



# 2007 Minerals Yearbook

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## DIATOMITE

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Production of diatomite in the United States decreased by 14% to 687,000 metric tons (t), with a corresponding decrease in value of \$162 million free on board (f.o.b.) plant in 2007 compared with 799,000 t valued at \$176 million f.o.b. plant in 2006 (table 1). The United States remained the world's leading producer and consumer of diatomite.

Diatomite used for filtration represented 51% of consumption. Its use as a cement additive was next at 26%, followed by its utilization as a filler (9%), an absorbent (7%), and as an insulation constituent (2%). Other diatomite applications, including abrasives, insecticide, and soil conditioner, accounted for the remainder (table 2). Major diatomite products were sold as various grades of calcined powders.

Encroachment into diatomite markets by natural and synthetic substitute material remained minimal, particularly for beverage filtration. Use as a biological filter for human blood plasma continued to grow. Following concerns of free crystalline silica, the use of diatomite as a filler experienced a drop in 2006, but remained constant in 2007.

Diatomite is a chalk-like, soft, friable, earthy, very fine grained, siliceous sedimentary rock comprised of fossilized diatom remains. Diatomite often has a light color (white if pure, commonly buff to gray in-situ, and rarely black). It's extremely light because of its low density and high porosity, and essentially chemically inert. Diatomaceous earth (often abbreviated as D.E.) is a common alternate name but is more appropriate for the unconsolidated or less lithified sediment. Diatomite is also known as kieselguhr (Germany), tripolite (after an occurrence near Tripoli, Libya), and moler (an impure Danish form). Alfred Noble named his explosive invention, dynamite, following his discovery that nitroglycerin could be stabilized if first absorbed in diatomite (Nobel, 1868).

Diatomite deposits form from an accumulation of amorphous hydrous silica cell walls of dead diatoms in both oceanic and fresh waters. These microscopic single-cell aquatic plants (algae) contain an internal, elaborate siliceous skeleton consisting of two frustules (valves) that vary in size from less than 1 micrometer ( $\mu\text{m}$ ) to more than 1 millimeter in diameter, but are typically 10 to 200  $\mu\text{m}$  in diameter. The frustules have a broad variety of delicate, lacy, perforated shapes, including cylinders, discs, feathers, ladders, needles, and spheres. Additional information on the environmental and physical properties of diatoms can be found in Dolley and Moyle (2003) and Moyle and Dolley (2003). The oldest occurrences are thought to be of Cretaceous age, deposited about 66 million to 138 million years ago. Older diatomite occurrences may have been 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).

## Domestic Data Coverage

Domestic production data for diatomite were developed by the U.S. Geological Survey (USGS) from a voluntary annual survey of U.S. diatomite-producing sites and company operations. The canvass for 2007 covered 7 diatomite-producing companies with 12 mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. For the single company that did not respond, its 2007 production was estimated on the basis of historical production, coupled with hours worked in 2007, as reported to the Mine Safety and Health Administration. Data were rounded to no more than three significant figures. All percentages in this report were computed based on unrounded data.

## Production

In 2007, 687,000 t of diatomite was produced from 12 separate mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Major producers were Celite Corp. (a subsidiary of Imerys USA, Inc.) with mines and facilities in California, Nevada, and Washington, and EP Minerals, LLC (a subsidiary of EaglePicher Corp.) with operations in Nevada and Oregon. California was the leading producing State, followed by Nevada. The combined output of these two States accounted for about 86% of the U.S. production in 2007.

Because diatomite occurrences are at or near the earth's surface, recovery from most deposits is achieved through low-cost, open pit mining. Outside the United States, however, underground mining is fairly common owing to deposit location and topographic constraints. Explosives are generally not required for surficial or subsurface mining because of the soft, friable nature of the deposits. In Iceland, dredging is used to recover diatomaceous mud from a local lake bottom.

Diatomite is often processed near the mine to reduce transportation costs associated with 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. Fine-sized diatomite grains, especially from baghouses, are used most often for filler-grade products, while coarser particles are employed for filtration purposes. In the latter processing stages, calcining is performed in rotary kilns to effect chemical and physical changes.

Production costs for the United States average 10% for mining, 60% to 70% for processing, and 20% to 30% for packing and shipping. Energy costs compose a large and growing portion (25% to 30%), both in the direct costs of mining and transportation, as well as within the energy-intensive

calcining process. Diatomite used for cement production does not normally require calcining, and the reported unit value is considerably lower. For 2007, overall diatomite production was down, most likely as a result of the continuing decline in the domestic housing sector, a major user of cement, fillers, and insulation.

## Consumption

Apparent domestic consumption (production, plus imports of 4,000 t, less exports) of diatomite in 2007 was approximately 548,000 t, a decrease of roughly 16% from 656,000 t in 2006. The total domestic and export quantity of filter-grade diatomite sold or used by U.S. producers was 350,000 t in 2007, a decrease of 26% from 474,000 t in 2006, accounting for 51% of total diatomite sold or used. Diatomite remains the dominant filtration medium with estimates suggesting it represents 65% of the total filtration market (Moore, 2008). Diatomaceous earth used in cement manufacture accounted for 26%, or 179,000 t, of total consumption in 2007, a slight increase from the 176,000 t, which accounted for 22% of the 2006 production.

Use of diatomite as a filler was 62,000 t in 2007, down by 17% from the 75,000 t in 2006, which accounted for 9% of total diatomite sold or used. For absorbents, 48,000 t of diatomite was reported, an increase of 33% from 36,000 t in 2006, accounting for 7% of total diatomite sold or used. Diatomite use for insulation decreased by 15% to 14,000 t in 2007 from 16,500 t in 2006, accounting for 2% of total diatomite sold or used.

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 chemically inert, have a low refractive index, are mildly abrasive, have a 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-content Danish moler). Both dried natural products and calcined products are used in the aforementioned building applications. The major use of diatomite continues to be as a filtration medium for beverages (especially beer and wine), sugar and sweetener liquors, oils and fats, petroleum and chemical processing (including reprocessing waste dry cleaning fluids), pharmaceuticals, and water (industrial process, potable, swimming pool, and waste). Another leading 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 flattening 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 catalysts, dry pesticides, pharmaceuticals, and other chemicals. Other significant uses are as an insulation material in bulk (loose) and molded forms, and as a silica additive in various compounds, including mortar and

portland cement where its pozzolanic properties are utilized.

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). Other factors include silica content, impurity levels (especially iron), and the presence of clay, sand, and organics. Brightness, whiteness, and abrasive hardness are considered for specialized diatomite applications. Free-crystalline silica content, although normally low, is required to be identified, particularly for calcined products. Calcining removes organics, increases filtration rate, oxidizes iron, increases specific gravity, increases particle hardness, and can lighten color. Flux-calcining significantly affects the physical and chemical properties and makes a white product. Most filter grades are calcined.

In antiquity, diatomite was used by the Greeks as an abrasive and in the production of lightweight building bricks and blocks. In the late-1800s, diatomite became of industrial interest in Western Europe when pulverized diatomite was the preferred absorbent and stabilizer of nitroglycerine used to make dynamite. Maryland was the site of the first U.S. production of diatomite in 1884. By the late 1880s, very pure, huge deposits near Lompoc, CA, became the focus of interest and have continued to dominate world markets (Dolley and Moyle, 2003). While diatomite is principally used as a filtration medium, other uses include those of a silica additive in cement and various other compounds, a filler in a variety of products from paints to dry chemicals, an absorbent for industrial spills and pet litter, an insulation medium in sawn and molded shapes and loose granules, a mild abrasive in polishes, and for the purification and extraction of DNA.

## Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 2007, using USGS survey data and estimates, was \$237 per metric ton free on board (f.o.b.) plant, an increase of about 8% compared with about \$220 per ton in 2006 (table 3). The average values for filtration uses rose by 33% in 2007 to about \$352 per ton from \$264 per ton reported in 2006. The value for diatomite used for absorbent purposes rose by 10% to \$41 per ton. The unit value for material used as fillers increased by 11% to \$438 per ton in 2007 and in insulation increased by 10% to \$49 per ton in 2007. The average value for specialized or other uses in 2007 decreased by approximately 75%, to \$230 per ton, from \$932 per ton in 2006. This substantial decrease represents an interpretation change in the data, specifically in the category of specialized or other uses, which were dominated by lower-cost abrasives and lightweight aggregates in 2007.

## Foreign Trade

Export and import data presented here, from the U.S. Census Bureau, may be of limited accuracy. This is a result of reporting inconsistencies from producers and a lack of detail for various materials, one of which includes diatomite, specified in the 2007 Harmonized Tariff Schedule of the United States (HTS)

issued by the U.S. International Trade Commission. Exports of diatomite from the United States in 2007 were approximately 143,000 t, about 7,000 t less than in 2006 (table 4). Exports accounted for about 21% of total domestic production sold or used. The trade data were issued under heading 2512 of the HTS, described as applying to siliceous fossil meals, including kieselguhr, tripolite, diatomite, and similar siliceous earths of an apparent specific gravity of 1 or less. Industry sources, however, indicated that exports also included some flux-calcined material, which is included under 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 collected under data classification code 6806.90.0090 and are not exclusively identified as diatomite. Lastly, fired, sawn, and molded shapes of diatomite are covered under heading 6901, which is not exclusively used for diatomite data.

According to the U.S. Census Bureau data, diatomite and diatomite products were exported to 89 countries in 2007, with 27 countries accounting for 91% of the total. The main export markets were Canada (26,248 t), Germany (17,212 t), Belgium (12,063 t), Russia (7,527 t), Japan (6,819 t), Thailand (5,868 t), Australia (5,362 t), Taiwan (4,798 t), France (4,578 t), and the United Kingdom (4,302 t). These 10 countries accounted for 66% of the total exports reported. Based on the available data, the average unit value free alongside ship of exported diatomite was \$421 per ton in 2007 compared with \$1,050 per ton in 2006, a decrease of 60% (table 4). The large drop reflects what may have been a spike in 2006; the 2005 export average unit value was \$425, and \$375 in 2004. Import data available for diatomite show that 3,570 t came from 14 countries in 2007. Spain was the leading source with 1,640 t (46%), Italy with 799 t (22%), the Netherlands with 349 t (10%), Mexico with 270 t (8%), France with 222 t (6%), and China with 105 t (3%). The remainder came from Argentina, Australia, Belgium, Canada, Chile, India, Indonesia, and Japan.

## World Industry Structure

The estimated world production in 2007 was about 2.1 Mt (table 5). World reserves are thought to be almost 1 billion metric tons (Gt), which is more than 500 times the current annual estimated world production rate of 2.06 Mt. About 250 Mt, or 25%, of the estimated 1 Gt world reserve is in the United States (Dolley, 2008). The world reserve base was estimated by the U.S. Bureau of Mines in 1985 to be almost 2 Gt (Meisinger, 1985). The world's reputed largest producing district in terms of volume is near Lompoc, CA. A resource assessment of this location suggests these deposits could singularly meet the world's current diatomite consumption for hundreds of years. Data regarding reserve calculations can be challenging because some data are proprietary and not released by companies and countries. Huge deposits, on the order of at least 110 Mt of reserves, occur in China (Lu, 1998, p. 53; Dolley, 2008).

The five leading diatomite producers in 2007 were, in decreasing order of production, the United States, China, Denmark, Japan, and France. The United States continued to be the leading producer, consumer, and exporter of diatomite, and accounted for 33% of total world production, followed by China

with 20%, Denmark with 11% (all molar products), and Japan with 6%. The Commonwealth of Independent States and France each represented 4% of world production, Mexico, 3%. Smaller amounts of diatomite were mined in 24 additional countries.

## Outlook

The recent and increasing use of diatomite as a lightweight aggregate for construction and cement uses were responsible for a 22% increase in sold and used diatomite between 2005 and 2006. The decline in the U.S. residential housing sector in 2007 was likely a contributing factor for the 14% decrease in U.S. diatomite sales and uses. Should the housing sector remain depressed, diatomite production may continue to see future declines. Likewise, sharp increases in energy costs may further impede future expansion within the industry. As a filtration medium, however, the demand for diatomite remains strong and could continue to grow, particularly as used in the filtration of human blood plasma and other biotechnical applications. Previous concerns regarding the encroachment of more advanced filter applications, including carbon membranes, ceramics, and polymers, were not a major concern in 2007. The high costs associated with these alternatives, and a cultural preference toward the use of diatomite in the brewing and wine industries, indicates a strong likelihood for the continued and widespread use of diatomite in filtration.

Disposal of diatomite waste continued to be a problem, which was not fully resolved through recycling. The associated issue of free-crystalline silica, particularly after diatomite is calcined, was expected to continue to be a concern, especially in the filler and absorbent markets. Although some diatomite deposits were reported as low in free-crystalline silica, an effort to classify diatomite, and related absorbent products, as free of this material remains contentious, litigious, and, to date, unsuccessful. The use of uncalcined diatomite has replaced its calcined counterpart in some markets. Adequate supplies of diatomite, owing to the large domestic and world reserve bases and coupled with small or static changes in demand, will probably remain available for the foreseeable future.

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## GENERAL SOURCES OF INFORMATION

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TABLE 1  
 DIATOMITE SOLD OR USED BY PRODUCERS IN THE  
 UNITED STATES<sup>1</sup>

(Thousand metric tons and thousand dollars)

	2006	2007
Domestic production, sales:		
Quantity	799	687
Value	176,000	163,000

<sup>1</sup>Data are rounded to no more than three significant digits.

TABLE 2  
 DIATOMITE SOLD OR USED, BY MAJOR USE<sup>1</sup>

(Percentage of U.S. production)

	2006	2007
Absorbents	5	7
Cement <sup>2</sup>	22	26
Fillers	9	9
Filtration	59	51
Insulation	2	2
Other <sup>3</sup>	3	5

<sup>1</sup>Includes exports.

<sup>2</sup>As ingredient in portland cement.

<sup>3</sup>Includes abrasives, lightweight aggregates, and unspecified uses.

TABLE 3  
AVERAGE VALUE PER METRIC TON OF DIATOMITE,  
BY MAJOR USE<sup>1</sup>

	2006	2007
Absorbents	\$37	\$41
Cement <sup>2</sup>	3	9
Fillers	395	438
Filtration	264	352
Insulation	44	49
Other <sup>3</sup>	932	230
Weighted average	220	237

<sup>1</sup>Rounded estimates.

<sup>2</sup>As ingredient in portland cement.

<sup>3</sup>Includes abrasives, lightweight aggregates, and unspecified uses.

TABLE 4  
U.S. EXPORTS OF DIATOMITE<sup>1,2</sup>

(Thousand metric tons and thousand dollars)

Year	Quantity	Value <sup>3</sup>
2006	150	158,000 <sup>4</sup>
2007	143	60,000

<sup>1</sup>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.

<sup>2</sup>Data are rounded to no more than three significant digits.

<sup>3</sup>Free alongside ship value.

<sup>4</sup>All or part of these data have been referred to the U.S. Census Bureau for verification.

Source: U.S. Census Bureau.

TABLE 5  
DIATOMITE: WORLD PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Thousand metric tons)

Country	2003	2004	2005 <sup>e</sup>	2006 <sup>e</sup>	2007 <sup>e</sup>
Algeria	3	3	2 <sup>3</sup>	2 <sup>r</sup>	2
Argentina	36	27 <sup>r</sup>	34 <sup>r,3</sup>	38 <sup>r,3</sup>	39
Australia <sup>c</sup>	20	20	20	20	20
Brazil, marketable <sup>c</sup>	7	7	8	11 <sup>r,3</sup>	10 <sup>p</sup>
Chile	26	30	27 <sup>3</sup>	29 <sup>r,3</sup>	29
China <sup>e</sup>	380	390	410	420	420
Colombia <sup>e</sup>	4	4	4	4	4
Commonwealth of Independent States <sup>e,4</sup>	80	80	80	80	80
Costa Rica	26	27 <sup>e</sup>	26	25 <sup>r</sup>	25
Czech Republic <sup>c</sup>	41	33	38	53 <sup>r</sup>	55
Denmark <sup>e,5</sup>	232	233	234	235	230
Ethiopia <sup>6</sup>	1	2	(7)	(7)	(7)
France <sup>c</sup>	80 <sup>3</sup>	75	75	75	75
Germany	55	54 <sup>e</sup>	54	54	54
Iceland	28	28	29	28	28
Iran <sup>8</sup>	10	8	8	9 <sup>r</sup>	9
Italy <sup>c</sup>	25	25	25	25	25
Japan	112	125	130	130	120
Kenya	(7)	(7)	(7) <sup>3</sup>	(7)	(7)
Korea, Republic of	16	2	2 <sup>3</sup>	3 <sup>r</sup>	4
Macedonia <sup>c</sup>	5	5	5	5	5
Mexico	53	59	62 <sup>3</sup>	63 <sup>r,3</sup>	63 <sup>3</sup>
Mozambique	--	3 <sup>e</sup>	5	6	6
Peru <sup>c</sup>	35	35	35	35	35
Poland	1 <sup>e</sup>	1 <sup>e</sup>	1	1	1
Portugal <sup>c</sup>	(7)	(7)	(7)	(7)	(7)
Romania	33 <sup>r</sup>	21	1 <sup>3</sup>	-- <sup>r</sup>	--
Spain <sup>e,9</sup>	53 <sup>r</sup>	34	34	34 <sup>r</sup>	34 <sup>p</sup>
Thailand	1	1	1	1 <sup>r</sup>	1
Turkey <sup>c</sup>	10	20 <sup>r</sup>	25 <sup>r</sup>	30 <sup>r</sup>	35
United States <sup>10</sup>	599	620	653 <sup>3</sup>	799 <sup>3</sup>	687 <sup>3</sup>
Total	1,970	1,970 <sup>r</sup>	2,030 <sup>r</sup>	2,220 <sup>r</sup>	2,100

<sup>e</sup>Estimated. <sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>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.

<sup>2</sup>Table includes data available through April 4, 2008.

<sup>3</sup>Reported figure.

<sup>4</sup>Information is inadequate for formulation of reliable estimates for individual countries.

<sup>5</sup>Data represent "extracted moler" (reported cubic meters times 1.5). Contains about 30% clay.

<sup>6</sup>Year ending July 7 of that stated.

<sup>7</sup>Less than ½ unit.

<sup>8</sup>Data are for year beginning March 21 of that stated.

<sup>9</sup>Includes tripoli.

<sup>10</sup>Sold or used by producers.