5. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.1 PRODUCTION

Barium is a dense alkaline earth metal that occurs naturally in ore deposits and makes up 0.05% of the Earth's crust (Genter 2001). Barium and its compounds may be found in nature or produced industrially for various uses. The largest natural source of barium is barite ore, which is composed largely of barium sulfate and is found in beds or masses in limestone, dolomite, shales, and other sedimentary formations (Miner 1969b). The major impurities in crude barite ore are iron(III) oxide, aluminum oxide, silica, and strontium sulfate (WHO 2001). Crude barite is turned into crushed barite which not only has its own industrial uses but also serves, in turn, as the source for the production of other barium compounds. Crushed barite is first converted to barium sulfide by high-temperature, solid-phase reduction with a carbonaceous reducing agent. Barium sulfide is the starting point for the chemical manufacture of most other barium compounds (Dibello et al. 2003). One such useful compound is lithophone consisting of 28% zinc sulfide (ZnS) and 72% barium sulfate ($BaSO_4$), which is used as a white pigment in paints. Barium sulfate is produced from high-grade (75–98%) ore in association with granite and shale, crushed, and then beneficiated by washing, jigging, heavy-media separation, tabling, floatation, or magnetic separation (Stokinger 1981; USGS 2004). Barium carbonate ($BaCO_3$) occurs in nature as witherite; however, it has little economic significance due to its rareness, impurities, and almost fully depleted deposits (Kresse et al. 2007).

In 2005, the major producer of barite in the United States was from mines in Nevada. Significantly smaller amounts were produced from a single mine in Georgia. Total U.S. production for 2004 was 532,000 metric tons, a figure that represented 7.3% of world production. This production figure is 14% higher than for 2003. In 2004, 24 grinding plants within the United States produced 2,440,000 metric tons of ground or crushed (processed) barite ore. Fourteen facilities, 6 in Louisiana and 8 in Texas, produced American Petroleum Institute (API)-grade barite in 2004. These stand-alone grinding plants received barite from China and India for grinding to API specifications for the oil and gas drilling markets. Of the total production of ground and crushed barite ore in 2004, 94% (2,300,000 metric tons) was used in well drilling operations. Louisiana and Texas were the major U.S. consumers of processed barite ore (1,803,000 metric tons); much of this consumption was driven by exploration for natural gas. The demand for barite in the United States is expected to increase, while the level of drilling activity in North America remains high due to a strong demand in the United States for natural gas. The remaining 6% (142,000 metric tons) was used as filler and extenders and in the manufacture of glass and barium chemicals, such as barium sulfide (USGS 2004, 2006). A list of production and processing facilities for

barium and barium compounds in the United States along with the production or processing volume for each are provided in Tables 5-1 and 5-2 (TRI04 2006). A listing of specific manufactures of barite and barium compounds is given in Table 5-3.

5.2 IMPORT/EXPORT

For the year 2004, U.S. imports of crude barite ore totaled 1,960,000 metric tons, which was a 17% increase from levels reported in 2003. Estimates for 2005 predict a 17% increase in imports to 2,350,000 metric tons. Export volumes were at 70,000 metric tons, a 37% increase from 2003 levels. Estimates indicate a 22% increase in exports to 90,000 metric tons in 2005. Import of barium chloride, barium nitrate, and barium carbonate amounted to 130, 4,300, and 10,200 metric tons in 2004, respectively. Imports of barium oxide, hydroxide, and peroxides were reported to be 3,540 metric tons (USGS 2004, 2006).

5.3 USE

Barium and its compounds are used in oil and gas drilling muds, automotive paints, stabilizers for plastics, case hardening steels, bricks, tiles, lubricating oils, and jet fuel as well as in various types of pesticides (Bodek et al. 1988; Venugopal and Luckey 1978; WHO 2001). The largest use of mined barite, which accounts for 94% of the total output, is oil and gas well drilling (USGS 2006). The rest of barite ore (or crude barium sulfate) is utilized frequently as a colorant in paint, as a flux to reduce melting temperature in the manufacture of glass, and as a filler in plastics, rubber, and brake linings as well as in the production of other barium compounds (Dibello et al. 2003). Such barium compounds as the carbonate, chloride, and hydroxide are important in the brick, ceramic, photographic, and chemical manufacturing industries (Bodek et al. 1988).

Industrial uses of barium and its compounds are wide and varied. Barium metal and its alloys, for example, are often used as "getters" to remove gases from vacuum tubes due to their ability to absorb gases (Stokinger 1981). One of barium carbonate's major uses is as a rodenticide (Meister 2004; Worthing 1987); however, it also plays an important role in the brick, tile, ceramics, oil drilling, and chemical manufacturing industries (Dibello et al. 2003; ILO 1983). Barium sulfate, in the chemically treated, *blanc fixe* form, is used in high-quality paints as well as in glass- and papermaking (ILO 1983; Kresse et al. 2007). Barium sulfate is also added to concrete to increase the radiation shielding of this material. The chloride is used for chlorine and sodium hydroxide manufacture, as a flux for aluminum alloys, in pigment and textile dye manufacture, and in the treatment of boiler water (Dibello et al. 2003).

Table 5-1. Facilities that Produce, Process, or Use Barium

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AK	8	0	999,999	1, 5, 12, 13, 14
AL	23	0	999,999	1, 2, 3, 5, 6, 7, 8, 10, 11, 12, 13, 14
AR	10	0	49,999,999	1, 3, 5, 7, 8, 11, 12
AZ	8	0	9,999,999	1, 5, 7, 10, 13
CA	34	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
CO	8	100	99,999	2, 6, 7, 8, 12, 14
CT	3	100	999,999	1, 2, 4, 6, 7, 8, 9, 12
DE	4	100,000	999,999	2, 3, 9, 13, 14
FL	2	0	999,999	1, 5, 8
GA	13	0	49,999,999	1, 2, 3, 4, 6, 7, 8, 14
IA	12	0	999,999	1, 2, 5, 7, 10, 11, 12
ID	7	10,000	999,999	1, 3, 5, 12, 13
IL	22	100	49,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
IN	19	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12
KS	13	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13
KY	14	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9
LA	6	0	99,999	1, 5, 6, 8, 12
MA	6	1,000	99,999	1, 3, 7, 8, 11
MD	7	100	999,999	1, 2, 3, 4, 5, 6, 7, 8, 11, 12
ME	4	100	99,999	1, 5, 8, 13
MI	36	0	999,999	1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MN	21	100	999,999	1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14
MO	11	0	999,999	1, 3, 4, 5, 6, 7, 8, 9, 13, 14
MS	10	100	999,999	2, 3, 7, 8, 11
MT	3	10,000	99,999	1, 5, 8, 9, 12
NC	18	0	999,999	1, 2, 3, 5, 6, 7, 8, 10, 11, 12, 13
ND	1	100,000	999,999	1, 5, 9, 12
NE	14	100	9,999,999	1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14
NJ	17	0	999,999	2, 3, 6, 7, 8, 10, 11
NM	6	0	49,999,999	6, 7, 8, 9, 11, 12, 14
NV	6	100	9,999,999	1, 5, 6, 7, 10, 13
NY	20	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 13
OH	54	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OK	19	0	999,999	1, 2, 3, 5, 7, 8, 11, 12, 13
OR	9	0	999,999	1, 2, 3, 5, 6, 7, 12, 13
PA	27	0	999,999	1, 2, 3, 5, 6, 7, 8, 10, 11, 12, 13
PR	2	10,000	999,999	12
RI	3	10,000	99,999	2, 3, 4, 6, 7
SC	21	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 11, 12
SD	2	100,000	999,999	1, 5, 12, 14

Table 5-1. Facilities that Produce, Process, or Use Barium

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
TN	19	100	999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
TX	46	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
UT	9	1,000	999,999	1, 2, 3, 5, 7, 8, 11, 12
VA	15	0	999,999	1, 2, 5, 6, 7, 8, 10, 12
VT	1	1,000	9,999	11
WA	3	0	999,999	2, 5, 7, 8, 12, 13, 14
WI	13	0	999,999	1, 3, 5, 6, 7, 8, 10, 11, 12, 14
WV	10	0	999,999	2, 3, 7, 8, 10, 12
WY	2	0	999	1, 2, 13

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI04 2006 (Data are from 2004)

Table 5-2. Facilities that Produce, Process, or Use Barium Compounds

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AK	4	0	9,999,999	1, 5, 12, 14
AL	58	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
AR	47	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
AZ	41	100	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
CA	89	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
CO	41	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14
CT	25	100	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13
DE	17	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13
FL	51	0	999,999	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
GA	79	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
HI	2	1,000	99,999	1, 5, 10
IA	42	100	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
ID	14	0	9,999,999	1, 2, 3, 5, 7, 8, 10, 11, 12, 13, 14
IL	136	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
IN	109	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
KS	48	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14
KY	80	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
LA	56	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14
MA	42	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MD	52	100	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
ME	25	0	99,999	1, 2, 3, 5, 7, 8, 10, 11, 12, 13
MI	125	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MN	46	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MO	68	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14
MS	39	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MT	14	100	9,999,999	1, 3, 4, 5, 6, 7, 9, 12, 13, 14
NC	77	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
ND	18	0	9,999,999	1, 5, 8, 9, 12, 13, 14
NE	32	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13
NH	10	0	99,999	1, 2, 3, 4, 5, 7, 8, 9, 10, 12
NJ	103	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
NM	21	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14
NV	19	0	499,999,999	1, 2, 3, 4, 5, 7, 8, 9, 12, 13
NY	121	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OH	169	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OK	43	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OR	27	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13
PA	153	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14

Table 5-2. Facilities that Produce, Process, or Use Barium Compounds

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
PR	3	10,000	999,999	1, 2, 4, 5, 6
RI	12	100	99,999	2, 3, 4, 6, 7, 8, 11
SC	50	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
SD	7	1,000	999,999	1, 5, 7, 8, 9, 12, 13
TN	71	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
TX	114	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
UT	41	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
VA	44	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14
VT	6	1,000	99,999	1, 5, 7, 8, 11
WA	26	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
WI	54	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
WV	34	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
WY	23	0	9,999,999	1, 3, 4, 5, 9, 12, 13, 14

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI04 2006 (Data are from 2004)

Table 5-3. Current U.S. Manufacturers of Barium Metal and Selected Barium Compounds[a]

Company	Location
Barite (barium sulfate, natural):	
CIMBAR Performance Minerals	Cadet, Missouri
	Cartersville, Georgia
	Chatsworth, Georgia
Elementis Pigments, Inc.	East St. Louis, Illinois
Huber Engineered Materials Division	Quincy, Illinois
M-I, SWACO	Amelia, Louisiana Battle Mountain, Nevada Galveston, Texas Westlake, Louisiana
New Riverdale Ochre Company, Inc.	Cartersville, Georgia
Unimin Corporation	Plant location not specified
Barium sulfate (synthetic):	
Barium and Chemicals, Inc.	Steubenville, Ohio
CIMBAR Performance Minerals	Cartersville, Georgia
GFS Chemicals, Inc.	Columbus, Ohio
Johnson Matthey, Inc. Alfa Aesar	Ward Hill, Massachusetts
Mineral and Pigment Solutions, Inc.	South Plainfield, New Jersey
Barium acetate:	
Barium and Chemicals, Inc.	Steubenville, Ohio
Barium carbonate:	
Barium and Chemicals, Inc.	Steubenville, Ohio
CERAC, Inc.	Milwaukee, Wisconsin
Chemical Products Corporation	Cartersville, Georgia
Johnson Matthey, Inc. Alfa Aesar	Ward Hill, Massachusetts
Mallinckrodt Inc. Pharmaceuticals Group	St. Louis, Missouri
Osram Sylvania Inc.	Towanda, Pennsylvania
Barium chloride:	
Barium and Chemicals, Inc.	Steubenville, Ohio
Chemical Products Corporation	Cartersville, Georgia
GFS Chemical, Inc.	Columbus, Ohio
Johnson Matthey, Inc. Alfa Aesar	Ward Hill, Massachusetts
Mallinckrodt Inc. Pharmaceuticals Group	St. Louis, Missouri
Osram Sylvania Inc.	Towanda, Pennsylvania
Barium hydroxide:	
Barium and Chemicals, Inc.[b,c,d]	Steubenville, Ohio
Johnson Matthey, Inc. Alfa Aesar[b,c]	Ward Hill, Massachusetts
Mallinckrodt, Inc. Pharmaceuticals Group[e]	St. Louis, Missouri
Barium oxide:	
Barium and Chemicals, Inc.	Steubenville, Ohio

Table 5-3. Current U.S. Manufacturers of Barium Metal and Selected Barium Compounds[a]

Company	Location
Barium sulfide:	
Barium and Chemicals, Inc.	Steubenville, Ohio
Chemical Products Corporation	Cartersville, Georgia
Johnson Matthey, Inc. Alfa Aesar	Ward Hill, Massachusetts

[a]Derived from SRI 2006 unless otherwise noted. SRI reports production of chemicals produced in commercial quantities (defined as exceeding 5,000 pounds or $10,000 in value annually) by the companies listed.
[b]Barium hydroxide, anhydrous [$Ba(OH)_2$]
[c]Barium hydroxide octahydrate [$Ba(OH)_2 \cdot 8H_2O$]
[d]Barium hydroxide monohydrate [$Ba(OH)_2 \cdot H_2O$]
[e]Barium hydroxide, hydration not specified

Barium oxide is used to dry gases and solvents, strengthen ceramics, and as a component in some specialty cements. Barium hydroxide plays a role in glass manufacturing, synthetic rubber vulcanization, in the production of barium greases and plasticizers, as a component in sealants, pigment dispersion, paper manufacturing, sugar refining, in animal and vegetable oil refining, and in the protection of objects made of limestone from deterioration. Barium acetate is used in printing fabrics, in lubricating grease, and as a catalyst for organic reactions. Finally, the main function of barium sulfide is to act as a starting point for the production of a number of other barium compounds (Dibello et al. 2003; ILO 1983). This compound is also used in the production of thin-film electroluminescent phosphors and the vulcanization of carbon black-filled neoprene rubbers.

Barium and its compounds have several important medical uses as well. Barium chloride was formerly used in treating complete heart block, because periods of marked bradycardia and asystole were prevented through its use. This use was abandoned, however, mainly due to barium chloride's toxicity (Hayes 1982). Characterized by extreme insolubility, chemically pure barium sulfate is non toxic to humans. It is frequently utilized as a benign, radiopaque aid to x-ray diagnosis in colorectal and some upper gastrointestinal examinations, because it is normally not absorbed by the body after oral intake (de Zwart et al. 2001; Doull et al. 1980; ILO 1983; Lin 1996; Newman 1998; Pijl et al. 2002; Rae 1977).

5.4 DISPOSAL

In case of a spill, it is suggested that persons not wearing protective equipment be restricted from the area. Furthermore, ventilation should be provided in the room and the spilled material collected in as safe a manner as possible. Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 1,000 pounds or 454 kg (HSDB 2007). Barium compounds (particularly soluble ones) should be placed in sealed containers and reclaimed or disposed of in a secured sanitary landfill (IPCS 1991; NIOSH/OSHA 1978). It is also suggested that all federal, state, and local regulations concerning barium disposal should be followed (HSDB 2007). No other guidelines or regulations concerning disposal of barium and its compounds were found.