assets of the company and formed a new company called Rossborough-Remacor llc. The company experienced an explosion in December 2001 at its magnesium grinding plant in Indiana. There were no injuries.

Canada

Norsk Hydro is the major magnesium metal producer in Canada, using magnesite imported from China to produce approximately 43,000 t/y of primary magnesium by a special proprietary process in Quebec. The plant also operates a 10,000 t/y recycling facility. When Norsk Hydro closes down its Norwegian plant, it will increase the production by 10% at its 45,000 t/y plant in Canada by debottlenecking.

The Noranda Magnola 63,000 t/y magnesium production at Danville, Quebec, started to produce magnesium in September 2000. At the end of the year, 16 of 24 -180,000 amp electrolytic cells of Alcan design were running at 65% of capacity. In 2001, the plant produced 10,000 t.

Timminco continues to operate the 7,000 t/y silicothermic (Pidgeon) process plant at Haley, Ontario and a magnesium extrusion plant in Aurora, Colorado. The company has had some financial problems and entered into a forbearance agreement with its principal lender, the Bank of Nova Scotia, in Dec 2001. Under this agreement, the bank will not

enforce its rights arising from defaults in the loan agreement while Timminco pursues alternatives to maximise shareholder value, which may include a direct investment, strategic alliance, refinancing or a sale of all or a part of its operation.

Magnesium Alloy Corp. continues to work to get funding in place for the Kouilou Magnesium project located in the Republic of Congo. An agreement was put in place with Amphora Group Holding, Luxembourg, for arranging funding for the project. This agreement was never fully implemented and then it was dropped.

Globex Mining has sponsored a scoping study by Hatch Associates that indicates that construction of a mine and mill to process a magnesite-talc ore and a 90,000 t/y magnesium plant would be economically feasible. The project plans include a mine-mill complex near Timmins, Ontario, Canada, and a smelter complex west of Rouyn-Noranda, Quebec. The entire complex would require C\$966 million.

Hatch conducted test work on a magnesium silicate material from Leader Mining International Inc.'s Cogburn magnesium project located near Hope, British Columbia. It was concluded that the magnesium silicate mineral could be efficiently leached to a pure magnesium chloride brine suitable for subsequent dehydration and fused salt electrolysis to magnesium metal.

SOUTH AMERICA

Brasmag has continued to run the silicothermic plant at Bocaiuva. The plant is estimated to have produced 9,000 t in 2001. The plant uses a special modified silicothermic (Bolzano) process developed by Ravelli.

EUROPE AND THE MIDDLE EAST

Norsk Hydro announced that it would close the primary magnesium production plant in Porsgrunn by April 2002. The plant has a capacity of 50,000 t/y, including recycled metal. Only the primary production will be shut

down. Both the recycling and the melting and casting operations will be kept in operation, melting scrap or raw metal from other sources.

Feasibility studies on the Dutch Antheus Magnesium project and the potential economic and technical viability analysis for an integrated magnesium complex at Delfzijl in northeast Netherlands have been completed. The company has issued requests for proposals for a 15,000 t/y primary magnesium plant, a die-casting plant, and a recycling facility to several major engineering companies. Feed would be magnesium chloride from brine deposits at the location of the present Nedmag brine mining facilities. Discussions with potential partners and investors were continuing at the end of 2001.

Pechiney ceased production of magnesium metal at its Magnetherm process plant in Marignac, France in 2001. The company has plans to keep the melting and casting operation open to recycle magnesium scrap and raw magnesium metal from other sources.

Iceland magnesium production remains on hold. Australian Magnesium Investments holds a 40% stake in the Icelandic Magnesium project.

The Serbian magnesium producer, Bela Sterna operates a Magnetherm process and is estimated to have produced 3,000 t in 2001.

Thyssen Krupp Stahl AG, the large German steel producer, has founded Magnesium Flat Product Ltd at Freiberg in Saxony. The company will develop a new technology to produce magnesium sheets together with the Technical University of Freiberg. It was also reported that Salzgitte has founded Salzgitte Magnesium Corp. with the aim to develop magnesium coil technology to produce flat sheets from magnesium metal. Thyssen Krupp has also contracted with Pima Mining for the entire production of the planned 65,000 t/y SAMAG magnesium smelter at Port Pirie in South Australia.

Dead Sea Magnesium (DSM), the Israeli-owned company continued with reorganisation in 2001 and production was increased to 34,000 t/y. Volkswagen of Germany continues to own 35%. The company has been losing money since it started up in 1996. Whilst losses are continuing, they may be lessened by the decision by the US Commerce Dept not to apply additional antidumping and countervailing duties against shipments of pure magnesium to the US. Last year, DSM sold US\$14.7 million in the US, one of its largest markets. In the first half of 2001, DSM posted a net loss of US\$13.8 million on sales of US\$34.7 million, but it is hoped that that will improve. DSM is making plans to cut its production costs by using natural gas in place of oil. It estimates that it can save 20-23% on its energy bill. The changeover will take place in 2004-2005.

Company officials feel that there will be a drop in world magnesium production capacity due to plant closings. They hope to see an increase in price in late 2002 and DSM is currently producing 34,000 t/y of which half is alloy. DSM has focused on alloy, and its research group, MRI, has developed four new alloys in the past few years. The most sophisticated is the latest, MRI 153, which can be used in the production of auto engines because of its ability to withstand high temperatures. It was reported that several major auto-parts makers were currently testing the new alloy. Sales of the MRI 153 alloy are expected to begin in 2003.

Magnesium Elektron Ltd (MEL) started up its new 7,000 t/y magnesium recycling plant in the Czech Republic, northwest of Prague. The plant will toll melt magnesium scrap for customers across Europe, but primarily Germany. The capacity will be increased to 10,000 t/y in 2002.

Solikamsk Magnesium Works (SMZ) in Russia is a large magnesium producer with a 20,000 t/y plant. However, the company continues to attract controversy about its

management and plans for expansion are still on hold. The company experienced a sharp increase in energy prices from the State power supplier, Unified Energy Systems. Additional tariffs implemented in July 10, 2001 resulted in a 32% increase in Solikamsk's electricity costs.

Avisma has said that it would abandon plans to develop its magnesium production process using carnallite made from Siberian brucite ore. The plant was hit by 65% increases in electricity costs. Avisma produces over 30,000 t/y of magnesium, but more than half is magnesium that is recycled and re-used to produce titanium.

A new company was formed to run the Kalush Potassium and Magnesium works in the Ukraine. The new company, Magnii llc is owned by Oriana (25%) and ESKO-Pivnich (75%). When the plant is upgraded and made operational the capacity will be 17,000 t/y of magnesium.

ASIA

Australia

There were nine magnesium projects in some form of study or development at the start of 2001. By the end of the year, there were five projects still being discussed and worked on. Of these, Australian Magnesium Corp. has received its financing and is starting design and construction. Pima Mining is reported to be quite close to securing its financing.

Australian Magnesium Corp. has received A\$1.4 billion funding and has started on engineering and design of the 97,000 t/y primary production to be built at Stanwell, near Gladstone in Queensland. The plant will use the Australian Magnesium (AM) process technology to produce magnesium metal. Originally sponsored by Queensland Metals and CSIRO, the AM process has been developed and patented in a number of countries. The plant will start producing commercial magnesium in 2005.

Pima Mining NL has moved ahead on its SAMAG project that plans to build a 65,000 t/y primary magnesium plant in Port Pirie, South Australia. It has an environmental impact statement presented for approval and is completing a bankable feasibility study. The South Australian Government has committed A\$25 million for infrastructure improvements. Pima is continuing to talk with the Australian Federal Government about additional development funds. SAMAG will use the well-proven Dow Magnesium production process.

The bankable feasibility study will be finalised in April 2002 and financing arrangements for building the project are expected to be in place by the end of 2002.

Golden Triangle Resources NL has changed its name to Pacific Magnesium and continues to develop a magnesium process for the serpentinite tailings at the abandoned Woodsreef mine in New South Wales. This is

Table 4. Australian Magnesium Projects end of 2001

Location	Company/Project	Capacity (t)	Operating Cost	Capital Cost	Status
Tasmania	INDCOR formerly Crest	flexible	US\$0.55	US\$3.60 -US\$4.45/lb	Shelved- no partner found
New South Wales	PacificMagnesium Golden Triangle	80,000	US\$0.57	US\$423 million	Looking for development help
Queensland	Australian Mag	90,000	US\$0.66	US\$520 million	Engineering & Design started
South Australia	Pima/SAMAG	65,000	US\$0.52	US\$2.50/lb Mg Production	Bankable study under way
Northern Territory	Batchelor/Mt Grace	12,000	US\$0.70	US\$120 million	Feasibility end of 2001

a serpentinite tailings resource that could supply 80,000 t/y of magnesium production for more than 50 years.

Mt Grace Resources NL is working towards becoming Australia's first thermal magnesium producer. An initial feasibility study has concluded that the optimum size for the initial stage of the project is a 14 MW furnace with projected annual production capacity of 12,500 t of magnesium metal. The estimated direct capital cost of the project including mining infrastructure, calciner, furnace, condenser and other ancillaries is A\$76 million. The company has received all tender documents for the bankable feasibility study on its magnesium project at Batchelor in the Northern Territory. Mt Grace has licensed silicothermic DC arc furnace magnesium reduction technology, pioneered by the South African metallurgical group Mintek. The latter is presently operating a 1.5 MW demonstration furnace for the project in Johannesburg. Mt Grace has now received a number of magnesium ingots produced from the output of the Mintek demonstration furnace. These are being made available to potential off takers.

Crest Magnesium, which had changed its name to INDCOR, did not find a partner for its Tasmanian magnesium project. It has forfeited its licence agreements for the VAMI-UTI magnesium processes.

Anaconda Nickel has had a total company reorganisation and has dropped plans to work on a magnesium production operation.

The early 1970 project to produce magnesium from fly ash at several Victoria power generation sites, has again come to life. In November 2001, shareholders in Rambora Technologies Ltd approved a placement to assist it in the financing of an investment of A\$1 million over the next six months to complete the pre-feasibility study, earning the company a 15% interest in the project.

Rambora Technologies, Hazelwood Power and Magnesium Investments Pty Ltd, have signed a joint venture agreement, with the aim of developing an A\$800 million magnesium project in the Latrobe Valley, Victoria. The partners are undertaking a pre-feasibility study of the project, which could eventually see the creation of hundreds of jobs in the Latrobe Valley and significantly improve the environment in the area through a reduction in greenhouse gas emissions. The partners have commenced discussions with the Victorian Government with a view to obtaining its support. The project involves the extraction and production of magnesium metal from brown coal fly ash produced in the generation of power from coal deposits in the Latrobe Valley, with the first deposit located adjacent to the Hazelwood power station. Initial magnesium extraction tests utilised a standard acid leach process, followed by purification of the magnesium chloride solution. It is anticipated that this process will be followed by dehydration to anhydrous magnesium chloride and standard electrolysis utilising established Alcan cell technology to produce magnesium metal.

India

Southern Magnesium and Chemical, with a 1,000 t/y capacity silicothermic plant in Hyderabad is the only producer. India has requirements of about 1,000 t/y of magnesium and some of that demand is being filled by imported Chinese magnesium.

China

The Chinese Magnesium Association (CMA) was formed several years ago to help develop the total magnesium industry in China. An international magnesium forum was sponsored by the Chinese Non-Ferrous Metals Industry Association in Nov 2001. Mr Wu Xiuming, president of the CMA, told the meeting that China has a 40% share of the world magnesium market, but is far from being a magnesium 'Power'. He cited the need to work hard to stay abreast with international advanced levels for both production technique and process

and equipment. Mr Wu explained that China gave a high concern and great support to the magnesium industry. He said, "China magnesium enterprises will be advancing the traditional industry into high-technology by innovating their administrative and operation systems. They will seek for co-operation with foreign counterparts and new technology." Mr Wu outlined the many programmes that are being developed to help the industry in various areas such as alloy and special product development, and the study of casting equipment, etc. China magnesium industry experts predict that there will be relatively rapid development in the next five years, although this will be impacted to some extent by global economics.

Table 5. Chinese Magnesium Production and Exports ('000 t)

Year	1997	1998	1999	2000	2001 ^e
Output	92	120	157	195	195
Exports	78	100	137	166	173

Chinese Magnesium Association.

^e estimated

China continued to lead the world in magnesium production and exports. Production was similar to in 2001 and exports also increased slightly. Major production is by the labour-intensive Pidgeon thermal production process that uses ferrosilicon as a reducing agent. There are many small plants in many areas, but the largest magnesium producing province is Shanxi followed by Ningxia and Hebei.

In 2001, China produced about 195,000 t of magnesium and exported a total of 173,400 t of magnesium in all forms. The estimated production capacity is 250,000 t and plant expansions are being regularly announced. Magnesium industry growth in China has averaged 40% per year for the seven year period 1994-2001.

Magnesium Uses

The interest in magnesium usage in the global auto industry continues to increase. While die-casting remains the main area, both magnesium sheet and magnesium extrusions are attracting research and development attention.

Table 6. Export Categories of Products from China ('000 t)

	1998	1999	2000	2001 ^e
Unwrought Mg (Mg 99.8%)	73.7	91.6	98.0	94.1
Other unwrought Mg (alloy)	11.4	17.4	18.4	25.2
Mg Scraps	0.8	1.6	3.6	5.0e
Filings, turnings, granules, powder	11.2	24.5	41.3	43.2
Wrought Mg	2.6	1.7	4.7	6.0 e
Mg products	0.2	0.3	0.5	0.8e
TOTAL	100	137.1	166.5	173.4

Source: Chinese Magnesium Association.

^e estimated

Ford has new applications for magnesium in its automobiles. The company is planning to introduce magnesium valve covers on its 5.4-litre Triton V-8 engines, which will come out in the second quarter of 2002. The engines will be used in standard-size and heavy-duty pickup trucks and in some Sport Utility Vehicles (SUV). Magnesium consumption for this application will use about 2,000 t/y. In addition, Ford is developing a magnesium frame for the liftgate for standard-size SUV. This frame will support inner and outer aluminum or plastic panels, with an estimated weight saving of 50% over the currently used steel assembly. Ford is also working to develop a front-end radiator support module made entirely of magnesium for use in Explorer SUV.

European automakers are becoming increasingly aware of magnesium advantages and have many excellent development programmes. A new study

estimates that European cars and light commercial vehicles use an average of 99.4 kg of aluminum and 1.25 kg of magnesium. By 2006, this is expected to grow to 125.9 kg and 1.74 kg respectively.

The total weight of magnesium castings produced in Germany increased from 15,346 t

in 1999 to 21,129 t in 2000, a 37.7% increase. In 2001, the total is approximately 25,000 Mt.

GM has developed a new family of creep-resistant magnesium alloys that may have the potential to replace aluminum and iron in some large powertrain components such as engine blocks and transmission cases.