MAGNESITE/MAGNESIA

By Brian Coope
Industrial Minerals Consultant

The year 2003 marked an important turnaround for the world's magnesia industry. After what seems like a decade or more of oversupply and low prices the market has finally entered a period of sustained tightness in supply and rising prices. Western producers will take heart from their reversal in fortunes, even if the tightness is largely a result of supply side issues (plant closures and production problems in China), and that price rises are due in part to rising costs (particularly energy and transportation) rather than any fundamental new growth in demand.

The main plant closures concerned the Harbison-Walker (ANH Refractories) plant in the US and the Cogema plant in Italy, which took a combined 200,000 t/y out of the top grade end of the market – equivalent to 17% of the DBM1 market (see below). The closure of Harbison-Walker's plant at Ludington, Michigan, is permanent and was enforced by the cessation of brine operations by Dow Chemical at Ludington from whence H-W had obtained its magnesium hydroxide raw material for over 60 years. Uncertainty remains over the permanence of the closure of Cogema's Priolo plant in Sicily but a combination of factors were held responsible – including high energy costs, technical problems with new equipment, and contamination problems associated with plant's proximity to Mount Etna.

China's magnesia production problems have much to do with power and fuel shortages and the rising cost of energy and transportation. The country's massive growth in industrial output – led by high energy-consuming industries such as steel, aluminium, other non-ferrous metals, cement, glass and ceramics – has put enormous strain on the energy supply system. Constraints to energy supply have also appeared as the Chinese Government places increasing restrictions on the use of low-quality coal – responsible for horrendous air pollution in many parts of the country. China's magnesite/magnesia producers have also been faced with major increases in transportation costs – both internal and external. With regard to the latter, ocean freight rates to the main consuming centres of Europe, North America and Japan have doubled in certain cases over the past year or so.

The major market for magnesia is the refractories industry, which manufactures furnace linings based on both the sintered and fused forms of magnesia – generally referred to as dead-burned magnesia (DBM) and electrofused magnesia (EFM) respectively. In turn, magnesia-based refractories are consumed primarily in steel where their role is to line steelmaking furnaces and ladles. World steel output has been on a more or less continuous upward path since the mid-1990s and reached a record 965 Mt in 2003. Yet magnesia consumption in refractories has remained fairly constant, as steelmakers have continued to reduce unit consumption – ie, less refractories per tonne of steel.

China's steel output more than doubled between 1997 and 2003 – from 109 Mt to 220 Mt – and now accounts for 23% of world production. Not surprisingly, China is now the world largest consumer of magnesia-based refractories and many Western refractories manufacturing groups, such as RHI, Shinagawa, Krosaki, and Orissa Industries, now operate plants in China.

Raw magnesite production

World production of magnesite (Table 1) was estimated to be of the order of 20 Mt in 2003 of which around 12.5 Mt – over 60% -- was produced in China and Russia. Over 98% of this raw ore production is converted to magnesia for commercial application. Around 75% of magnesia is used in refractory end uses – for lining furnaces used in the production of steel, non-ferrous metals, cement, glass, ceramics and petrochemicals etc. The remaining 25% is used in agriculture and a wide range of industrial applications ranging from insulation to environmental uses. At present only 0.4-0.5 Mt/y of raw magnesite is used as direct feed for conversion to nitrate (for fertiliser application) or to chloride (for the production of magnesium metal).

Magnesia capacity and output

Magnesia (magnesium oxide) is produced on a large scale both from magnesite and from magnesium hydroxide or chloride prepared from brines and seawater. Total magnesia production capacity (Table 2) is of the order of 8 Mt/y although in 2003 output was around 7.3 Mt, of which 6.5 Mt was obtained from natural magnesite and 0.8 Mt from seawater and brines.

New production from Jordan will appear in the 2004 figures as the new plant builds up towards full capacity of 50,000 t/y DBM and 10,000 t/y CCM. The Safi plant, which is operated by Jordan Magnesia, started commissioning in late 2003 and is based on magnesium chloride brines produced as a by-product of potash processing operations by its parent company, Arab Potash Co.

An approximate production breakdown of the three main magnesia types (Table 3) was 5.1 Mt (70%) DBM, 1.7 Mt (22%) CCM and 0.6 Mt (8%) electro-fused magnesia.

DBM1 and DBM2

DBM is obtained by high-temperature conversion (usually in the 1,500-1,800^{o}C range) of natural magnesite or magnesium hydroxide or, in the case of DBM1 grades, by high-temperature firing (in the 1,800-2,200^{o}C range) of calcined magnesia. DBM is used exclusively in refractories for the lining of furnaces used for the melting of steel, non-ferrous metals, and glass and in kilns for the manufacture of cement.

Production of high-purity, high-density grades – generally referred to as first-grade magnesias or DBM1 products – was around 780,000 t in 2003. About 36% of this production was derived from natural magnesite (in Turkey and Australia) and the remaining 64% from seawater/brine producers in Europe, North America and Asia. DBM1 products are used predominantly for magnesiagraphite (mag-carbon) bricks for use in steelmaking (to line oxygen converters, electric arcs and ladles) and for magnesia-spinel bricks used for lining rotary cement kilns.

The 3.5 Mt of second-grade DBM2 products was dominated by production from China (2.5 Mt) and Russia (0.55 Mt). Major Western producers include Austria, Slovakia, Greece, and Brazil. DBM2 products are used for the production of magnesia/chromite or 'mag-chrome' bricks (as used in linings for cement kilns and furnaces used in melting glass and non-ferrous metals) and for monolithic refractories (castables, mouldables, gunning mixes, maintenance materials, etc).

Caustic-calcined magnesia

CCM is obtained by low-temperature conversion (usually in the 700-1,000°C range) of natural magnesite or magnesium hydroxide from seawater and brines.

The bulk of CCM production (around 80%) is based on natural magnesite and destined largely for agricultural applications such as feedstuffs and fertilisers (involving grades in the 85-90% MgO range) or for bulk industrial applications such as construction and paper processing (involving grades in the 90-95% MgO range). Major producers of natural CCM are China, Greece, Spain, Austria, Slovakia, and Brazil. The Greek company, Grecian Magnesite, has strengthened its influence in this market and, in addition to wholly-owned operations in Greece and Turkey, is a also a major shareholder in operations in Spain (Magnesitas Navarras) and the US (Premier Chemicals).

The remaining 20% of CCM production based on seawater/brine includes both high (+99% MgO) and medium (+96% MgO) purities for specialised industrial applications ranging from chemicals, pharmaceuticals, anti-scorch agents in rubber, steel coating, and environmental uses. In the latter area, demand for CCM and magnesium hydroxide in water and effluent treatment has been a major growth area in recent years.

Electro-fused magnesia – EFM

In Western countries, electro-fused magnesia (EFM) is obtained by fusing CCM in an electric arc furnace at temperatures of 2,800-3,000°C. However, some Chinese EFM producers use natural magnesite as feed, which is less efficient in terms of energy consumption and product recovery, and yields a more variable, lower-quality product. Thus the more sophisticated Chinese EFM producers have adopted Western practices and use CCM as feed for EFM production. China now accounts for around 80% of total world EFM production.

The EFM market is divided into two distinct sectors – refractory and electrical. The refractory EFM market is now around 550,000 t/y worldwide and is served primarily by producers in China (Dashiqiao Shifo, Haicheng Pailou, Haicheng Huayu, Yingkou Dayi), Australia (QMag), Canada (Baymag) and Israel (Tateho Dead Sea). Applications are similar to DBM1 and, indeed, EFM and DBM1 products are often blended in mag-carbon brick formulations.

Meanwhile, the electrical EFM market, where fused magnesia is used as an insulating material in heating elements for electrical goods – kettles, immersion heaters, cookers, grills, irons, etc – is of the order of 60,000 t/y worldwide. The world's major producer is the UCM Group with existing production in the UK, US and China, and future production in Greece. Other producers include Tateho Chemical in Japan and Minco in the US.

China

China is estimated to have produced around 3.8 Mt of magnesia products in 2003 from over 10 Mt of raw magnesite ore. An approximate breakdown by type would be 2.5 Mt DBM, 800,000 t CCM and 500,000 t EFM. The five major producers of DBM and CCM are Yingkou Qinghua, Haicheng Huayu (Huaziyu), Haicheng Pailou, Haicheng Houying, and Haicheng Xiyang, with a combined output approaching 1.5 Mt/y DBM and 500,000 t/y CCM. The once-dominant Liaoning Magnesite Corp now concentrates on the production of high-grade double-burned DBM and fused magnesia. A large number of medium- and small-sized companies make up the remainder of production.

Chinese exports of magnesia have totalled around 2 Mt/y in recent years of which 50% is DBM, 33% CCM and 17% EFM. Around 80% of these exports are destined for consumption in Europe, North America and Japan. In 2003, the imports of Chinese magnesia of all types to these regions totalled 700,000 t in Europe, 450,000 t in North America and 530,000 t in Japan.

Magnesite for magnesium metal

Until now the amount of raw magnesite consumed in magnesium metal manufacture has been limited to the 150,000-200,000 t/y requirement to feed Norsk Hydro's Becancour plant in Quebec, Canada. This plant has operated for the past 14 years using high-purity natural magnesite from China although both Australia and Spain have supplied significant tonnages for trial in recent years.

Australia had been expected to be host to two new plants producing magnesium metal from magnesite but the first project (at Stanwell in Queensland) was terminated in 2003 and the second (at Port Pirie in South Australia) has transmogrified into a Middle East project. Construction of Australian Magnesium Corp (AMC)'s Stanwell project in Queensland was halted early in 2003 as a major hole appeared in financing arrangements and the company is reorganising in order to commercialise the saleable parts of its technologies and to maintain the Qmag magnesia business as a viable concern.

AMC's problems impacted unfavourably on Magnesium International Ltd's Samag project in South Australia since it occurred at a delicate stage in its money-raising process. Despite a number of clear attributes – lower capital costs, tried and trusted technology, and a robust offtake agreement with Thyssen-Krupp – the climate for raising money for magnesium projects in Australia had taken a battering. Other factors such as exchange rates and higher electricity costs were also reducing the appeal of a South Australian and the company has since turned its attention to a Middle East location

(Egypt, Abu Dhabi or Qatar) where costs – and particularly energy costs – can be reduced to give any new project a leading edge. It may well be that Australian magnesite would be used to launch the project although a more local source would be more likely in the long run.

Prices

Prices (Table 4) have risen continuously since early 2003 and for some grades are now 50% higher than a year ago. As suggested above, some of the reasons for these rises involve increased energy and transportation costs and thus the higher levels may become the norm.

Table I: World production of natural magnesite ('000 t)

	2001	2002	2003
Australia	605	485	473
Austria	700	550	550
Brazil	1,100	1,000	1,000
Canada	200	200	200
China	10,000	10,000	10,000
Greece	500	450	450
India	360	280	280
North Korea	650	450	450
Russia	2,600	2,600	2,600
Serbia	36	36	36
Slovakia	1,000	1,000	1,000
Spain	500	500	500
Turkey	2,000	2,000	2,000
Others*	200	200	200
World total	**20,451**	**19,751**	**19,739**

Source: USGS, BGS and author's estimates

* Inc the US, Colombia, South Africa, Zimbabwe, Poland, Pakistan and Iran

Table 2; World magnesia production capacity 2003		
Natural – from natural magnesite		
Country	**Magnesia '000 t/y**	**Companies**
Australia	200	QMag
Austria	300	Radex, Styromag
Brazil	350	Magnesita
Canada	120	Baymag
China	3,800	Houying, Huayu, Xiyang, Pailou
Greece	180	Grecian Magnesite
India	80	Dalmia, Burn Std, Tanmag, Almora
North Korea	200	Korea Magnesia Clinker
Russia	800	Magnezit Satka
Slovakia	375	Slovmag Lubenik, SMZ Jelsava,
Spain	270	Mag Navarras, Mag Rubian
Turkey	350	Kumas, Manyezit, Comag
Others*	110	inc US, Iran, Poland, S Africa
Total Natural	7,135	
Synthetic – from seawater and brines		
UK	20	CJC Chemicals
Ireland	90	Premier Periclase
Netherlands	160	Nedmag
Italy	70	Cogema (idle)
Israel	90	Dead Sea Periclase
Jordan	60	Jordan Magnesia
US	250	M Marietta, Premier Chemicals
Mexico	90	Quimica del Rey
Japan	100	Ube
S Korea	40	POSREC
Total Synthetic	970	
Total Natural	7,135	
Total Synthetic	970	
Total Magnesia	8,105	

Table 3: World magnesia production by type 2003 ('000 t)

	Natural	**Synthetic**	**Total**
DBM1	280	500	780
DBM2	4,300	--	4,300
CCM	1,500	240	1,740
EFM	560	40	600
	6,640	**780**	**7,420**

Table 4: World magnesia prices (US$/t cif Europe)

		May 2003	May 2004
Dead-burned	First grade DBM1	225-250	280-400
	Chinese 94-95% MgO	130-145	185-240
	Chinese 90-92% MgO	105-115	160-185
Caustic	Industrial	180-240	200-300
	Agricultural	110-130	160-180
Electrofused	EFM1 (Australia, Canada)	550-750	650-850
	Chinese 97-98	350-400	450-550
	Chinese 95-96	300-350	350-450

Source: *Industrial Minerals* and author's estimates