Barite (BARIUM)

Introduction

Barite is a mineral composed of barium sulfate, $BaSO_4$. It is usually colorless or milky white, but can be almost any color, depending on the impurities trapped in the crystals during their formation. Barite is relatively soft, measuring 3-3.5 on Moh's scale of hardness. It is unusually heavy for a non-metallic mineral. The high density is responsible for its value in many applications. Barite is chemically inert and insoluble.

Barite ($BaSO_4$) is the most common mineral of Barium. It occurs as a vein filling and as a gangue mineral in silver, zinc, copper, nickel and lead ores. It is colourless or white, often tinged with yellow, red, brown or bluish. Barite is used in the production of wallpaper and asbestos goods as well as in the manufacture of white paint.

Barite (barium sulphate) is a fairly common heavy mineral that often occurs in Pb-Zn ore deposits as a gangue mineral, in sedimentary deposits, and rarely in basalts. When found in sufficient quantity, it is mined for it's barium content. It occurs either in crystalline form, as tabular, prismatic, or bladed crystals, sometimes as a "cockscomb" habit, or else massive. It is often colourless, cream-coloured or white, but may also be yellow, blue, pink or brown.

Barite, a name that was derived from the Greek word "barus" (heavy), is the mineralogical name for barium sulfate. In commerce, the mineral is sometimes referred to as "barytes." The term "primary barite" refers to the first marketable product, which includes crude barite (run of mine) and the products of simple beneficiation methods, such as washing, jigging, heavy media separation, tabling, flotation, and magnetic separation. Most crude barite requires some upgrading to minimum purity or density. Barite that is used as an aggregate in a "heavy" cement is crushed and screened to a uniform size. Most barite is ground to a small, uniform size before it is used as filler or extender, an addition to industrial products, or a weighting agent in petroleum well drilling mud specification barite. Although barite contains a "heavy" metal (barium), it is not a toxic chemical under Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986, because it is very insoluble.

Name

Barite (spelled *baryte* in British publications) was named from the Greek word *baros* which means *weighty*, a reference to its unusually high specific gravity. (Specific gravity is a mineralogist's measure of the density of a mineral; this is done by comparing the weight of the mineral to the weight of an equal volume of water.)

Chemical Formula:	BaSO4
Composition:	Molecular Weight = 233.39 gm Barium 58.84 % Ba 65.70 % BaO Sulfur 13.74 % S 34.30 % SO_3 Oxygen 27.42 % O 100.00 % 100.00 % = TOTAL OXIDE
Empirical Formula:	$Ba(SO_4)$
Environment:	Sedimentary rocks and late gangue mineral in ore veins.

Sources

Most barite is mined from layers of sedimentary rock which formed when barite precipitated onto the bottom of the ocean. Some smaller mines utilize barite from veins, which formed when barium sulfate was precipitated from hot subterranean waters. In some cases, barite is a by-product of mining lead, zinc, silver, or other metal ores.

There are nine barite mines in the U.S., in Nevada, Georgia, Tennessee, and Missouri. China produces nearly ten times as much barite as the U.S., and India also produces more. About 40 other countries are also producers.

Many barite deposits are known worldwide, but some are uneconomic because barite can be mined more cheaply in China.

Uses

Barium: used as a heavy additive in oil-well-drilling mud; in the paper and rubber industries; as a filler or extender in cloth, ink, and plastics products; in radiography ("barium milkshake"); as getter (scavenger) alloys in vacuum tubes; deoxidizer for copper; lubricant for anode rotors in X-ray tubes; spark-plug alloys. Also used to make an expensive white pigment.

By far, the principal use for barite is as a "weighting agent" in oil and natural gas drilling. In this process, barite is crushed and mixed with water and other materials. It is then pumped into the drill hole. The weight of this mixture counteracts the force of the oil and gas when it is released from the ground. This allows the oil and gas rig operators to prevent the explosive release of the oil and gas from the ground. Currently, over 75% of barite consumption in the U.S. is for this drilling application. However, the consumption in drilling "mud" fluctuates from year to year, as it is dependent on the amount of exploration drilling for oil and gas, which in turn depends on oil and gas prices.

BARITE (Barium Sulfate) with the chemical formula of $BaSO_4$. is used as a weighting agent in all types of drilling fluids. Application of barite

- Increase mud density up to 21 lb/gal (2.5 g/cm^3)
- Control formation pressure
- Stabilize the borehole
- Prepare solids-laden plugs for well control application

Advantages

- Standard weighting agent for drilling fluids
- Chemically inert
- Cost - effective weighting agent

Physical and Chemical Properties

Appearance :	Fine, beige-coloured powder
Solubility :	Insoluble in oil and water
pH in water :	Neutral
Specific gravity :	4.2 - 4.35 g/cm^3
Bulk density :	2160 kg/m (135 lbs/ft^3)

Recommended Treatment

The quantity of barite needed to increase mud density is given in the formula below:

$$\text{Barite required (kg)} = \frac{4200\,(W_2 - W_1)}{4.2 - W_2}\,V_1$$

Where:

W_1: Initial mud weight (g/cm3);
W_2: Desired mud weight (g/cm3);
V_1: Initial volume of the mud (m3)

[$BaSO_4$]

A dense sulfate mineral that can occur in a variety of rocks, including limestone and sandstone, and is commonly used to add weight to drilling mud. Barite is of significance to petrophysicists because excess barite can require a correction factor in some well log measurements.

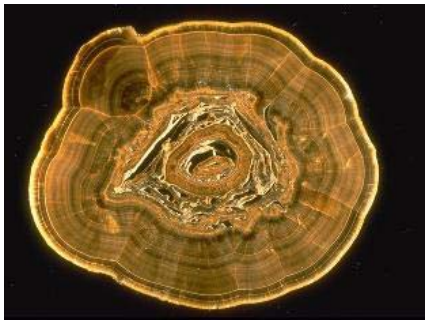
2. *n.* [Drilling]

Weighting material with a specific gravity of 4.37 used to increase the apparent density of a liquid drilling fluid system. Barite [$BaSO_4$] is the most common weighting agent used today. It is a mined material ground to an API specification such that particle sizes are predominantly in the 3 to 74 micron range.

3. *n.* [Drilling Fluids]

A dense mineral comprising barium sulfate [$BaSO_4$] that commonly occurs with a range of accessory minerals, such as quartz, chert, dolomite, calcite, siderite and metal sulfides. Used as a weighting agent for all types of drilling fluids, barites are mined in many areas worldwide and shipped as ore to grinding plants in strategic locations. Pure barium sulfate has a specific gravity of 4.50 g/cm^3, but drilling-grade barite is expected to have a specific gravity of at least 4.20 g/cm^3 to meet API specifications. Contaminants in barite, such as cement, siderite, pyrrhotite, gypsum and anhydrite, can cause problems in certain mud systems and should be evaluated in any quality assurance program for drilling-mud additives.

Barite Photo from MII, courtesy of the Smithsonian Institution



COMBINED API/COMPANY BARITE SPECIFICATION

PROPERTY	UNITS	REQUIREMENTS
Density	g/cm^3	4.20 minimum
Water Soluble Alkaline Earth Metals as Calcium	mg/kg	250 maximum
Residue greater than 75 micrometers	% w/w	3.0 maximum
Particles less than 6 micrometers in equivalent spherical diameter	% w/w	30 maximum
Particles less than 4 micrometer in equivalent spherical diameter	%w/w	20.0 maximum
C.E.C	meq/10gms	0.18 maximum
Extractable Carbonates	mg/kg	3000 maximum
Cadmium	mg/kg	5 maximum
Lead	mg/kg	1000 maximum
Mercury	mg/kg	5 maximum
Moisture Content	% w/w	1.0 maximum
Flotation Chemicals	% w/w	zero
Hematite	% w/w	zero
SAPP	% w/w	zero
Other: The presence of sand can be observed under a microscope . Additional properties may be determined according to API standardized test procedures (Reference RP 131, June 1, 1995, for the following controls: - abrasive capacity of the weighting agent - presence of mercury, cadmium and lead.		

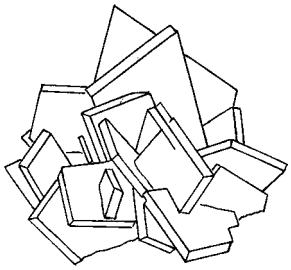
Beyond this, barite is used as an additive to paints, enamels, and plastics, in the production of so-called "lead" crystal or "leaded" glass, and as the source of barium chemicals.

Barite has the unique ability to strongly absorb x-rays and gamma rays. Consequently, it is used in medical science for special x-ray tests on the intestines and colon. It is also mixed with cement to make special containers used to store radioactive materials. A more recent application of barite is in the production of brake pads for cars and trucks.

Substitutes and Alternative Sources

Possible substitutes for barite, especially in the oil drilling industry, include other similar minerals, such as *celestite* (strontium sulfate, $SrSO_4$) and iron ore. A German company is producing synthetic iron ore (*hematite*) which is proving a good substitute for barite. However, these alternatives have yet to be widely used in the oil industry, and barite continues to be the preferred commodity for this application as long as barite production remains strong.

Barite crystal drawings by Darryl Powell



Typical Analyses of barite

Specific Gravity (g/cm3)	**4.35**
Specific Resistance (ohms/cm) (ASTM D-2448-85)	**7750**
Average Particle Diameter (MV)	**11**
Median Particle Diameter	**10.5**
325 Mesh Retention (%£©	**0.5**
Hegman Fineness (ASTM D-1210)	**4.5**
Brightness (%)	**91**
Oil Absorption (g oil/100g) (ASTM D-281)	**8**
Weight/solid gallon (lb)	**36.3**
One Pound Bulk (gal)	**0.0275**
Bulk Density (lbs/ft.3) (ASTM C-110)-Loose	**85**
Tapped	**144**

Typical Chemical Analyses

BaSO4	**95%**
Fe2O3	**0.03%**
CaO	**0.01%**
MgO	**0.04%**
Al2O3	**0.035%**
Silicates	**0.01%**
Loss On Ignition (LOI)	**0.5%**
Total Heavy Metals	**0.001%**
Water Soluble Salts	**0.1%**
pH	**7-9.5**
Moisture%	**0.1%**

MAJOR MINERALS STATISTICS OF MALAYSIA (Baryte)

Name of Minerals		1995	1996	1997	1998	1999	2000	2001
Tin-In Concentrate	Production Imports Exports (Metals) Consumption	6.4 34.9 35.2 6.3	5.2 32.3 34.3 6.0	5.1 30.5 31.8 6.6	5.8 22.0 22.4 5.4	7.3 20.1 24.0 5.7	6.3 19.3 21.0 5.6	5.0 24.1 27.2 4.0
Copper Concentrate	Production Imports Exports	87.7 - 85.0	87.6 - 87.0	80.7 - 87.0	61.7 - 62.0	20.7 - 27.0	na. na. na.	na. na. na.
Iron Ore	Production Imports Exports	202.3 1,757.2 3.0	325.1 1,689.5 12.1	271.0 2,618.0 9.2	376.0 1,071.9 129.1	337.5 1,356.0 147.2	258.6 1,386.5 80.2	376.5p 1,527.9p 42.2p
Coal	Production Imports Exports	112.1 1,824.0 77.0	82.7 2,720.0 2.0	105.2 2,523.0 2.0	349.9 3,239.0 1.0	308.5 2,641.0 4.0	382.8 2,028.0 5.0	545.9p 3,798.0p 3.0p
Raw Gold (gms)	Production Imports Exports	3,161.8 112,996. 0 1,458.0	2,829.5 95,942.0 920.0	4,487.6 2,444.0 1,614.0	3,394.3 1,340.0 350.0	3,449.4 - 15.0	4,026.0 6.0 -	3,965.0 - 156.0p
Bauxite	Production Imports Exports	184.4 4.4 168.7	218.7 5.0 195.3	279.0 1.0 177.1	160.3 3.1 87.1	222.7 5.2 92.5	123.3 6.5 102.3	64.1 6.8p 73.0p
Kaolin	Production Imports Exports	211.2 65.0 934.0	209.5 48.0 1,268.0	187.5 31.0 476.0	176.5 71.0 297.0	209.1 19.0 240.0	233.0 na. na.	350.0e - -
Ilmenite	Production Imports Exports	151.7 79.8 180.8	244.6 109.0 115.1	167.5 121.6 146.2	124.6 91.6 69.2	128.5 103.0 103.6	124.8 110.3 102.0	129.7p 120.5p 154.5p
Silver (gms)	Production	11,080.0	9,719.7	9,646.6	7,285.3	2,744.0	na.	3,117
Barite	Production	17.0	17.5	2.6	1.3	11.7	7.3	1.0e
Mica	Production	5.8	5.5	5.7	3.6	3.7	3.8	4.0e
Limestone	Production	2,963.8	3,294.2	3,335.4	4,848.7	3,413.5	16,017.0	13,900.0e
Silica	Production	287.5	268.8	205.0	162.2	274.8	446.8	400.0e
Industrial Sand	Production	na.	1,522.3	2,076.4	717.2	na.	na.	na.

Note: In thousand tonnes except for gold and silver
p - provisional
e - estimated
na - not available
Source: Department of Minerals and Geoscience, Malaysia
Department of Statistics, Malaysia

Occurences and Economic Deposits of Barite

(In a case of Tasmania)

In Tasmania, only two deposits have been mined commercially, at Beulah, near Sheffield, and at Madame Howard Plains, near Queenstown.

Beulah
The Beulah deposits are veins in slate and greywacke of massive crystalline barite with a greyish tinge, containing disseminated galena, sphalerite and pyrite.

Madame Howard Plains
This deposit consists of a number of lenticular bodies of very pure barite, first discovered in 1910, and located near the Strahan-Zeehan Road junction. There are two main deposits and both have lodes varying in width from a few centimetres to about 4 metres. The Southern deposit has been worked by trenches, mostly shallow but with the largest around 3 metres wide and 5 metres deep, and one adit. The Northern deposit has been worked from 3 adits and a series of shallow trenches. Most of the barite is cream to grey and massive, although many individual crystals have been collected up to many centimetres across. Other minerals reported from this deposit include quartz, well-crystallised purple fluorite (only seen in drill cores), albite, talc, pyrite, apatite, epidote, hematite, calcite, chlorite, muscovite and galena, with most of these occurring in the host rock, a keratpohyre.

In Mineral Veins and Ore Bodies
Hellyer Mine
The Hellyer Mine in northwestern Tasmania is a massive sulphide orebody average 54% pyrite, 20% sphalerite, 8% galena, 2% arsenopyrite, and 1% chalcopyrite, with minor tetrahedrite. The lower and inner regions are rich in Cu and Fe, while the upper and outer sections are higher in Pb, Zn, Ag, Au and As. Bands of crystalline barite occurred above the massive sulphides.

Rosebery
The Rosebery deposit was discovered in 1893, but due to problems processing the ore, mining was only carried out on a small scale until 1936. The orebody is made up of two distinct types, a sulphide body with pyrite, chalcopyrite, sphalerite and galena as the principal minerals, and a barite body where galena and sphalerite are the main sulphides. The barite generally occurs as fine-grained massive material. In the 1980s however, specimens of very well crystallised “golden barite” were found in veins.

Prospecting for Barite (U.S.A situation)

The mineral barite, barium sulfate, $BaSO_4$, is unusually heavy with a specific gravity of 4.2 - 4.6. This means it is that many times as heavy as an equal volume of water and that it is over half again as heavy as most common rocks such as granite, lava, sandstone, and limestone. This heft is most noticeable in a fist-sized specimen. The mineral is moderately soft. A fingernail cannot scratch it, a copper penny may or may not, but a knife blade will.

A few other minerals may be mistakenly identified as barite: Witherite (another barium mineral), celestite and strontianite (both strontium minerals), cerussite and anglesite (both lead minerals) and hydrozincite (a zinc mineral) also have a high specific gravity, similar color (colorless, white, yellow, gray, green, blue and red) and a nonmetallic appearance. They are rare and also of potentially greater value than barite. In fact, the identity of any heavy mineral should be determined. No prospector should ignore any other potentially valuable mineral de-posit by searching only for barite.

A specific chemical test for the element barium is given in Field Tests for The Common Mineral Elements, Arizona Bureau of Geology and Mineral Technology, Bulletin 175, by George H. Roseveare. The test is not simple or specific for barite, as it will indicate the presence of barium in any mineral or rock. A note of caution, barium typically occurs as a constituent of light colored igneous rocks at a concentration of 0.07% to 0.50%. The semi quantitative spectrographic analysis often purchased by prospectors will nearly always show a concentration of 0.50% barium. This may be expected, has little significance to the barite prospector, nor does such a low value have any economic significance.

There are two tests for barite that are simple and usually specific, though not always: 1. The first test requires an ultra-violet (mineral) light and an alcohol lamp with a blow pipe or a propane torch. Frederick H. Pough de-scribes the test in his A Field Guide To Rocks and Minerals. "Barite is only occasionally fluorescent, but all barite samples tested were found to be fluorescent yellow orange after roasting. Hence, with two similar minerals (celestite and barite) we have only to roast an edge intensely in the flame (to red heat, briefly), allow them to cool, and examine them with our ultraviolet light. The orange one will be barite, the yellow green one, celestite."

2. The second method requires only a steel prospector's pick. When a barite sample is scratched across the head of the pick it adheres to the steel leaving a distinctive white streak. Other white rocks usually leave only a scratch or nothing.

Field prospecting for barite, like any other mineral, should be preceded by a study of typical types of occurrences and areas of past discoveries. Commonly white to grey, barite occurs in veins, replacements or residual deposits commonly associated with quartz, fluorspar and calcite. Deposits may be sought in highly weathered (rather crumbly or fractured) rocks especially those of Cambrian or Ordovician age, which overlay carbonate rich rocks such as limestone. Nearly all the barite deposits in Arizona, however, occur in veins associated with faults, breccias and fracture zones. Most of these are in igneous rocks, some are in sedimentary and a few are in metamorphic rocks. The veins are typically a few feet wide and usually have been traced for only a few hundred feet in outcrop. Even less is known about the extent of the veins at depth.

The geochemistry of barium in the earth's surface environment is complex and not fully understood. Under some conditions, barium is released from weathered igneous rocks, carried to the sea and precipitated as barite. Some deposits in sedimentary rocks may form in this manner. Prospecting for this type of barite occurrence first requires a determination of the location of marine sediments. The regional delineation of barite beds may be best determined by panning. Most extensive areas of sedimentary rocks contain very limited heavy minerals. Check any panned "heavies" with the ultraviolet light.

Barite's specific gravity is only 13% lower than the mineral magnetite, which is the magnetic constituent of the placer miners familiar "black sand." Fragments of barite in a stream, wash or crushed outcrop will concentrate with the black sand in a pan. Unlike gold, however, barite will not travel far from its outcrop before it is crushed to slime size particles by tumbling action. The other heavy minerals mentioned previously (witherite, celestite, cerussite, anglesite, hydrozincite) can also be concentrated by panning. Any barite found in the pan should then be traced upstream until an outcropping or residual hillside source is found. However, as barite is a common gangue mineral in vein deposits, many occurrences found in this manner will be too low grade or too small. The barite must occur in such a mode as to either be of a minimum specific gravity of 4.25 or is amenable to simple concentration.

Principal uses for barite are as a weighting agent in oil well drilling mud, which accounts for about 90% of consumption, in barium com-pounds, in paints, in glass, in paper fillers, and in refining sugar. Freight rates are high and barite being a dense, heavy mineral of relatively low unit value, the distance from producer to consumer is economically critical. For current prices contact the Arizona Department of Mines and Mineral Resources.

Arizona has produced approximately 1% of the over 30 million tons of barite mined in the United States since 1882. The first commercial barite productions came from Cochise County in 1925. From available records it is estimated that Arizona's barite production between 1929 and 1955 was about 317,000 tons. Close to 312,000 tons came from the veins of the Granite Reef (aka Arizona Barite or Macco) mine, Maricopa County between 1931 and 1955. Eight other mines in five counties yielded the other 5,000 tons. Since 1986 there is no record of barite production in Arizona. The standards of quality vary by use. A barite product for drilling mud must have a mini-mum specific gravity of 4.25 (about 92% BaSO4) and at least 90% of the product must be ground to minus 325 mesh. Many other uses require a product that is 95-98% BaSO4 with no more than minor amounts of iron oxides, silica and alumina.

In 1979 Nevada continued to be the largest producer with 82.5% of the total, followed by Missouri with 7.4%. Other producing states were Arkansas, Georgia, Idaho, Illinois, Montana, and Tennessee. The average price per ton, f.o.b. mine in 1979 was $22.93. This is over $2.00/st higher than the 1978 average. In 1999 well drilling consumed over 94% of the barite used in the United States. Imports and domestic production for the year totalled 1.4 mil-lion tons. Nevada remains the largest U.S. producer but production is about one third of the 1979 level due largely to low-priced imports of barite. China supplies most of the imported barite; domestic production was only 33% of the total. The average price per ton was $25.58.

The Arizona Department of Mines and Mineral Resources has numerous references on the geology, mineralogy, mining and processing of barite, and, in the museum, specimens for examination.

References

Anon, 1970: The Catalogue of the Minerals of Tasmania. Geological Survey Record No. 9, Tasmania Department of Mines.
Anon, n.d.: Database of Tasmanian Mines and Prospects (Mir797o.xls), Mineral Resources Tasmania.
Birch, W.D., (Ed), 1989: Zeolites of Victoria. The Mineralogical Society of Victoria Special Publication No. 2.
Bottrill, R.S. (in prep): Catalogue of the Minerals of Tasmania.
Burton, C.C.J., 1975: Rosebery Zinc-Lead-Copper Orebody. Economic Geology of Australia and Papua New Guinea, 1. Metals, pp619-626.
Groves, D.I., 1964: Madam Howard Plains Barytes Deposit. Technical Reports No. 8. Tasmania Department of Mines.
Reid, K.O., 1975: Mount Lyell Copper Deposits. Economic Geology of Australia and Papua New Guinea, 1. Metals, pp619-626.
Noldart, A.J., 1964: Notes on Barite Deposits, Lower Beulah, Sheffield District. Technical Reports No. 8. Tasmania Department of Mines.
Ward, L.K., 1908: The Mount Farrell Mining Field. Geological Survey Bulletin No. 3, Tasmania Department of Mines.
Circular No. 4, February, 1981, revised 2001 by Ken A. Phillips, Mineral Resource Engineer & Clifford J. Hicks, Field Engineer