Commodity profile

MAGNESIUM

Magnesium, chemical symbol Mg, is the eighth commonest element in the Earth's crust. As a constituent of many rock-forming minerals it makes up, on average, about 2% by weight of igneous rocks and about 0.13% of seawater. By far the greater part of the industrial use of magnesium is in the form of magnesium oxides, which are used as refractory products such as furnace linings, crucibles and shapes. Magnesium metal is relatively soft, silvery-white in colour, and is the lightest of the metals in general structural use. It is used where weight-saving is at a premium and is normally either a constituent of aluminium alloys or a competitor with aluminium and non-metallic materials.

Deposits

For the most of the second half of the twentieth century, seawater provided almost 50% of the magnesium produced in the western world and it remains a major source of magnesium oxide in many countries. However, with the closure of the US seawater magnesium plant in 1998, and the increase in output from China, production of metal is now dominated by mineral sources. These are dolomite rock, which accounts for 47% of world output, magnesite rock (18%) and carnallite (13%); brines from saline lakes and seawater provide the balance (22%).

Dolomite (calcium-magnesium carbonate $CaCO_3.MgCO_3$) is the raw material for the majority of the magnesium plants in China and is also used in Canada, Brazil and Yugoslavia *(Serbia).* **Carnallite** (potassium magnesium chloride, $KCl.MgCl_2.6H_2O$) has long been the major source of magnesium in the states of the former Soviet Union and is also significant in China. Carnallite is normally delivered as brine produced by the solution-mining of the solid carnallite deposits. **Lake brines**, which supply operations based on the Great Salt Lake, Utah, USA and the Dead Sea, Israel, are also used for their magnesium chloride content. **Magnesite** (magnesium carbonate, $MgCO_3$) normally occurs in association either with dolomite or with altered ultramafic igneous rocks. It is fairly widespread but high-purity deposits of adequate size are uncommon. It may become a more important source with the commissioning of new magnesium producers in Australia. **Serpentine** (a group of hydrated magnesium silicates) may become a significant source in the near future, with production based on asbestos mine waste. **Brucite**, (magnesium hydroxide, $Mg(OH)_2$) has been used as a source of magnesium in the past and is being tested as a future source in Russia. **Bischofite** ($MgCl_2.6H_2O$) may be used in future in Ukraine.

Extraction

Magnesium metal is produced by variations of two fundamental processes, thermic and electrolytic.

Dolomite is normally treated by the thermic method: this consists of reducing magnesium oxide, produced by calcining the dolomite raw material, with ferrosilicon to produce metallic magnesium and a calcium iron silicate slag. In the 'Magnetherm ' variation of the process an electric furnace is used and alumina is added to the charge to produce a liquid calcium aluminium silicate slag. This process was used in France, Yugoslavia and a recently-closed plant in USA. The 'Pidgeon' process uses an externally-heated vacuum retort. It is the dominant method used in China. A development of the early 'Bolzano' process, which uses an internally heated vacuum furnace, is used by the Brazilian producer.

The electrolytic process is used to treat magnesite, serpentine, seawater magnesia and brines from both carnallite and lake waters. Magnesite and magnesia have first to be converted to magnesium chloride by treatment with hydrochloric acid. The magnesium chloride is dehydrated to produce an anhydrous magnesium chloride, which is the electrolyte in the cells. Cells vary in design but almost all variants have carbon anodes and steel cathodes with collection compartments for the magnesium metal which, being lighter than the electrolyte, tends to rise gradually as it is deposited.

Specifications and uses

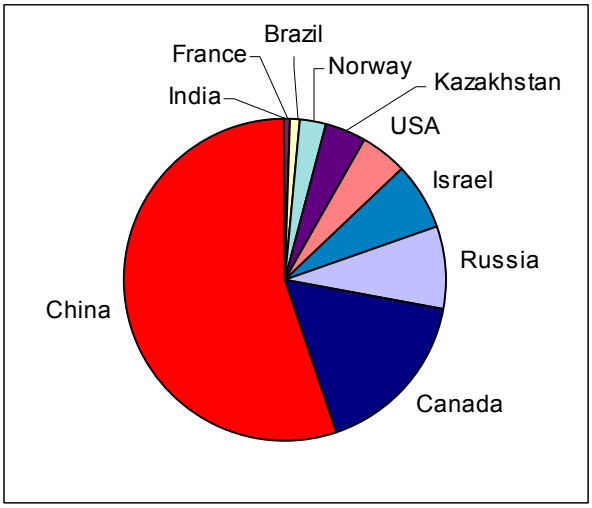
Pure magnesium is generally specified as a minimum of 99.8% Mg and this is the basis for spot market pricing. However several producers are able to provide a higher-grade material that is favoured for the die-casting industry. According to figures published by the International Magnesium Association the end-use of magnesium in terms of shipments in 2002 were: aluminium alloys 40% of the total, die casting 35%, steel desulphurisation 16% and other uses (sacrificial anodes, metallurgical processing

etc.) 9%. The most widely used aluminium alloys contain some magnesium, typically between 0.1% and 5% magnesium by weight. The most notable feature of magnesium usage has been the rapid increase in use for die casting which has increased by 50% since 1995. It is highest in North America (33% of total use), lower in Western Europe (29%) and least in Asia/Oceania (25%). The cause is a significant increase in magnesium use by car-makers, with the object of saving weight, in parts such as transmission housings, seat frames, instrument panels, steering wheels and many other frames and housings. Other uses are in the aerospace industry, sports goods and power tools.

Production, trade and prices

World production of primary magnesium was around 419,000 tonnes in 2002. China, Canada and Russia accounted for over three-quarters of total 2002 production. The major producers are also the main exporters with the notable exception of USA which has moved from being a net exporter in 1995 to become a major net importer (80 000 tonnes in 2003) raising US import reliance from around zero to 47% (US Geological Survey). The USGS also estimates that recycling of new and old scrap in the US was 75 000 tonnes. This is equivalent to about 65% of total apparent consumption and two-thirds was in the form of aluminium-base alloys.

Production of magnesium metal, 2002 (tonnes)



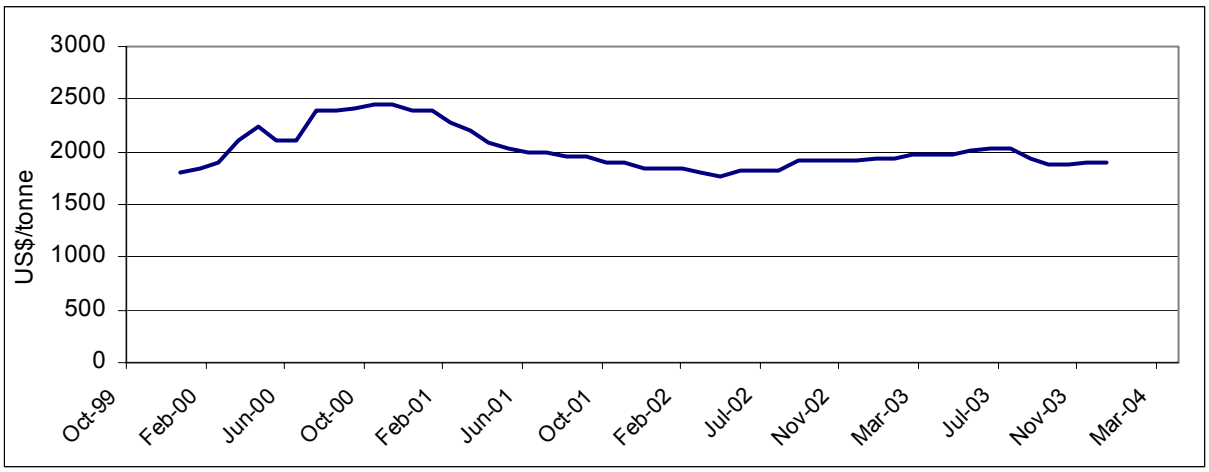
Source: World Mineral Statistics database, BGS

The magnesium production situation is dynamic at present. The last primary magnesium producer in western Europe closed in 2002. The expected continuation of increasing demand from the automotive industry could be met by the addition to world capacity of new plants that have been proposed in Australia, Iceland, Canada, Republic of Congo (Brazzaville) and the Netherlands. However, production in China has increased steadily from 18% of the world total in 1998 to 55% in 2002 and will probably continue to dominate world supply in the immediate future.

Prices

The European spot-market price of magnesium is published by Metal Bulletin as a range of prices, representing recent transactions for standard grades for uses such as desulphurisation and aluminium alloying. High-grade material, chiefly for die-casting, commands a considerable premium — between 25% and 50% — over standard grade. The two-year price history follows a peak, in Europe, of around $4 000/tonne in 1995. The magnesium price had been slowly rising since May 2002, before a generally falling price trend started in October 2003.

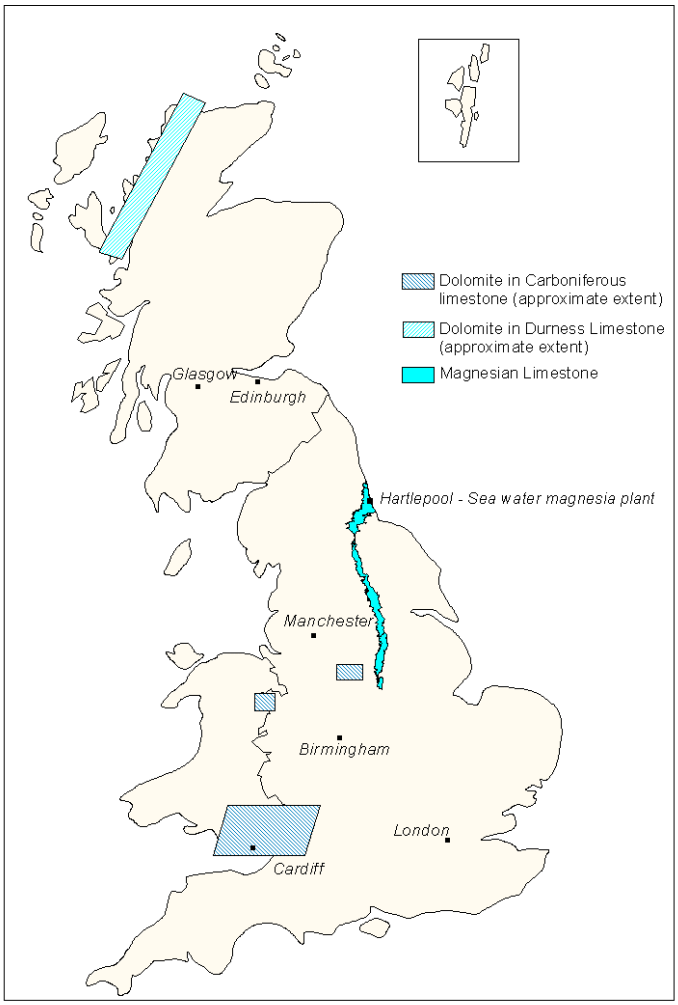
Magnesium prices European Free Market (Min. 99.8% Mg) May 1999– January 2004
(Metal Bulletin monthly averages)



The ratio of magnesium price to aluminium price has always been critical for the structural applications market for magnesium. Since 1995 this ratio has varied between 2.7 (late 1995) and 1.4 (April 2003). Demand for structural metal, especially in the motor vehicle market, is strongly price elastic and it is generally believed that for magnesium to be competitive with aluminium in this sector the price ratio for the primary metals must be no greater than 1.8.

Magnesium in Britain

Location of principal magnesium occurrences and refineries in Britain



Carnallite occurs in association with the evaporite sequence containing the Boulby Potash deposit in North Yorkshire, which is being mined at present. No carnallite has been commercially produced but a large carnallite resource lying offshore at Boulby is being investigated at present. Elsewhere around the southern margins of the North Sea, evaporites of Permian age have been important sources of both potassium and magnesium products, notably in Germany and the Netherlands.

Resources of dolomite are fairly widespread in Britain. Dolomitic limestone and marble of Cambrian age (Durness Limestone) occur in north-west Scotland and dolomitic limestones occur associated with the Carboniferous limestones of the Pennines and Mendips. The Magnesian Limestone (Permian) of north-east England is a significant resource of dolomitic limestone that is worked at present for its magnesium content, although not for metal production.

A sea-water magnesia plant is operated by Britmag Ltd. at Hartlepool, Co. Durham. Its raw materials are sea-water and dolomitic limestone from the Magnesian Limestone. These are reacted together to precipitate magnesium

hydroxide, which is then calcined to produce magnesia and magnesium hydroxide products for a number of markets.

Britain is a significant consumer of magnesium metal, chiefly in aluminium alloys. Apparent consumption averaged 9,560 tonnes/year for the five years 1996–00. Imports are chiefly as unwrought metal and alloys, and scrap.

There is no primary production of magnesium metal in the UK but Magnesium Elektron Ltd. process scrap and primary metal in Manchester to produce magnesium metal and alloys in a variety of forms. Capacity of the plant has recently been expanded from 5,000 tonnes/year to 11,400 tonnes/year. Since 1996 UK imports of scrap have increased from 3,089 tonnes to 11,385 tonnes/year in 2001. Concomitant exports of unwrought magnesium alloys have increased from 1,542 tonnes/year in 1996 to 11,879 tonnes/year in 2001.