BARITE

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Barite, or baryte, derived from the Greek word *baros* (heavy), is the mineralogical name for barium sulphate. Barite is a common gangue mineral in hydrothermal mineral deposits, and also appears as a cavity-filling mass and vein in shale, limestone, sandstone and other sedimentary rocks. For a nonmetallic mineral, it has an unusually high relative density (4.48 g/cm^3). Barite is brittle, and its average hardness on the Mohs scale is 3 (similar to a copper penny). It shows extremely low solubility (it is insoluble in HCl), and is chemically inert. It is also quite thermally stable, degrading only at 1,580°C.

Applications

Approximately 80-85% of the world's barite is used in the petroleum industry as one of the key ingredients in drilling mud for oil and gas wells. Drilling mud is pumped down through the center of the drill stem and out of the drill bit as a well is being drilled. The mud lubricates the bit and also carries rock cuttings from the bottom of the drill hole up to the surface. Ground barite is added to the drilling mud to increase its density. This is done to prevent high-pressure gas or oil encountered during drilling from blowing the mud out of the drill hole and venting to the surface where it could be accidentally ignited or spilled. Barite is also the mineral of choice due to its chemical inertness and its low Mohs hardness, which limits wear on the drill bits, drill pipe and other equipment, such as pumps, etc. An additional feature of barite is its lack of interference with magnetic measurements taken in the borehole. And, together with bentonite, barite may also help seal and encase the drill hole wall to prevent fluid loss into voids.

Most people are exposed to, and benefit from, barite through its various smaller volume applications. In the automotive industry, barite is sold as a functional filler. It is used in paints and coatings, in sound and vibration deadening materials, and in numerous friction applications, including brake pads. In paint and coating applications, barite's high particle packing density (due to its particle shape) helps improve surface finish (and thus, gloss), as well as increasing the sealing capability of the coating, and the associated resistance against chemical impact, weathering and UV rays. Due to its high refractive index, barite can provide a limited amount of hiding in coatings.

From a cost-savings perspective, barite can also extend and replace higher-cost pigments and resins while maintaining or even improving their characteristics. Since barite is not particularly hard, it helps minimise wear on plant equipment, and is also easily sanded for additional coats of paint. It is rapidly wetted, so it disperses quite easily, and is neutral in pH, which provides low reactivity with binders and helps prevent negative reactions in paint systems.

Barite's high density is typically considered a negative in paints and coatings owing to its tendency to settle. However, there are certain applications where high density provides benefits, such as underbody coatings, where it helps seal out noise, and also road contaminants (such as salt), providing a certain amount of weather and chemical resistance. This noise reduction benefit carries over into other automotive applications, such as sound deadening mats and panels, which are used throughout the car. They can be placed on the firewall between the engine and passenger compartment, in the floor pans under the carpeting, as well as in other locations in the car that might help reduce noise and vibration levels. Not only does the firewall mat benefit from barite's high thermal stability, but also the panel affixed to the inside of the hood. Engine-part covers also use barite because it helps dissipate the heat and prevents distortion of these parts.

Another key area for barite in the automotive industry is friction applications. Barite is used extensively in brake pads. As indicated above, barite's chemical inertness and thermal stability are the primary benefits. Barite does not react negatively with other components in the friction formulation, and it also does not react to road or weather contaminants. During braking, the pads build up temperatures to very high levels, but still within the thermal limits of barite. A particular benefit of barite, though, is that it is just hard enough to provide some abrasion benefits. The use of barite in the brake pad helps scrub the brake rotor and prevent build-up of other components from the pad onto the rotor, which can lead to brake fade.

Barite's benefits to the automotive industry are carried over to other industries, such as industrial coatings (particularly marine paints), industrial carpeting (tighter packing in foam backings provides better rebound characteristics and lower wear), and piping (to help with noise reduction). With the dramatic increase in the popularity of golf and tennis, more and more people are being exposed to barite since it is used in golf and tennis balls as a weight additive. Within the medical field, many are familiar with barium 'meals' for gastro-intestinal X-rays, but perhaps not as familiar with barite in rubber and plastics for children's toys and medical devices so that they can be easily located within the body. The radiation absorption that barite provides in the above applications also transfers to the use of barite for radioactive shielding in X-ray labs, nuclear installations and other similar applications.

One of the larger markets for barite outside the petroleum industry is as a feedstock for the production of barium carbonate. For every tonne of barium carbonate, 1.5 t of barite is used. Barium carbonate is added to the glass melt process for TV faceplates in order to contain the high-intensity radiation from the cathode-ray tubes. The other main application for barium carbonate is as a flux for ceramics.

Within the past several years, there has been a significant shift in the industrial barite industry from naturally ground, larger particle size barites to chemically precipitated, smaller particle size barite. The paint and coating market has seen this shift more than any other segment, primarily because

the precipitated barite is purer and smaller in size. The purity affects the interaction, or lack thereof, between the barite and the other ingredients in the formulation, and the particle size helps extend the more expensive pigments, while improving the gloss of the final coating.

Sources

More than 50% of the world's barite comes from China. There are numerous large reserves of varying quality in many Chinese provinces, the key ones being Guangxi, Guizhou, Hunan, Fujian, Guangdong and Yunnan. Most of the exported barite comes from Guangxi because of its particular suitability for oil-drilling applications, which form the bulk of the global demand. However, the largest single deposit in the world, with 89 Mt, is located in Hunan Province. Material is primarily exported either through former provincial offices of China National Minerals Import and Export Group (CNMIEG), most of which have been privatised and have since invested directly in mining operations throughout the barite-bearing provinces, or else through companies run by individuals that were once employed in these provincial offices of CNMIEG.

It is always difficult to verify China's actual production of barite. Based on Chinese official statistics, as reported by the US Geological Survey (USGS), China's production has remained steady at between 3.3 Mt and 3.6 Mt from 1997 to 2001; this contrasts with China's major market, the US, whose own import demand has swung from a low of 871,000 t to a high of 2.5 Mt during this same period. With this in mind, the Barytes Association reduced the annual production figures in 2002 to 2.7 Mt in order to approximate more closely the true production numbers for barite in China. This adjustment closely follows the dramatic fall in US import volume by 900,000 t from 2001 to 2002. In 2003, we saw a restoration of imports back to 2.17 Mt (from 1.7 Mt in 2002, but still below 2001's figure of 2.5 Mt) and, as a result, the Baryte Association is planning to report a figure of 3.1 Mt for 2003 production numbers.

The second most significant source of barite is India. In contrast to China's seemingly endless number of deposits scattered throughout the southern half of the country, India has one primary reserve located at Mangampet, in the Cuddapah district of Andhra Pradesh, located approximately 280 km north of Chennai (Madras). This 70 Mt reserve (as measured in 1979) is one of the largest-known reserves in the world, and is controlled and managed by a government-established corporation, Andhra Pradesh Mining and Development Corp (APMDC). In spite of its size, production is quite low, although 2003 saw some slight increase in drilling activity, and therefore there was a slight increase in barite production from 780,000 t in 2002 to 800,000 t in 2003, according to APMDC; 500,000 t were exported, and the balance was either used domestically or put towards year-end stock.

In 2002, the Indian Government established a committee to discuss and determine methods to improve competitiveness in the barite market. It invited current barite exporters, end users, and other industry experts to present recommendations to the committee. Although the committee clearly understood the direction that the mining and sales operations needed to

follow, there were no structural changes in the mining or sales tenders in 2002, nor in 2003. In the meantime, IBC, one of the three main barite exporters (the largest being Trimex, followed by Gimpex), has been developing alternative reserves in the Khammam district of Andhra Pradesh, and is close to completion of a beneficiation plant to take full advantage of this deposit.

Morocco is another significant source of barite, although its total production fell significantly in 2003 to 380,000 t, down from 450,000 t in 2002. As in China, there are various mines located throughout the country. The largest operator is Comabar, a joint venture with M-I (US), which produces approximately 120,000 t/y from its own mine at Zelmou in eastern Morocco, and sources perhaps as much as 100,000 t/y from various other mining operations for its grinding plant in Safi. Societe Nord Africaine de Recherches et d'Exploitation des Mines d'Argana (SNAREMA), with its mine located in Seksaoua, northeast of Agadir, is another significant producer of primarily drilling-grade barite, as well as a beneficiated chemical grade from its plant in Argana. Production by SNAREMA fell substantially in 2003, to 40,000 t of drilling grade compared with 85,000 t in 2002; chemical grade remained constant at 15,000 t. SNUMM, an operating division of Societe Commerciale de Metaux et Minerais (SCMM) of Paris, France, is the remaining key player in Morocco. Its principal mines are located in Tijerkht and Bouizriri, where it has a processing capacity of 80,000 t/y, and it has two other mines as well. They reported production in 2003 of 85,000 t, most of which was drilling grade. Of this total, 35,000 t came from its own mines, and 50,000 t was purchased from outside sources.

Although Turkey is another key source for barite, it is somewhat unusual in that it exports primarily ground material, as opposed to crude ore for grinding near usage points. The two key producers are Ado Mining (part of the Ado Group), with operations in Konya, and Baser Mining Industry, with operations near Isparta in southern Turkey. Ado reported production of 110,000 t in 2003, and based on Baryte Association totals of 150,000 t for 2003, this leaves 40,000 t contributed by the remaining, smaller producers.

The largest single barite market in the world, the US, has significant mining production of barite, mainly from Nevada, but also from Georgia. The three main oilfield services companies (Halliburton/Baroid, M-I and Baker Hughes Inteq) each owns mines and beneficiation plants in Nevada. There is now only one mining operation in Georgia, owned by New Riverside Ochre (Chemical Products Corp). In early 2003, CIMBAR Performance Minerals, a division of Halliburton, halted mining operations and resorted to importing all of its requirements; by the end of the year, they were sold by Halliburton to United Minerals & Properties of Georgia. The end of CIMBAR's mining operations is the primary reason that production did not increase further but, in any case, 2003 was a very healthy year for the barite mining industry in Nevada. Volume in Nevada alone increased from 350,000 t in 2002 to 425,000 t in 2003, an increase of 21%. More than 90% of US mining production goes into the oil and gas market, primarily to the West Coast, the Great Plains, Alaska, and Canada. Production from New Riverside Ochre

goes into the industrial market, and it is also used as a feedstock in the manufacture of barium compounds by its parent, CPC.

Mexico is another significant source of barite although, like US production, it is used almost exclusively for domestic demand. Due to increased drilling activity in Mexico during 2003, production increased from 163,600 t in 2002 to approximately 250,000 t in 2003. Baramin (of the Alfil Group) is the main producer, almost doubling production from its major vein deposit in Galeana (northeast Mexico) to 150,000 t; Baramin is followed by Minar (Minerales Y Arcillas) with 50,000 t from the same barite-producing region, and several smaller producers in both northern and southern Mexico.

Europe has several key sources of barite, although few of them supply the oil and gas market. One of the key sources for the North Sea is M-I's Foss mine near Aberfeldy in Scotland. There has been some concern about the continued viability of this source because of its decreasing reserve base, but due to the complexity of the orebody, it is difficult to say how long M-I will be able to continue mining this source. In any case, M-I owns mining rights at Duntanlich, and is seeking to develop a mine although permitting has been somewhat problematic. 2003 figures put M-I's Foss mine output at 45,000 t, a slight decrease from 2002's figure of 50,000 t. Spain is the other European source for drilling-grade barite. Minerales Y Productos Derivados SA (Minersa) produced 50,000 t in 2003 from its Vera, Almería operation, situated very close to the deep-water port of Garrucha.

In reference to non-drilling grades of barite, Germany's Sachtleben is the largest source of barite in Europe. From its production operations in Wolfrach, it manufactures blanc fixe from imported sources of ore. Sachtleben is also the exclusive sales and marketing agent for Deutsche Baryt-Industrie (DBI), which mines barite from its underground reserves near Bad Lauterberg. Total production figures for 2003 put Germany at 110,000 t.

Barytine de Chaillac, with its mine and plant in Chaillac, is France's only barite producer. It supplies its barite entirely into the industrial market, mainly for barium salts, but also for the typical automotive filler applications. 2003 figures put France at 80,000 t, a slight decrease from 2002; the breakdown is approximately 65,000 t of chemical grade, and the balance filler grade. However, there have been reports about the limited life expectancy of this mine – perhaps as few as three years, and not more than five years. Barytine de Chaillac may look to reserves in Morocco in order to continue its business in the long term.

Market review

2003 saw a slight revival of the market from 2002 figures. Much of this can be attributed to the state of the petroleum industry in the North American market (including Mexico).

The Baker Hughes Inteq rig count is commonly used to gauge the condition of the drilling market. Activity picked up substantially in 2003, comparing favourably with the strongest periods from 1990-2002. When judged against

2002, the numbers were impressive: 1,032 rigs versus 831 rigs in the US (a 24% increase), 372 vs 266 for Canada (40%), and 244 vs 214 for Latin America (14%). These three locations are those that saw significant increases in 2003 over 2002, and they represent the three largest regions as measured by the BHI rig count (the US alone accounts for just under 50% of the total worldwide rig count, and the three combined represent 76%). All other smaller locations either remained constant or increased slightly. Since the oil and gas drilling market accounts for as much as 85% of the global demand for barite, these figures portray a relatively accurate picture of the global barite market in 2003.

Both Halliburton and Baker Hughes Inteq's annual reports for 2003 provide very clear explanations for the growth in drilling activity in the US, Canada and Latin America. Most of the US and Canada increases were driven by higher prices for both natural gas (from US$3.33/Mft^3 in 2002 to US$5.63/Mft^3 in 2003, Henry Hub average) and West Texas Intermediate oil (from US$25.92/bbl in 2002 to US$31.14 in 2003), which encouraged increased drilling activity as a result of increased revenues from the products themselves. A secondary driver in the US and Canada was the desire to replenish unusually low natural gas storage levels at the end of 2002 in time for the 2003/04 winter season. Looking at just the land-based gas drilling activity, this is clearly evident – of the 200 additional rigs in service in 2003, all of them were land-based, and 180 of them were for natural gas. As for Latin America, in spite of reduced activity by the national oil company of Venezuela (Pdvsa) due to strikes and the corresponding reduction of the workforce, Mexico's national oil company (Pemex) dramatically increased its drilling activity in the Gulf of Mexico region, netting a significant gain for the region.

However, the lingering uncertainty of the US economy, coupled with the renewed conflict in the Middle East, hampered further growth in North America. Major diversified oil and natural gas companies decided to direct their investments towards international projects, such as those in Russia and the Caspian Sea region, which took funds away from more capital-intensive offshore projects in the Gulf of Mexico.

This general trend of improvement carried over into the industrial market for barite in 2003. This was due to a slow but general recovery of the US economy. The paint and coatings, plastics, and automotive markets all saw improvements as a result of the increased confidence of consumers, as well as the growing weakness of the dollar, which strengthened exports.
Although, as a whole, the rest of the world was relatively stable, there were regions that encountered some weaknesses. The North Sea was weak, with a decline of 11% from 2002 to 2003, primarily driven by the UK sector. And Nigeria experienced continued political disruptions that hampered activity. On the other hand, Asia saw increases, particularly in India, and the Middle East continued its steady growth that began in 2001.

The global barium carbonate market continues to grow. Solvay estimated the global market of barium carbonate to be 550,000 t in 2002, with projected annual growth of about 3%. These figures have been generally confirmed by

Chemical Products Corp (CPC), and would put the corresponding global demand for this use at 825,000 t.

Most barium carbonate production has shifted to China, most likely because of the readily available raw material and the generally lower manufacturing costs. In 2003, China exported 255,000 t of barium carbonate, almost 20% more than its export volume of 215,000 t in 2002. Over the past several years, China's exports to the US have increased dramatically. In response, CPC filed an anti-dumping petition, which was approved by the US ITC in 2003, and resulted in a supplemental 61.3% dumping duty on all products from China, with the exception of Red Star, who protested the findings and subsequently received a reduced dumping duty of 34.4%. CPC's own production and corresponding barite demand continued to fall as one major company after another closed TV plants in the US and shifted production to Asia. From using over 100,000 t in 2002 to 50,000 t in 2003, CPC's continued existence in this market is highly questionable.

Environmental issues

2003 was a quiet year for regulatory issues related to barite. In the early part of the year, the Norwegian Water Institute (NIVA) performed a study on the level of trace metals in barite and ilmenite and the degree to which these trace metals transferred to marine organisms. The NIVA study showed a transfer of trace metals to marine organisms. This led the Norwegian regulators to propose that the quality of barite in drilling muds must be regulated. However, the oil and gas industry argued that no biological effect was shown in the study, and this position was fully supported by most North Sea countries. Thus, the regulatory status of marine barite discharges remains unchanged in the North Sea and US offshore areas.

Pricing

Since most barite is purchased on a contract basis, it is difficult to determine actual pricing for most volume. However, there is no question that costs started to rise dramatically at the end of 2003 as a result of the unprecedented increases in the global freight market. This was caused by a combination of factors – the dramatic growth in the Chinese economy and its resulting demand of iron ore, the strong coal market in Asia, and the lack of new bulk vessels entering the carrier fleet. These three items alone caused the Panamax freight index to more than double, from US$13,000/d throughout 2002 and the first half of 2003 to almost US$40,000/d by the end of 2003. This resulted in spot rate increases in the CIF price of barite of more than 40% within a six-month period.

Since there is no expectation that the Chinese economy will slow down to its former levels, we expect this strong freight market to continue for a year or two longer, until new bulk vessels enter the market in 2007 and ease the demand for bulk carriers. Furthermore, with this dramatic demand for raw materials, China's internal logistics system has been stressed and, as a result, railcars and trucks are in short supply. This may ultimately lead to

further cost increases for barite on an FOB China basis. This will ultimately encourage end users to find local sources of supply in order to meet their ongoing demand, and to rely less on imported ore.

Table over two pages

World barytes production (t)

Country	**2002**	**2003**
China	2,700,000	3,100,000
Thailand	137,500	115,600
Laos	2,000	2,000
Malaysia	3,100	600
Afghanistan	2,000	2,000
Iran	180,000	150,000
Vietnam	58,500	81,500
Pakistan	25,000	25,000
India	780,000	800,000
Burma	18,000	18,000
Australia	-	16,000
Sub- Asia-Australasia	3,906,100	4,310,700
Morocco	450,000	400,000
Tunisia	5,500	5,000
Algeria	51,700	50,000
Saudi Arabia	9,000	9,000
Nigeria	5,000	15,000
Sub - Africa	521,200	479,000
US	420,000	390,000
Mexico	163,600	250,000
Canada	13,000	13,000
Guatemala	100	10,000
Argentina	3,000	3,300
Bolivia	1,600	2,000
Brazil	54,900	54,500
Chile	400	700
Colombia	600	2,400
Ecuador	5,000	5,800
Peru	3,800	2,900
Sub-Americas	666,000	734,600
Germany	100,000	110,000
UK	62,000	61,000
France	85,000	80,000
Spain	55,000	50,000
Italy	15,000	15,000
Sub -EU15	317,000	316,000

Bulgaria	110,000	90,000
Turkey	160,000	150,000
Romania	100	1,500
Slovakia	14,000	14,000
Poland	5,000	5,000
Georgia	15,000	10,000
Russia	60,000	60,000
Kazakhastan	46,000	40,000
Sub-Europe	727,100	686,500
Total World	**5,820,400**	**6,210,800**

Source: The Barytes Association