



2014 Minerals Yearbook

DIATOMITE [ADVANCE RELEASE]

DIATOMITE

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Production of diatomite in the United States increased by 15% to 901,000 metric tons (t), with a corresponding value of \$269 million free on board (f.o.b.) plant in 2014 compared with 782,000 t valued at \$229 million f.o.b. plant in 2013 (table 1). The United States was the world's leading producer of diatomite in 2014, providing 40% of the estimated world production total of 2.3 million metric tons (Mt) (table 5). Other leading producers, China and Peru, produced 19% and 6% of diatomite production, respectively. Diatomite was produced in 25 countries in 2014.

Diatomite used for filtration represented 55% of consumption, followed by its use as a cement additive (21%), as a filler (14%), and as an absorbent (9%). Other diatomite applications, including abrasives, insecticides, insulation, 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.

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 is extremely lightweight because of its low density and high porosity and is 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 Nobel named his explosive invention "dynamite" following his discovery that nitroglycerin could be stabilized if first absorbed in diatomite (Nobel, 1868). A unique attribute of diatomite is found within its microstructure, which often contains thousands of individual holes. These hollows are typically present in three distinct sizes, from micron to submicron diameters. The number and sizes of holes vary with the species (Imerys Minerals, Ltd., 2013).

Diatomite deposits form from an accumulation of amorphous hydrous silica cell walls of dead diatoms in 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 (μm) to more than 1 millimeter in diameter but are typically 10 to 200 μm 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 of diatomite 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).

Legislation and Government Programs

In uncommon instances of extreme heat coupled with slow cooling conditions, amorphous silica, the primary constituent of diatomite, may be altered to crystalline silica (Centers for Disease Control and Prevention, 1978; Oregon Department of Consumer and Business Services, 2007). 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 to be 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.

Production

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 USGS canvass for 2014 was sent to 6 diatomite-producing companies with 12 mining areas and 9 processing facilities. Although most companies responded, some data were not complete, and in those instances and for nonresponding operations, production was estimated on the basis of Mine Safety Health Administration reported hours worked, coupled with previous-year production information. All percentages in this report were computed based on unrounded data.

In 2014, 901,000 t of diatomite were produced from 12 separate mining areas 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 this year, followed by Nevada. The combined output of these two States accounted for about 80% of U.S. production.

Maryland was the site of the first U.S. production of diatomite in 1884. By the late 1880s, very pure, large deposits near Lompoc, CA, became the focus of interest and have continued to dominate world markets (Dolley and Moyle, 2003). Because U.S. 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 lake-bottom diatomaceous mud deposits.

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, and coarser particles are employed for filtration purposes. In the latter processing stages, calcining is performed in rotary kilns to effect chemical and physical changes.

Diatomite production costs for the United States average 60% to 70% for processing, 20% to 30% for packing and shipping, and 10% for mining. Energy costs account for a large and growing portion (25% to 30%) of diatomite production costs, such as 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, thus, processing costs are lower (Yilmaz and Ediz, 2008).

Consumption

Apparent domestic consumption of diatomite was approximately 823,000 t in 2014, an increase of approximately 19% from 691,000 t in 2013. The total quantity of filter-grade diatomite sold or used by U.S. producers was 496,000 t in 2014, an increase of 9% from 454,000 t in 2013, accounting for 55% of total diatomite sold or used. For use in absorbents, 81,000 t of diatomite was reported, a decrease of 26% from 109,000 t in 2013. Use of diatomite as a filler was 126,000 t in 2014, an increase of 24% from 102,000 t in 2013 (table 2).

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.

Commercial diatomite products provide fine-sized, irregular-shaped, porous noncaking particles that have a large surface area and high liquid-absorption capacity. The products 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). Dried natural products and calcined products are used in construction 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 in 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, nontoxic pesticides (as a desiccating agent), pharmaceuticals, and other chemicals.

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.

Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 2014, using USGS survey data and estimates, was \$298 per metric ton f.o.b. plant, a slight increase compared with about \$293 per ton in 2013 (table 3). The average unit value for diatomite used in filtration increased by 8% in 2014 to \$409 per ton from \$379 per ton reported in 2013. The value for diatomite used for absorbent purposes was \$106 per ton, an increase of 16% from 2013. The unit value for material used as fillers decreased slightly to \$394 per ton in 2014. The average value for specialized or other uses in 2014 remained unchanged at \$404 per ton.

Foreign Trade

Export and import data presented here from the U.S. Census Bureau may be of limited accuracy, which is a result of a lack of detail caused by the inclusion of diatomite with other mineral commodities within several categories in the Harmonized Tariff Schedule of the United States (HTS) administered by the U.S. International Trade Commission. Trade data were issued under heading 2512 of the HTS, described as applying to siliceous fossils, 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 HTS 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 HTS 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 U.S. Census Bureau data, diatomite and diatomite products were exported to 96 countries in 2014. Exports of diatomite from the United States in 2014 were approximately 82,000 t, about 10,000 t less than those in 2013 (table 4). Exports accounted for about 9% of total domestic production sold or used. The main export markets were Canada (18,800 t), Germany (9,480 t), the Republic of Korea (4,790 t), South Africa (4,150 t), and China (3,860 t). These five countries accounted for 50% of the total reported exports. Based on

available Census trade data, the average unit value free alongside ship of exported diatomite was \$539 per ton in 2014 compared with \$529 per ton in 2013 (table 4). Import data for diatomite show that 4,030 t came from eight countries in 2014. Canada was the leading source with 2,610 t (65%), followed by Mexico with 886 t (22%), Japan with 236 t (6%), Italy with 131 t (3%), and France with 91 t (2%). These five countries provided 98% of the imports to the United States in 2014.

World Review

Estimated world production of diatomite in 2014 was 2.3 Mt (table 5). The large increase in production reported by the Republic of Korea in 2013 and 2014 was likely a result of recategorizing diatomite with other siliceous materials and should not be interpreted as a corresponding increase in diatomite mining. World reserves are thought to be almost 1 billion metric tons (Gt), which represents approximately 500 times the annual estimated world production rate. About 250 Mt, or 25% of the estimated 1 Gt of world reserves, is in the United States (Crangle, 2015). The world's largest producing district in terms of volume is near Lompoc, CA. A resource assessment of this location indicated that these deposits could supply all of the world's current diatomite consumption for hundreds of years. Compilations of reserve estimates are not comprehensive because some data are proprietary and not released by companies or countries. Huge deposits, on the order of at least 110 Mt of reserves, have been reported in China (Lu, 1998, p. 53).

In 2014, the United States was the leading producer of diatomite, accounting for 40% of total world production, followed by China with 19%, Peru with 6%, and Argentina and Denmark (all molar products), each with 4%. Smaller quantities of diatomite were mined in 21 additional countries (table 5).

Outlook

With the exception of depressed production while the world was recovering from an economic downturn, annual U.S. production has been more than 600,000 t for more than 20 years, with production exceeding 900,000 t in 2014. Adequate supplies of diatomite, owing to the large domestic and world reserves, coupled with small or no changes in demand, probably will remain available for the foreseeable future. The economic stability of the diatomite industry was largely due to its use as a filtration medium, where its demand remains strong, particularly in the filtration of spirits as well as human blood plasma and in other biotechnical applications. Likewise, the encroachment of more advanced filter applications, including carbon membranes, ceramics, and polymers, were not a concern in 2014. The high costs associated with these alternatives and a cultural preference toward the use of diatomite in the brewing and wine industries indicate a strong likelihood for the continued widespread use of diatomite in filtration.

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TABLE 1
DIATOMITE SOLD OR USED BY PRODUCERS IN THE
UNITED STATES¹

(Thousand metric tons and thousand dollars)

	2013	2014
Domestic production, sales:		
Quantity	782	901
Value	\$229,000	\$269,000

¹Data are rounded to no more than three significant digits.

TABLE 2
DIATOMITE SOLD OR USED, BY MAJOR USE¹

(Percent of U.S. production)

	2013	2014
Absorbents	14	9
Cement ²	14	21
Fillers	13	14
Filtration	58	55
Other ³	(4)	1

¹Includes exports.

²As ingredient in portland cement; includes lightweight aggregates.

³Includes abrasives, insulation, and unspecified uses.

⁴Less than ½ unit.

TABLE 3
AVERAGE VALUE PER METRIC TON OF DIATOMITE,
BY MAJOR USE¹

(Dollars per metric ton)

	2013	2014
Absorbents	91	106
Cement ²	10	10
Fillers	398	394
Filtration	379	409
Insulation	54	54
Other ³	404 ⁴	404
Weighted average	293	298

¹Revised.

¹Rounded estimates.

²As ingredient in portland cement.

³Includes abrasives, lightweight aggregates, and unspecified uses.

TABLE 4
U.S. EXPORTS OF DIATOMITE^{1,2}

(Thousand metric tons and thousand dollars)

Year	Quantity	Value ³
2013	92	\$48,700
2014	82	\$44,200

¹Harmonized Tariff Schedule (HTS) number 2512.00.0000, natural and straight-calcined grades, but in practice may include an undetermined quantity of flux-calcined product, which should be reported as HTS number 3806.90.2000.

²Data are rounded to no more than three significant digits.

³Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 5
DIATOMITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Thousand metric tons)

Country	2010	2011	2012	2013	2014
Algeria	2 ³	2	2	2 ³	2 ³
Argentina	54 ³	61 ³	100 ^r	100	100
Armenia	(4)	(4)	(4)	-- ^r	--
Australia	20	20	20 ^r	20	20
Brazil, marketable	4 ³	4 ³	2	2	2
Chile	31 ³	23 ³	23	27 ³	27
China	400	440	420	420	420
Costa Rica	14 ³	4 ³	4	4	4
Czech Republic	--	46	43	49	49
Denmark ⁵	100 ^r	101 ^r	89 ^r	103 ^r	95
Ethiopia	4	4	5	5	5
France	75	75	75	75	75
Italy	25	25	25	25	25
Japan	110	100	100	90	90
Kenya	(4) ³	1 ³	2	1	1
Korea, Republic of, diatomaceous earth	2 ³	5 ³	6	34	34
Mexico	92 ³	84 ³	85	87	88
Mozambique	(4) ³	(4) ³	1 ³	87 ^r	88
Peru	11	10	94 ³	125	125
Poland	1	1	1	1	1
Russia	32	33	70	70	70
Spain ⁶	64	54	61 ^r	36	36
Thailand	7 ^r	38	9	-- ^r	--
Turkey	18 ³	45 ³	86	85	85
United States ^{3,7}	595	813	735	782	901
Total	1,690 ^r	1,990 ^r	2,230 ^r	2,140 ^r	2,260

¹Revised. -- Zero.

²World 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.

³Includes data available through September 29, 2015.

⁴Reported figure.

⁵Less than ½ unit.

⁶Data represent "extracted moler" (reported cubic meters times 1.5). Danish extracted moler figures, in thousand cubic meters, are as follows: 2010—199 (revised); 2011—201 (revised); 2012—177 (revised); 2013—205 (revised); and 2014—190 (estimated).

Contains about 30% clay.

⁷Includes tripoli.

⁸Sold or used by producers.