DIATOMITE

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Production of diatomite in the United States increased by 4% to 620,000 metric tons (t), and its value increased 12% to $177 million free on board (f.o.b.) plant in 2004 compared with 599,000 t valued at $159 million f.o.b. plant in 2003 (table 1). The United States remained the world's leading producer and consumer of diatomite. Diatomite is used primarily for filtration; major diatomite products were sold as various grades of calcined powders (table 2). Encroachment into diatomite markets by natural and synthetic substitute materials remained minimal, and use as fillers and for biological filtration, including filtering human blood plasma, continued to grow. Other uses of diatomite included absorbents and insulation.

Domestic Data Coverage

Domestic production data for diatomite was developed by the U.S. Geological Survey (USGS) from an annual voluntary survey of U.S. diatomite-producing sites and company operations. The canvass for 2004 covered 6 diatomite-producing companies with 12 separate mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Two of the mining operations were reported inactive in 2004. Because two of the companies did not respond to the 2004 survey, sold and used data for these companies were estimated based on past production figures. Data are rounded to no more than three significant figures. All percentages in this report were computed based on unrounded data.

Description and Terminology

Diatomite is a chalk-like, soft, friable, earthy, very fine grained, siliceous sedimentary rock, usually light in color (white if pure, commonly buff to gray in situ, and rarely black). It is very finely porous, very low in density, and essentially chemically inert in most liquids and gases. Diatomaceous earth (often abbreviated as D.E.) is a common alternate name but is more appropriate for the unconsolidated or less lithified sediment. The deposits result from an accumulation in oceans or fresh waters of the amorphous hydrous silica (opal, $SiO_2 \cdot H_2O$) cell walls of dead diatoms, which are microscopic single-cell aquatic plants (algae). The diatom cells contain an internal, elaborate siliceous skeleton consisting of two valves (frustules) that vary in size from less than 1 micrometer (µm) to more than 1 millimeter in diameter but are typically 10 to 200 µm across and have a broad variety of delicate, lacy, perforated shapes varying from spheres and cylinders to discs, ladders, feathers, and needles. Additional information on the environmental and physical properties of diatoms can be found in Moyle and Dolley (2003) and Dolley and Moyle (2003).

Diatomite can form an excellent reservoir rock for hydrocarbons. The Belridge diatomite in the San Joaquin Basin in California is an example of an oil-producing diatomaceous formation (Schlumberger Limited, 2005§[1]). Diatomite is also known as kieselgur (a German name compounded from the words for flint and for an earthy sediment in water) and as tripolite after a diatomite occurrence near Tripoli, Libya. The term tripolite is used in some Government trade documents and tariff codes as the short name for a group of siliceous fossil meals and similar siliceous earths that can include diatomite (U.S. International Trade Commission, 2005§). An impure (up to 30% clay) Danish variety of diatomite is called moler.

The estimated world production in 2004 was about 1.93 million metric tons (Mt) (table 5). World reserves are estimated to be 920 Mt, which is about 450 times more than the current estimated world production rate of about 1.93 million metric tons per year (the average world production of the last 5 years). About 250 Mt of the estimated 920 Mt in world reserves is in the United States (Founie, 2005). The world reserve base was estimated by the U.S. Bureau of Mines in 1985 to be almost 2 billion metric tons (Meisinger, 1985). A resource estimate based just on the dimensions of the deposits near Lompoc, CA, suggests that collectively they could meet the world's current needs for centuries. Information on reserves is difficult to calculate because some companies are reluctant to release proprietary data and data from some nations is inadequate. The reputed world's largest producing deposit is near Lompoc, CA. Huge deposits also occur in China (Lu, 1998, p. 53).

Commercial deposits worldwide are reported to be mostly fresh water (lacustrine) deposits of Miocene to Pleistocene age. The oldest occurrences are thought to be of Cretaceous age, deposited about 138 million to 66 million years ago. It is thought that older diatomite occurrences may have altered into other forms of silica, particularly chert, owing to diagenesis, burial, and exposure. Detailed information on the geology of diatomite can be found in Wallace (2003) and Moyle and Dolley (2003).

In antiquity, diatomite was used by the Greeks as an abrasive and in making lightweight building bricks and blocks. However, diatomite only became of industrial interest in Western Europe in the mid-1800s when pulverized diatomite became the preferred absorbent and stabilizer of nitroglycerine used by Alfred Nobel to make dynamite. The site of the first U.S. production of diatomite was in Maryland in 1884. By the late 1880s, the very pure, huge deposit near Lompoc, CA, became the focus of interest and has continued to dominate world markets (Dolley and Moyle, 2003). Diatomite is now used principally as a filter aid, but it is also used as an absorbent for industrial spills and for pet litter, as a filler in a variety of products from paints to dry chemicals, as an insulation material in sawn and molded shapes and loose granules, as a mild abrasive in polishes, and as a silica additive in cement and various other compounds.

[1]References that include a section mark (§) are found in the Internet References Cited section.

Production

Recovery of diatomite from most deposits is by low-cost open pit mining because many occurrences are at or near the surface and the topography allows for open pit mining. Outside the United States, however, underground mining is fairly common owing to deposit form and depth as well as topographic and other constraints. Explosives are not normally needed either at surface or in underground mines because of the soft, friable nature of the rock. In Iceland, dredging is used to recover diatomaceous mud from the bottom of a lake.

Diatomite usually is processed near the mine to reduce the cost of hauling the crude ore, which can contain up to 65% water. Processing typically involves a series of crushing, drying, size reduction, and calcining operations, using heated air for conveying and classifying within the plant. Fines, especially from baghouses, are used mostly for filler-grade products, and coarser particles are used for filter grades. In the latter stages of processing, calcining is normally done in rotary kilns to effect physical and chemical changes.

Production cost allocations have been reported for the United States as 10% for mining, 60% for processing, and 30% for packing and shipping with energy costs composing 25% to 30% of direct costs (Breese, 1994, p. 405). The proportion of the product that is calcined directly affects energy consumption.

The diatomite production data used to prepare table 1 were collected by a canvass of all known mine producers in the United States by the USGS. In 2004, 620,000 t of diatomite was produced from 10 separate mining areas and 8 processing facilities in California, Nevada, Oregon, and Washington. Major producers were Celite Corporation (a subsidiary of World Minerals Inc.) (Lompoc, CA, and Quincy, WA) and Eagle-Picher Industries, Inc. (Lovelock and Fernley, NV, and Vale, OR). California was the leading producing State, followed closely by Nevada. The combined production of these two States accounted for about 78% of the U.S. production in 2004.

Consumption

Apparent domestic consumption (production sold or used based on the USGS survey plus imports minus exports using trade data furnished by the U.S. Census Bureau; stock data were not available) of diatomite in 2004 was about 478,000 t, up by about 3% from 464,000 t in 2003. According to data from the USGS survey, the total domestic and export quantity of filter-grade diatomite sold or used by U.S. producers was 467,000 t in 2004, up by 10% from 425,000 t in 2003. Use of diatomite as a filler was 75,000 t in 2004, down slightly from 76,000 t in 2003. For absorbents, 46,000 t was consumed, down by 27% from 64,000 t in 2003. Diatomite used as insulation fell by 19% to 12,000 t in 2004 from 15,000 t in 2003. Other consumption applications rose slightly in 2004 to 20,000 t, with special product sales and cement manufacturing constituting the majority of that amount. Filter use accounted for 75% of diatomite in 2004, up from 71% in 2003. Use as a filler fell slightly in 2004 to 12% of total consumption, while absorbent use fell to 7%. The percentage of diatomite used for insulation and in other uses accounted for 2% and 3%, respectively, about the same percentage of total consumption for both of those use categories as in 2003.

Commercial diatomite products provide fine-sized, irregular-shaped porous noncaking particles that have a large surface area and high liquid absorption capacity. They are relatively inert chemically, have a low refractive index, are mildly abrasive, have low thermal conductivity with a reasonably high fusion point, can be slightly pozzolanic, are very high in silica, and can be produced and delivered at a cost consistent with customer applications. Sawn shapes, which continue to account for a significant part of world diatomite production, have long been used as lightweight building material, especially in China, and primarily for thermal insulation (especially the high-clay-containing Danish moler). Both dried natural products and calcined products are used in the aforementioned building applications.

The major use of diatomite is as a filtration medium for beverages (especially beer and wine), sugar and sweetener liquors, oils and fats, petroleum and chemical processing (including reprocessing waste drycleaning fluids), pharmaceuticals, and water (potable, industrial process, waste, and swimming pool). Another large use is as an absorbent for industrial spills (oil and toxic liquids) and for pet litter. Another important broad category of use is as a filler, often serving a dual purpose, such as an extender and flatting agent in paints and coatings; a bulking and anticaking agent in granular materials; and as a multieffect component in plastics (including preventing films from sticking). Other filler uses are as an extender and absorbent carrier for dry pesticides, pharmaceuticals, catalysts, and other chemicals (Crossley, 2000, p. 135).

Significant other uses are as an insulation material in bulk (loose) and molded forms, other insulation products that include calcium silicate as a component, and as a silica additive in various compounds, including mortar and portland cement where it is used also for its pozzolanic properties. Commercial diatomite products are offered in a great variety of grades. Principal grading factors are the size, shape, overall arrangement, and proportions of the various types of frustules (factors that affect filtration rate, product clarity, and absorption capacity), the content of silica, and various impurities, such as certain minerals and chemicals especially iron, a major impurity, as well as clay, sand, and organics.

Additional specialized application specifications are brightness/whiteness and abrasive hardness. Reduced free-crystalline silica content, although normally low, also is required by some environmental regulations, particularly for calcined products. Calcining removes organics, increases filtration rate, oxidizes iron, increases specific gravity, increases particle hardness, and can lighten the color. Flux-calcining significantly affects the physical and chemical properties and makes a white product. Most filter grades are calcined.

Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 2004, using USGS survey data, was $286 per metric ton f.o.b plant, an increase of about 8% compared with about $265 per ton in 2003 (table 3). The average values per ton for filtration uses rose in 2004 to about $269 per ton, up by 9% from the 2003 values. The value for diatomite used for absorbents decreased by about 24% to $72.94 per ton, and for diatomite used as fillers, the value decreased by 3% to $360.65 in 2004 compared with 2003. The value for diatomite used in insulation increased by about 23% to $43.41 in 2004 compared with 2003. The 2004 average value for specialized or other uses rose by about 5% to about $1,020 per ton from the average value in 2003.

Foreign Trade

Export and import data presented here, which are from the U.S. Census Bureau, are of limited accuracy owing to inconsistencies in producer reporting and because there is a lack of detail for the various materials specified in the 2004 Harmonized Tariff Schedule (HTS) issued by the U.S. International Trade Commission. Exports of diatomite from the United States in 2004 were about 143,000 t, according to the U.S. Census Bureau (table 4). This accounted for about 22% of total domestic production sold or used, as shown in data collected by the USGS survey, and was 10,000 t more than 2003 exports.

The data were issued under heading 2512 of the HTS, described as applying to natural and straight-calcined diatomite, but industry sources indicated that exports also included some flux-calcined material. However, according to HTS explanatory notes issued by the World Customs Organization, flux-calcined material is included under another code (3802.90.2000) where it is not differentiated from activated clays. Similarly, heat-insulating mixtures and sawn and molded unfired shapes of diatomite are in an "other" data classification (code 6806.90.0090) and are not exclusively identified as diatomite. Also, fired, sawn, and molded shapes of diatomite are covered in a separate category (heading 6901) that is not exclusively for diatomite data. According to the U.S. Census Bureau data, products were exported to 93 countries (table 5).

The main export markets were Canada (17,600 t), Belgium (13,700 t), Germany (12,390 t), the Netherlands (12,380 t), Japan (9,000 t), and Australia (7,000 t), accounting for 53% of the total exports reported. Based on the available data, the average unit value free alongside ship of exported diatomite was $375 per ton compared with $318 per ton in 2003, an increase of 18% (table 4). Because the data may not include all the higher value material, as discussed above, actual average unit values may be higher. Import data available for diatomite show that 1,707 t came from eight countries in 2004. Spain provided 65%, France provided 13%, and the remainder came from Italy, Australia, Mexico, China, Japan, and Switzerland, in descending order of tonnage.

World Review

For 2004, world output was estimated to be 1.93 Mt, only slightly higher than that of 2003 (table 5). Chinese and Japanese diatomite production increased slightly in 2004 when compared with the previous year. The United States was the leading producer, consumer, and exporter of diatomite and accounted for 32% of total world production, followed by China with 20%, Denmark with 12% (all moler products), Japan with 7%, France with 4%, the Commonwealth of Independent States with 4%, and Mexico with 3%. Small amounts of diatomite were produced in 20 other countries.

Outlook

The rise in production was small, and the diatomite market grew slightly in 2004. Industry representatives expected the diatomite market to be stable for the next several years, with the export market continuing to remain strong. A change in the amount of diatomite used as a filtration medium would be linked to changes in the markets of products that use diatomite in their filtering process. Diatomite use in filtration for human blood plasma was expected to continue expanding. Increased energy costs and possible global overcapacity, however, may represent impediments to future expansion. The past encroachments into filter applications by more advanced technology (carbon membranes, ceramic, and polymeric) were not a major concern to diatomite producers possibly because of cost factors and tradition, particularly in the brewing and wine industries. Disposal of diatomite waste, however, was a problem not fully resolved by recycling. The problem of free-crystalline silica associated with diatomite, particularly when calcined, was expected to continue to be a concern. Finally, with the large domestic and world reserve bases, it appears that the projected demand will be adequately supplied for the foreseeable future.

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TABLE 1
DIATOMITE SOLD OR USED, BY PRODUCERS IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars)

	2003[r]	2004
Domestic production, sales:		
Quantity	599	620
Value	159,000	177,000

[r]Revised.
[1]Data are rounded to no more than three significant digits.

TABLE 2
DIATOMITE SOLD OR USED, BY MAJOR USE[1]

(Percentage of U.S. production by metric tons)

	2003	2004
Absorbents	11 r	7
Fillers	13 r	12
Filtration	71 r	75
Insulation	2 r	2
Other[2]	3	3

[r]Revised.
[1]Includes exports.
[2]Includes silicate admixtures (especially for cement) and unspecified uses.

TABLE 3
AVERAGE VALUE PER METRIC TON OF DIATOMITE, BY MAJOR USE[1]

	2003	2004
Absorbents	$95.59 r	$72.94
Fillers	371.08 r	360.65
Filtration	246.94 r	269.25
Insulation	35.27 r	43.41
Other[2]	970.12	1,020.00
Weighted average	264.77 r	285.72

[r]Revised.
[1]Based on unrounded data.
[2]Includes absorbents and silicate admixtures.

TABLE 4
U.S. EXPORTS OF DIATOMITE[1, 2]

(Thousand metric tons and thousand dollars)

Year	Quantity	Value[3]
2003	136	43,300
2004	143	53,700

[1]Harmonized Tariff System (HTS) heading 2512.00.0000, natural and straight-calcined grades, but in practice probably includes an undetermined quantity of flux-calcined product HTS heading 3806.90.2000.
[2]Data are rounded to no more than three significant digits.
[3]Free alongside ship U.S. customs value.

TABLE 5

DIATOMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2000	2001	2002	2003[e]	2004[e]
Algeria	3 [e]	3	3	3	3
Argentina	18	17 [r]	23	25 [r, 3]	25
Australia[e]	20	20	20	20	20
Brazil, marketable[e]	13	13	13	13	13
Chile	13	23	30	26 [r, 3]	25
China[e]	350	350	370	380	390
Colombia[e]	4	4	4	4	4
Commonwealth of Independent States[e, 4]	80	80	80	80	80
Costa Rica	35	26	26 [e]	26 [r, 3]	26
Czech Republic	34	83	28	41 [r]	30
Denmark[e, 5]	234	231	230 [r]	232	233
France[e]	75	75	75	75	75
Iceland	28	30	31 [e]	30	29
Iran[e, 6]	5	5	5	5	5
Italy[e]	25	25	25	25	25
Japan	136 [r]	132 [r]	112 [r]	129 [r, 3]	130
Kenya	(7)	(7)	1	1	1
Korea, Republic of	34	28	21	16 [r, 3]	16
Macedonia[e]	5	5	5	5	5
Mexico	96	69	62	68 [r, 3]	70
Mozambique	--	--	--	-- [3]	3
Peru[e]	35	35	35	35	35
Poland	1	1	1	1	1
Portugal[e]	2	2	2	2	2
Romania	9	10	20	31 [r, 3]	30
Spain[e, 8]	35	35	35	35	35
Thailand	(7)	1	1	1 [r, 3]	1
United States[9]	677	644	624	599 [r, 3]	620 [3]
Total	1,970 [r]	1,950 [r]	1,880 [r]	1,910 [r]	1,930

[e]Estimated. [r]Revised. -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown. Purity and moisture content are generally not reported or estimated.

[2]Table includes data available through April 4, 2005.

[3]Reported figure.

[4]Information is inadequate for formulation of reliable estimates for individual countries.

[5]Data represent "extracted moler" (reported cubic meters times 1.5). Contains about 30% clay.

[6]Data are for Iranian years beginning March 21 of that stated.

[7]Less than ½ unit.

[8]Includes tripoli.

[9]Sold or used by producers.