

GYPSUM

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Although there are some other uses for gypsum, by far the greatest proportion is used in the construction industry in the production of plaster and plasterboard and as a setting retarder for Portland cement. These applications account for all but a few percent of world demand. Gypsum's use in cement is probably still the largest single application worldwide. However, in North America, Western Europe and Japan, there is a large consumption of plasterboard. The US consumes by far the most because of the prevalence of wood-frame construction with plasterboard panels in housing. The use of plasterboard has been spreading to other regions, but is still limited in many areas.

Gypsum and anhydrite are two naturally occurring forms of calcium sulphate but gypsum is by far the most important commercially. Gypsum is the hydrated form ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and anhydrite, the anhydrous form (CaSO_4). Gypsum is a monoclinic mineral, whereas anhydrite is orthorhombic. Crystals are commonly colourless, although the rocks generally appear white or grey. The hardness of gypsum on Moh's scale is 1.5-2 and it can be scratched easily with a fingernail. Anhydrite is about twice as hard at 3-3.5. Gypsum has a relative density of 2.3, considerably less dense than anhydrite, at 2.93.

Whereas anhydrite is more common, gypsum is of greater economic importance because of use in making plaster products. In addition, reserves of gypsum normally overlie associated anhydrite, making them closer to the surface and more amenable to open-pit mining. Anhydrite will rapidly convert to gypsum in regions where there is significant rainfall, although it does outcrop in arid regions. Calcium sulphate occurs less commonly as alabaster, a fine grained and compact variety; as selenite, found as large transparent euhedral crystals; and as satin spar, a fibrous variety with a silky lustre.

Gypsum is abundant in nature, and only the most accessible and highest quality deposits are exploited. There is much geological similarity between commercial deposits and the geology and extractive technology is relatively simple. Most deposits are mined by open pit, although there are many underground mines. Little or no processing is carried out beyond mining, crushing and grinding. Mines are located throughout the world and there are very few countries where there are no actual or potential commercial deposits. However, the major producing regions are the industrialised nations of North America, Western Europe, and the Far East. This is because gypsum is a low-cost commodity and, as such, production is only economical close to the main markets unless very cheap ocean transport is available.

Gypsum is also produced as a by-product from a number of industrial processes, eg, flue gas desulphurisation (FGD) at coal-fired power plants,

production of phosphate fertilisers, and titanium dioxide production using the sulphate route.

This should be borne in mind when referring to world production of gypsum as reported by the USGS, which reports actual mine production rather than total output from all sources. For example, an estimated 9.5 Mt of by-product gypsum was sold in the US last year. There are further quantities of by-product gypsum produced but not sold, either because of quality or because the gypsum is produced in regions where demand is insufficient to utilise all that is available. For Japan, the production quoted by the USGS is almost certainly all by-product material from various sources. The situation in the UK is similar to that in the US, where an even greater proportion of demand is satisfied by by-product gypsum, either from FGD units at coal-fired power stations or from titanium dioxide manufacturing plants. Product from these sources is likely at least to match the production of mined gypsum quoted in the table. In Germany an even greater proportion of demand is estimated to be supplied by material mainly from FGD, so much so that it no longer makes the list of the largest producers of mined gypsum and is included in the 'others' category. Consumption of gypsum has been as high as 5 Mt/y in Germany and it is probably still of that order of magnitude now.

If US sales of by-product gypsum are included, the world total for 2003 would be about 111 Mt, roughly the same as the estimates for 2002, although these were revised slightly upwards. There have been various revisions from estimates made for the 2002 figures. US sales were revised upwards from 23.8 Mt to just over 25 Mt. Production in a number of other countries was also revised upwards, including Iran, Canada, Thailand and Australia, but production in France was reduced by 1 Mt from previous estimates, possibly reflecting some increased use of by-product gypsum. French use of by-product gypsum has traditionally been looked on as rather small as it produces a far greater proportion of its electricity than many other countries from nuclear power, with less reliance on coal. However, it also has production of titanium dioxide via the sulphate route, which could supply by-product gypsum, and there are some coal-fired power plants that could be sources of gypsum to substitute for mined product.

Brazil, Uruguay and Austria were all added to the USGS list of leading producers and the level of production in the 'others' category was decreased significantly, by more than the aggregate from these additions. All of these amendments meant that total reported production for 2003 was about the same as in 2002. However the author estimates that total consumption of gypsum was probably of the order of at least 150 Mt and possibly as much as 160 Mt. The estimates show very little increase in production in China, but there is a construction boom in China, which is expected to have fuelled consumption. Some reports indicate that China accounted for as much as half the concrete poured in the world last year and it has a relatively small (given the huge population) but growing gypsum board consumption. Although some of its increased demand is met by imports, it is expected that there were also increases in production. China's production of cement alone could suggest a

requirement of 20-30 Mt/y of gypsum as a setting retarder, and world cement production would indicate a need for anything from 60-70 Mt/y of gypsum.

North America

In the US, production of mined gypsum last year amounted to an estimated 16 Mt, a significant decrease from the peak production levels of the 1990s. However, the usage of what is described as synthetic (by-product) gypsum has continued to increase to an estimated level of 9.5 Mt and it should be noted that this refers to amounts sold or used as there are substantial quantities produced but not used for various reasons. In addition to the domestic supply, the US imported a further 7.64 Mt of gypsum with only 165,000 t of exports. This resulted in total apparent consumption of almost 33 Mt. Of this, about 90% was used in the manufacture of plasterboard and plaster. Approximately 2.62 Mt was used as a cement retarder and 1 Mt as a soil conditioner. The US is unusual in that its use of gypsum wallboard is so high. This is due to building practices, particularly for homes where the main method of construction in many parts of the country is wood frame with wallboard panels.

Industry's estimated shipments of wallboard were 32.5 billion ft² (3 billion m²), higher than the 31.5 billion ft² estimated by the USGS, although the figure reported by the Gypsum Association as actual shipments was 31.72 billion ft². Whatever the figure, it was at record levels. The industry had previously peaked in 1999 then declined in 2000 and has risen steadily since then. Much of the demand has been fuelled by increases in new housing starts, which were reported at an annual rate of 1.89 million according to the US Bureau of Census. The remodelling market was also strong, but commercial construction was relatively weak reflecting poor demand for commercial construction.

Continuing excess capacity in the US wallboard industry is keeping a check on prices, which remained stable during 2003. Despite the excess capacity there is still extra capacity being planned. BPB is to build a 700 million ft² plant at Roxboro, North Carolina, based on by-product gypsum from a neighbouring power plant. National Gypsum is also planning to build a new plant, with a completion date in 2007. The company is investigating sites in both North and South Carolina, although it is expected that it will be somewhere near Charlotte, where the company has its headquarters. An agreement has been signed with Duke Power for by-product gypsum supply from their power plants in the region.

A new name emerged in the market during the year after Centex spun off its construction products division, which is now an independently quoted company with the new name of Eagle Materials Inc, although the wallboard operations will continue to operate under the name American Gypsum.

In Canada, production of gypsum amounted to an estimated 9 Mt in 2003, a modest increase over 2002. National Resources Canada reported shipments of 8.38 Mt although this does not include usage of by-product gypsum, which is estimated to be at least 0.5 Mt. It is notable that even a country such as

Canada, with large gypsum resources and significant exports, is using by-product gypsum. Environmental pressures to install FGD units at coal-fired power plants means that there is a greater supply available and the supply is often more conveniently located close to markets than the gypsum mines as the concentration of power plants is generally in areas of high population densities. A large portion of Canada's gypsum production is exported to the US, currently around 5 Mt/y, and largely from the Maritime provinces into East Coast US. However, these exports have been declining from over 6 Mt as recently as 2000. This is largely because US companies are replacing imports with by-product gypsum. Canadian domestic demand is currently strong, with wallboard production rising to 3.42 billion ft² in 2003, the pattern closely following that of the US, with high levels of housing starts. Canada is also a significant exporter of wallboard to the US, primarily to states bordering Canada.

Mexican production is closely linked to the strength of demand in the US. Like Canada it is a major exporter of gypsum to the US and also has increasing exports of wallboard from plants aimed at supplying southern US states. Exports of raw material are expected to decline in the face of competition from by-product gypsum in the US, and in 2003 sales fell by 16% to 6.3 Mt. By-product gypsum is also used in Mexico, at local wallboard plants.

Europe

Europe is dominated by three major players: BPB, Lafarge and Knauf, all of whom have diversified into other regions and are major players in world markets. BPB claims to have nearly 20% of the global market, which it estimates to be around 6 billion m², equivalent to about 1 m² per head of population. It sees considerable room for growth, with many markets far behind the US where consumption equates to about 10 m² per head of population. This represents roughly 50% of world demand for plasterboard but the US has less than 5% of the world population. Per capita consumption in Western Europe is less than in North America, and the market is seen as relatively mature, with only limited growth potential. However, with the inclusion of Eastern Europe, per capita consumption is about 3 m² and there is room for further growth.

Markets within Europe vary considerably from country to country. In 2003, there was strong demand for plasterboard in the UK and Spain, as well as in Eastern Europe, contrasting with continued poor demand in Germany and a slight decline in France. It should be remembered however, that in actual volume terms, the largest markets for plasterboard are still Germany, the UK and France, whereas consumption levels in Mediterranean and Eastern European countries are relatively low. This is because of different construction methods – wet plasters are often used in countries such as Spain or Italy, and even lime-based rather than gypsum-based plasters. Spain is the largest market for plaster, although the relatively low consumption of wallboard is growing rapidly. Greek consumption of plasterboard has also increased substantially, largely attributable to construction activity related to the Olympic Games. Continuing increased demand, often from a small base in Eastern Europe and the former Soviet

Union, encouraged BPB to start development of a new gypsum board plant at Turda in Romania, alongside its existing plaster plant, with a start-up date in 2005. This is designed to supply regional markets including Ukraine, where demand is growing particularly fast, but from a small base.

Lafarge, like BPB is now a global player. As recently as ten years ago, its gypsum and plasterboard production was almost exclusively European-based. Now, only 55% of the sales of the company's gypsum division are in Europe, with 19% in the US and 26% in the rest of the world, much of that in Asia, where it claims 31% of the market (excluding Japan) through its joint venture with Boral. However, it has not ignored Europe, and opened a new plant at Gacki in Poland during 2003.

Knauf has enlarged its production base to include the Americas and Asia, and has also developed considerable interests in Russia where it is now the largest producer. It accounts for about 70% of Russia's gypsum output through ownership of seven of the 18 largest producers. It also has operations in the Ukraine, Moldova and Kazakhstan, and plans to invest in Belarus.

All three major Europe-based producers were assessed by the European Commission as being liable to fines concerning "market stabilisation". These fines may have been paid in 2003, but the companies are appealing through the European Court of Justice. No decision is expected until at least early 2005.

Asia

This is probably the fastest-growing region for gypsum demand, fuelled largely by growth in China. Traditionally, Japan was the most developed market in Asia and it is still a significant producer of plasterboard, largely based on by-product sources, supplemented by imports from Australia and Thailand. However, in recent years there has been a surge in production in other countries such as China, Korea, India and Thailand. Thailand had originally been regarded as a source of raw material, but is increasingly becoming an important producer of wallboard, both for its own use and for export. Within the region, it is second only to China in its total production of gypsum.

The three major European producers of wallboard have been the drivers behind the development of wallboard capacity in Asia, together with Boral, the major Australian producer, which has increased its share in the Lafarge Boral Plasterboard JV to 50% from 47.7%.

Apart from continued strong demand growth in China, there have also been demand increases in Thailand, adding to its strong export performance. There has also been growth in Malaysia, where BPB is building a new plasterboard plant scheduled for completion in 2006. The Indian market is also strong with high levels of construction activity and increased penetration of gypsum and gypsum board into a market still dominated by traditional construction

methods. In India, BPB is building a new plant close to Mumbai as well as expanding its existing plaster production.

The Chinese market is estimated to be around 300 million m², and although the very high level of construction activity has boosted sales, consumption of plasterboard is still relatively low. There is considerable competition in the market as domestic producers have yet to reach capacity and there is also competition from imports, particularly from Thailand. Although many feel that the current rapid growth rates in China are unsustainable, long-term growth is still expected to be large compared with rates in Europe and North America. The use of gypsum board at the expense of traditional building methods seems set to grow and current per capita consumption is only about 0.23 m² (compared with a global average of 1 m² and the US figure of about 10 m²). It is unlikely that consumption in China will reach the same sort of levels as those in the US but it is not unreasonable to expect an increase in the long term to the world average. This would necessitate at least a four-fold increase in China's existing consumption of plasterboard.

Middle East

The situation in the Middle East is still very uncertain. Iran is a very large producer and consumer of gypsum because of its use in traditional building methods. Iraq was also a large user, and it is unlikely that the current production is anywhere near historic production levels. The market in Turkey has been growing, increased use of by-product gypsum being a contributory factor. Wallboard production capacity has been increasing, with the entry of foreign companies such as BPB into the market. Plaster sales have also been increasing, although the country traditionally uses wet lime plasters. In Egypt, state-owned National Cement Co has offered its gypsum operations for sale through a tender process, but the process was not complete at the time of writing. BPB also has operations in Egypt and has noted that the construction market is currently weak.

Rest of the world

In much of the rest of the world, production and consumption of gypsum is at relatively low levels. South American production has been growing, with significant development of wallboard plants in countries such as Brazil, Chile and Argentina in recent years. However, the economies of several of the Latin American countries have been weak and construction activity relatively low. Longer term there is some scope for further development of wallboard markets because of the low utilisation in current building practice. Much of this development has been carried out by the three major European producers.

In Africa, the only reasonably large producers are in South Africa and some north African countries, including Egypt. Elsewhere production is largely geared to supplying local cement industries, often from very small operations owned by the cement companies themselves.

Table following page.

Table 1 World production ('000 t)

	2002	2003e
US	15,700	16,000
Iran	11,500	11,500
Canada	8,850	9,000
Spain	7,500	7,500
China	6,850	6,900
Mexico	6,500	6,800
Thailand	6,330	6,500
Japan	5,900	5,700
Australia	4,000	4,000
France	3,500	3,500
India	2,300	2,300
Egypt	2,000	2,000
Brazil	1,510	1,650
UK	1,500	1,500
Italy	1,300	1,200
Poland	1,100	1,100
Uruguay	1,130	1,100
Austria	1,000	1,000
Others	12,500	12,500
World	101,000	102,000

Source USGS