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)[1]. 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 1580°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[2]. 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.

Although from a volume basis, the remaining applications are far less significant, it is precisely through these applications that most people are exposed to barite and benefit from its unique characteristics. The automotive industry is a key market into which barite is sold as a functional filler. Barite 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 is used because of its high particle packing density (due to its particle shape), which not only improves surface finish (and thus, gloss), but also increases 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

[1] Rock-forming Minerals, volume 5, Non-silicates, W.A. Deer, R.A. Howie and J. Zussman. John Wiley & Sons, New York, 1962.
[2] Manual of Mineralogy, Cornelis Klein, Cornelius S. Hurlbut, Jr., James D. Dana, John Wiley & Sons, New York, 1993.

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. It is also 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 due 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. Noise reduction is a key application for highly dense barite in the automotive industry. Sound deadening mats and panels 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 prevent 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 negatively react 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 'shakes' 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 few years, there have been two shifts in the barite industry. Particularly in the US, there has been a shift from brown/buff barite to white/off-white barite in the paint and coatings industry. This has occurred primarily due to the reduction in the number of coats of paint required on an automotive body. In the past, the primer was typically a reddish or brown colour, over which a base colour coat was laid, the primer now performs a dual duty as the base colour coat, and white/off-white barite is the only way to accomplish this. This shift in colour is also occurring in the automotive friction market, where manufacturers are trying to reduce the number of impurities that might cause problems, and white seems purer to these manufacturers. The other shift is in particle size. Finer material is being increasingly sourced by the industry as the use for barite changes. Finer particle products provide better gloss and allow the barite to be more effectively used as an extender for expensive pigments. This is the reason for the increase in volume for 'blanc fixe', which is a precipitated barite that is grabbing more and more market share at a higher price point.

Sources

The majority of the world's barite, more than 50%, comes from China. There are numerous large reserves of varying quality in many provinces within China. The key provinces are Guangxi, Guizhou, Hunan, Fujian, Guangdong, and Yunnan. Most of the exported barite comes from Guangxi due to its particular suitability for oil drilling applications, which forms the bulk of the global demand. Material is primarily exported either through former provincial offices of the China National Minerals Import and Export Group, most of which have become 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 the China National Minerals Import and Export Group.

It is difficult to verify China's actual production of barite (See table). Based on Chinese official statistics as reported by the US Geological Survey (USGS), China's production has remained steady between 3.3 and 3.6 Mt from 1997 to 2001, although US imports have varied from 871,000 to 2.5 Mt in this same period. (Given that the US is the largest importer of Chinese ore, the Chinese official production statistics might be imprecise.) The Chinese Government reported 3.1 Mt of production in 2002, a drop from 3.5 Mt in 2001. Total exports from China fell from 2.6 Mt in 2001 to 1.7 Mt in 2002. Imports into the US fell from 2.0 Mt 2001 to 1.5 Mt in 2002. Based on these export figures, The Baryte Association is planning to publish a more conservative production number of 2.65 Mt (instead of the Chinese Government's figure of 3.1 Mt) based on the 900,000 t drop in total exports.

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 the largest known reserve in the world, and is controlled and managed by a government-established corporation, the Andhra Pradesh Mining and Development Corp. (APMDC). In spite of its size, production is quite low, and it fell from 850,000 t

to 780,000 t between 2001 and 2002, according to APMDC – 460,000 t was exported, 140,000 t was used domestically, and the balance went to 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. Perhaps to circumvent this structure in Mangampet, 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, but it is still in the process of installing beneficiation equipment to take full advantage of this deposit.

Morocco is another significant source of barite. As in China, there are various mines located throughout the country. The largest operator is Comabar, which produced in 2002 approximately 120,000 t from its own mine at Zelmou in western Morocco, and sourced perhaps as much as 100,000 t 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, as well as a beneficiated chemical grade from its plant in Argana. Numbers for SNAREMA in 2002 were reported to be 80,000 t of drilling grade, and 15,000 t of chemical grade barite. SNUMM, an operating division of Societe Commerciale de Metaux et Minerais (SCMM) of Paris, France, is the remaining key player in Morocco. Its principal mine is located in Tijerkht, where it has a processing capacity of 80,000 t/y, and it has two other mines as well. They reported production in 2002 of 90,000 t, most of which was drilling grade. Of this total, 50,000 t came from its own mines, and 40,000 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 118,000 t in 2002, and based on Baryte Association totals of 160,000 t for 2002, this leaves 42,000 t for Baser and other small 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 own mines and beneficiation plants in Nevada. There are also two mining operations in Georgia, one owned by CIMBAR (Halliburton) and the other by New Riverside Ochre (Chemical Products Corp.). 2002 figures fell slightly to 370,000 t (from 400,000 t in 2001). 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 the two Georgian plants

goes into the industrial market and a significant portion of one operation is used as a feedstock in the manufacture of barium compounds by the parent, CPC.

Mexico is another significant source of barite, although like the US production, it is used almost exclusively for domestic demand. Its 2002 figures remained stable at 134,000 t, no change from 2001.

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 due to its decreasing reserve base, but due to the complexity of the ore body, 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 it, although permitting has been somewhat problematic. 2002 figures put M-I's Foss mine output at 50,000 t, a slight decrease from 2001's figure of 55,000 t. Spain is the other source for drilling-grade barite. Minerales Y Productos Derivados SA (Minersa) produced 55,000 t in 2002 from its Vera, Almeria operation, 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 2002 put Germany at 100,000 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. 2002 figures put France at 85,000 t, a slight increase over 2001; the breakdown is 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

When looking over the past ten years, 2002 was about average in terms of volume. However, against 2001, 2002 volumes were considerably lower and this was primarily due to the petroleum industry in the Americas.

Many look to the Baker Hughes rig count to gauge the condition of the drilling market. Activity was somewhat depressed in 2002. Average 2001 figures over the 12 month period show 1,155 rigs for the US, 342 rigs for Canada, and 262 rigs for Latin America. In 2002, these figures dropped to 831, 266, and 214 rigs respectively. These three locations are those that saw significant decreases in 2002 over 2001, and they represent the three largest regions as measured by the BHI rig count (the US alone accounts for 40-50% of the total worldwide rig count, and the three combined represent 72%). 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 provide a relatively clear picture of the global barite market in 2002. However, it is important to keep in perspective that 2001 was an unusually strong year for barite, and that 2002 merely fell back to average compared with the prior 10 years.

Halliburton's annual report for 2002 provides a very succinct explanation for this reduction in drilling activity in the US, Canada, and Latin America: decreased spending due to current uncertain global economic environment, the disruption of oil supplies from Venezuela, the armed conflict in the Middle East, budgetary constraints of some of the oil and gas companies, a focus on debt reduction by the oil and gas companies, and the level of US working gas in storage during the winter heating season.

The US economy started to decline in mid 2001, and this was exacerbated by the events of September 11, 2001. Political unrest and the resulting strikes in Venezuela practically crippled one of the largest exporters of oil into the US for several months, but it was unclear how long this would last, and therefore drilling activity did not immediately increase to cover any shortfall. The US's aggressive stance against Iraq and the regime of Saddam Hussein created a great deal of global concern, especially since it polarised the US against many of its historical allies, and it was also unclear how other governments in the Middle East would react. The September 11 event, as well as the US's stance against Iraq, encouraged people to travel less, and this directly affected the demand for fuel in the US (which is a much larger component of demand than in other parts of the world). Recent mergers in the oil and gas industry changed the perspective of operating companies since they were going through the complicated merger process and were being scrutinised by the markets to see if these mergers actually brought the benefits that they espoused during the run-up to approval. The 2001/2002 winter was unusually warm, which led to higher gas stock levels, which put downward pressure on gas prices. And finally, there were two weather events in the US Gulf Coast during the month of October (Tropical Storm Isidore and Hurricane Lili) that effectively shut down rig drilling activity for almost one entire month, although the BHI rig count did not reflect this situation because they were still on contract.

When looking at the 2002 industrial market for barite, the US saw a significant decrease in demand of 15-20% compared with 2001. This was primarily driven by the worsening of the US economy, which was compounded by the events of September 11, 2001, and further reinforced by the situations in Venezuela and the Middle East. The paint and coatings, plastics, and automotive markets all saw decreases as companies across these industries strove to maintain sales levels by driving costs down and offering incentives to customers, such as interest-free financing.

Other regions in the world did not experience the significant downturn of the Americas, but instead remained somewhat stable and see continued stability for the next year.

The global barium carbonate market continued to grow. Solvay estimated the global market of barium carbonate to be 550,000 t in 2002, with projected growth of about 3% per year. These figures have been generally confirmed by Chemical Products Corp. (CPC). This demand alone would put the corresponding global demand for this use at 825,000 t.

Most of the barium carbonate production has shifted to China, most likely due to the readily available raw material as well as generally lower manufacturing costs. 2001 figures put Chinese production at 310,000 t of barium carbonate, 215,000 t of which was exported. China's exports to the US have increased dramatically over the past few years; CPC puts 2002 figures coming in at 20,249 t, an increase from 18,000 t in 2001. In response, CPC filed an anti-dumping petition against the Chinese, which is now under review by the US ITC. CPC's own production was approximately 35,000 t of barium carbonate and 5,000 t of barium chloride each year over the past two years (2001 and 2002).

Environmental issues

With millions of tonnes of barite being used and discharged in offshore drilling activities, there continues to be a strong focus on the levels of heavy metals in barite, particularly mercury. 2002 saw discussions of this issue in the US as well as in Europe. The American Petroleum Institute commissioned the Battelle Memorial Institute to review the sources of mercury in the Gulf of Mexico and to evaluate the potential contribution of offshore oil and gas operations to mercury levels in seafood. The Battelle review's summary pointed out two key points – one is that most of the mercury in the Gulf of Mexico comes from air deposits and rivers.

Coal-fired power plants, municipal waste incinerators, and commercial/industrial boilers are the primary airborne sources; the Mississippi River is the primary riverine source. Secondly, mercury from oil and gas drilling discharges is insoluble and is not likely to be absorbed by marine organisms, even bacteria that can convert other forms of mercury into highly toxic methylmercury. In fact, the concentration of total mercury in sediments near most platforms studied is at or near natural levels, and in any case, mercury concentrations in seafood consumed by humans are similar, regardless of whether it comes from near or far away from an offshore platform.

In early 2003, 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. 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, it is clear that pricing for barite on a cif (cost, insurance, freight) basis fell in 2002. Much of this was based on the very weak freight market at the end of 2001 and throughout most of 2002. Since freight composes as much as one-third of the total cif cost, this is a key factor in any year. However, with the fall off in volume during 2002, there was also pressure on fob costs as well, not only out of China, but also India.

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World Barytes Production 2002* (t)

Country	2001 final	2002 prov
China	3,500,000	2,700,000
North Korea	70,000	70,000
Thailand	23,500	23,500
Laos	3,500	2,000
Malaysia	800	700
Afghanistan	2,000	2,000
Iran	185,000	220,000
Pakistan	25,400	25,000
India	850,000	780,000
Burma	34,000	23,000
Australia	16,000	16,000
Asia-Australasia	**4,710,200**	**3,862,200**
Morocco	350,000	450,000
Tunisia	2,500	5,500
Algeria	52,000	52,000
Saudi Arabia	8,000	9,000
Nigeria	5,000	5,000
Africa	**417,500**	**521,500**
US	400,000	370,000[1]
Mexico	134,000	145,000
Canada	24,000	13,000
Argentina	4,000	3,000
Bolivia	3,000	6,100
Brazil	53,000	53,000
Chile	600	600
Colombia	800	600
Peru	11,000	11,000
Americas	**630,400**	**602,300[1]**
Germany	115,000	100,000
UK	66,000	62,000
France	81,000	85,000
Spain	55,000	55,000
Italy	15,000	15,000
Bulgaria	120,000	120,000
Turkey	100,000	160,000
Romania	2,800	3,000
Slovakia	14,500	14,000
Poland	5,000	5,000
Georgia	15,000	15,000
Russia	60,000	60,000
Kazakhastan	42,600	40,000
Europe	**691,900**	**734,000**
Total World	**6,450,000**	**5,770,000**

* Provisional data for website

[1] Figures based on Nevada Bureau of Mines, as well as estimates for Georgia production volume.