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BARITE

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Barite is naturally-occurring barium sulfate (BaSO_4) that is utilized primarily for its high specific gravity (SG 4.5 in pure form) in addition to its chemical and physical inertness, relative softness, low solubility and in certain products, white color. Natural barite products typically contain impurities such as silicate minerals (e.g. quartz or chert) which reduce the SG.

Production

Barite occurs in veins, stratiform beds and lenses in addition to residual deposits. The largest deposits currently mined are stratiform beds in China, India and the United States, though residual deposits derived from veins contribute significantly to Chinese production.

The geometry and type of barite deposit affect mining economics and processing complexity. Vein

deposits have complex geometry and may often be extracted from surface or underground as a co-product of lead/zinc mining. Residual deposits are shallow enough to be mined opencast using dozers, excavators or front end loaders. Bedded barite deposits are more extensive, have more consistent grades and can be exploited by large-scale openpit methods.

Barite is extracted by both surface and underground mining, generally followed by simple physical processing methods such as crushing, washing (Fig. 1) and jigging to produce correctly sized product and to remove extraneous (mainly silicate gangue) materials. Flotation may be used to separate barite from finely intergrown gangue minerals. Hand sorting may be used in countries with low labor costs. Acid washing may be used in certain countries to remove iron oxide stains from white barite destined for coatings markets.

World barite production is directly linked to oil- and gas-well drilling activity and annual production has increased from around 5 Mt (5.5 million st) in the 1990s to approximately 9 Mt (9.9 million st) in 2014. China accounts for around 45 percent of world production followed by India (17 percent), Morocco (11 percent) and the United States (8 percent). A further 10 percent of supply was contributed collectively by Iran, Turkey, Kazakhstan and Mexico.

Whereas in 1998 China produced around 60 percent of the world's barite, by 2013 the Chinese share had slipped to approximately 45 percent, due largely to the spectacular rise of Indian and Moroccan production, which effectively more than doubled during this period. By 2013 production from India and Morocco accounted for 28 percent of global output. Chinese output during the period since 1998 has remained relatively consistent at around 3.5 to 4.5 Mt (3.9 to 4.9 million st).

Most of the U.S. production in 2014 was from four major mines in Nevada, followed by a much smaller

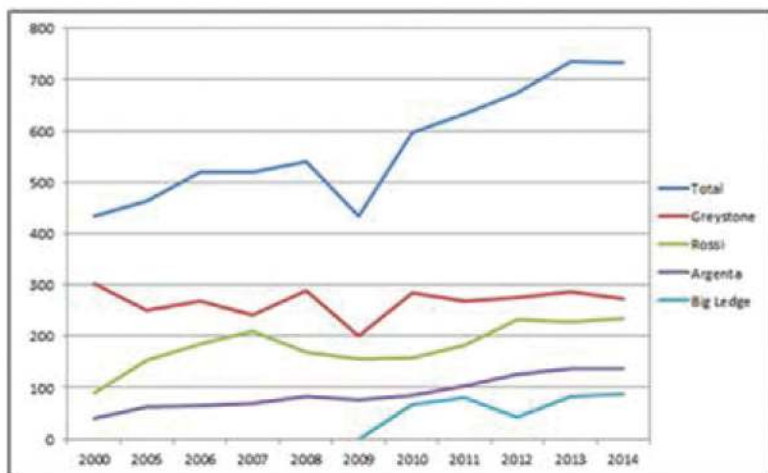
Figure 1

Residual barite ore in a washing screw, southern China. Source: Industrial Minerals Research.



Figure 2

Nevada barite shipped per mine, 2005 to 2014 (tonnes).



mine in Georgia. The Nevada Bureau of Mines and Geology reported that 2014 production (shipped product) in Nevada slowed slightly to 732 kt (808,000 st) compared with 736 kt (811,000 st) in 2013 (Fig. 2). Overall, barite production has increased by close to 60 percent since 2005, although this is still well short of the record peak production of approximately 2.2 Mt (2.5 million st) achieved in 1981.

The four Nevada barite mines are operated by Halliburton, Baker Hughes, MI-SWACO and National Oilwell Varco (NOV), but the proposed merger of Halliburton and Baker Hughes will see the number of operators reduced to three. Combined Halliburton/Baker Hughes production, based on 2014 tonnages, could account for more than 50 percent of total Nevada production in the future.

Most Nevada barite ore was ground at nearby company-owned grinding plants, although the crude barite from NOV Minerals LP's Big Ledge Mine was shipped out of Nevada to its grinding mill in Evanston, WY. The Evanston mill may be moved in the future and consolidated with NOV's Osino, Nevada facility.

The major drilling product suppliers, in addition to specialized mineral producers, have grinding plants around the Gulf of Mexico where there are 14 grinding mills (eight in Texas and six in Louisiana). These stand-alone plants processed imported crude barite that was primarily ground to API specifications for the oil and gas drilling market, although some was ground for other uses. Other mills in the Midwest and Southeast ground barite for use as extenders, fillers, and pigments, as well as producing API-grade barite for the oil and gas drilling market.

Exploration opportunities

Several exploration and development projects either underway, or of possible future interest, have been identified in Canada, Georgia, Ireland, South Africa, the United Kingdom and the United States. Significant amounts of barite (possibly exceeding 1 billion tonnes) have been identified but not quantified in northern Alaska, although these have not yet been brought to account due to remote location. Nevada continues to be an exploration 'hotspot' with well in excess of 100 known deposits and prospects.

Consumption, uses and specifications

The United States is the largest global barite consumer at around 3 Mt/a (3.3 million stpy) followed by China at approximately 1.5 Mt/a (1.65 million stpy). Globally more than 80 percent of barite produced is used as a weighting agent for drilling fluids in oil and gas exploration. Mineral weighting alternatives to barite include celestite, calcium carbonate, ilmenite and synthetic hematite. Apart from calcium carbonate, none of these mineral substitutes has had a major impact on the barite drilling mud industry.

According to The Barytes Association (www.barytes.org) global barite markets are skewed.

For example, 70 percent of European domestic production is for added-value manufacturing sectors where overall the chemical and filler industries account for half of the barite consumption. The Association notes that approximately 10 percent gets used in chemical applications, e.g. electronics, TV screen, glass, ceramics and medical markets, while the remainder is used as fillers in car insulation, rubber, paint and radiation shielding.

In contrast, the United States uses more than 95 percent of its barite output for the oil drilling industry, highlighting a general correlation between rig activity and barite consumption. This ratio has been affected over the past decade due to increased horizontal drilling, which in the U.S. currently accounts for 70 percent of drilling compared with only 15 percent in 2004. It appears that increased drilling of horizontal holes per rig platform has resulted in higher consumption of barite per rig.

Figure 3

U.S. barite production and imports 1919 to 2013 (1,000s tonnes).

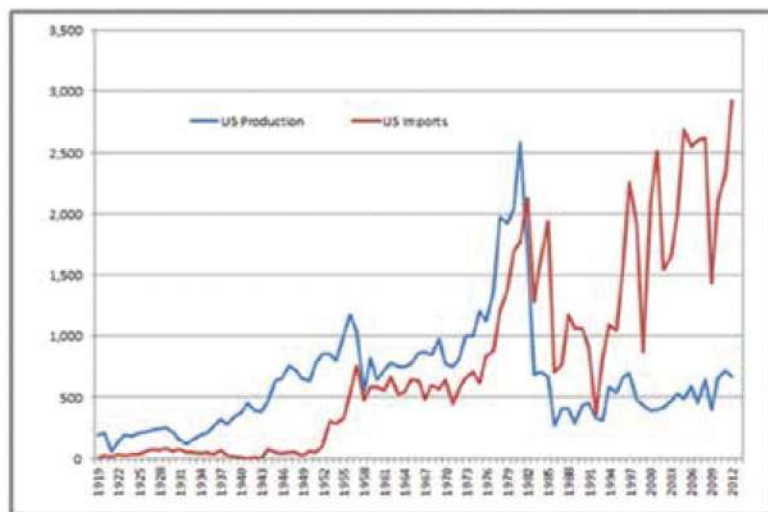


Table 1

Barite prices August 2014.

Product	Origin	US\$/t	
Lump (f.o.b.)		Low	High
Drilling grade SG 4.2	China	112	128
Drilling grade SG 4.1	China	109	113
Drilling grade SG 4.2	India	138	145
Drilling grade SG 4.1	India	110	125
Drilling grade SG 4.2	Morocco	115	127
Lump (c.i.f. Gulf Coast)			
Paint grade	China	235	275
Chemical grade	China	161	180
Drilling grade	China	145	160
Drilling grade	India	158	170
Ground (f.o.b.)			
Drilling grade	India	158	175
Drilling grade	Morocco	110	170
Drilling grade	Turkey	150	155

Source: Industrial Minerals www.indmin.com.

The American Petroleum Institute (API) introduced a new barite grade (SG 4.1) in August 2010, in addition to the long-standing 4.2 specification. The intention was not to replace the 4.2 grade but to provide the end-user with choice as to which material to use. This change was driven in part by a shortage of SG 4.2 barite, especially from mines in Nevada. Drilling-grade barite is specified by the API and must meet certain SG, chemical and sizing requirements.

Although not an API specification, drilling companies have started to focus on heavy metal content, in particular mercury (Hg <1ppm) and cadmium (Cd <3ppm), as specified by the US Environmental Protection Agency (EPA) for the Gulf of Mexico. Additional heavy metals may also be taken into account for example silver (Ag), arsenic (As), chromium (Cr), copper (Cu), lead (Pb), selenium (Se) and zinc (Zn), although there are no set limits for oilfield applications.

Product development

Finely ground drilling-grade barite has been promoted by several suppliers including Halliburton and MI-SWACO. The concept is to grind (micronize) barite to a fine particle size between 0.1 and 10 microns, which is significantly finer and in some cases denser (SG 4.35) than the conventional API-grade barite that is typically used in drilling operations.

The new technology is claimed to allow for low rheology fluids without static or dynamic barite sag in the well during drilling and completion operations, compared with normal API-grade barite which ranges up to 75 microns size. However, the smaller particles

have a larger surface area which could adversely affect the rheology of the drilling fluid; hence the micronized barite particles are treated to reduce viscosity. This lower viscosity is claimed to provide benefits during drilling and completion operations, such as reduced torque and lower equivalent circulating density.

Trade

The United States has long been a major world barite producer, primarily driven by the oil and gas drilling industry. During the first half of the 20th Century, the U.S. accounted for 30 to 60 percent of global production; this decreased to approximately 25 percent from the 1960s to 1980s, after which production plateaued out at around 8 percent. In terms of tonnage, U.S. production reached a peak of approximately 2.2 Mt (2.5 million st) in 1980 after which it declined, but has since rebounded to about 700 Kt (770,000 st) (Fig. 3).

The U.S. relies on imports of crude (lumpy) drilling grade barite which is shipped globally by sea, mainly from China and India, to milling plants strategically located close to oil and gas drilling hotspots such as the Gulf States, the North Sea and the U.S. Gulf of Mexico. Milled API-grade barite is shipped to numerous destinations both from barite producing countries such as India, China, Morocco, United States, Turkey, Kazakhstan, Mexico, Thailand and Vietnam, in addition to being shipped on from barite millers in Malaysia, Holland and the United States.

Prices

Barite prices are linked to purity and in the case of drilling-grade barite, the SG as illustrated by 2014 f.o.b. Chinese prices where a premium of approximately 15 percent is applied to SG 4.2 compared with SG 4.1. There is also a variation in price according to source, as illustrated by 2014 Indian lump f.o.b. being about 10 percent higher than China (Table 1).

Barite prices remained relatively steady until approximately 2006 relative to 1995 dollars, after which they increased rapidly until around 2012 and have currently fallen back slightly in 2014, but are still some 200 percent above the inflated 1995 dollar base. This sharp increase resulted from a number of factors including rationalization and consolidation of the Chinese barite mines, in addition to highly intensified U.S. onshore drilling for tight oil and gas.

Outlook

Liquid fuels remain the world's largest energy source throughout the IEO2010 Reference case projection, given their importance in the transportation and industrial end-use sectors. World use of liquids and other petroleum in the IEO2010 Reference case grows from 86.1m bpd in 2007 to 110.6m bpd in 2035. This growth suggests that petroleum exploration will continue to grow and along with it barite consumption, especially as more drilling has to be done per unit of

oil as hydrocarbon discoveries become smaller and less productive with time. Projecting global barite production based on trends from 1998 to 2014 indicates that 9.5 to 10 Mt/a (10.4 to 11 million stpy) may not be an unrealistic market by 2020, although the sharp

downturn in oil prices since late 2014 are likely to slow down exploration drilling in the short term.

Information included in this review is taken from Industrial Minerals Research's Drilling-Grade Barite report, published in February 2015 (www.indmin.com). ■