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DIATOMITE

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Diatomite

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Production of diatomite in the United States decreased by 25% to 575,000 metric tons (t), with a corresponding decrease in value of $171 million free on board (f.o.b.) plant in 2009 compared with 764,000 t valued at $147 million f.o.b. plant in 2008 (table 1). The United States remained the world's leading producer and consumer of diatomite.

Diatomite used for filtration represented 55% of consumption, followed by its use as a cement additive (24%), an absorbent (10%), a filler (9%), and an insulation constituent (2%). Other diatomite applications, including abrasives, insecticides, 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 increase.

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 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).

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 (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).

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 USGS canvass for 2009 covered 7 diatomite-producing companies with 12 mining areas and 9 processing facilities. All companies responded, accounting for 100% of the production listed in table 1. Some company data were not complete and were estimated on the basis of annual hours worked, as reported by the Mine Safety 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 2009, 575,000 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 85% of U.S. production in 2009.

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

Diatomite 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%) of diatomite production costs, 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 2009, overall diatomite production was lower as a result of the economic downturn and its negative impact on the construction industry, a large consumer of diatomite.

Consumption

Apparent domestic consumption of diatomite in 2009 was approximately 488,000 t, a decrease of approximately 21% from 616,000 t in 2008. The total domestic and export quantity of filter-grade diatomite sold or used by U.S. producers was 320,000 t in 2009, a decrease of 12% from 365,000 t in 2008, accounting for 56% of total diatomite sold or used. Diatomite remains the dominant filtration medium with estimates suggesting it represents 65% of the total filtration market (Moores, 2008). Diatomaceous earth used in cement manufacture accounted for 136,000 t, or 24%, of total diatomite production in 2009, a decrease of 46% from 254,000 t, or 33% of the 2008 production.

Use of diatomite as a filler was 53,000 t in 2009, a decrease of 16% from the 63,000 t in 2008, which accounted for 9% of total diatomite sold or used. For absorbents, 56,000 t of diatomite was reported, a decrease of 20% from 70,000 t in 2008, accounting for 10% of total diatomite sold or used. Diatomite use for insulation decreased by 17% to 10,000 t in 2009 from 12,000 t in 2008, accounting for 2% of total diatomite sold or used.

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 an agent in the purification and extraction of DNA.

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 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 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 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.

Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 2009, using USGS survey data and estimates, was $255 per metric ton f.o.b. plant, an increase of about 14% compared with about $224 per ton in 2008 (table 3). The average values for filtration decreased slightly in 2009 to about $375 per ton from $380 per ton reported in 2008. The value for diatomite used for absorbent purposes was unchanged at $41 per ton. The unit value for material used as fillers increased slightly to $421 per ton in 2009, while insulation remained unchanged at $50 per ton in 2009. The average value for specialized or other uses in 2009 decreased by 45% to $1,960 per ton from $3,600 per ton in 2008. This decrease was derived from a specialty-grade form of diatomite, which is subject to large price fluctuations, and represented less than 1% of total U.S production in 2009.

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 2009 Harmonized Tariff Schedule of the United States (HTS) issued by the U.S. International Trade Commission. Exports of diatomite from the United States in 2009 were approximately

88,000 t, about 63,000 t less than in 2008 (table 4). Exports accounted for about 15% of total domestic production sold or used. The 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 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 142 countries in 2009, with 25 countries accounting for 87% of the total. The main export markets were Canada (18,668 t), Germany (11,669 t), Belgium (6,175 t), Japan (4,257 t), Australia (3,964 t), Thailand (2,750 t), Taiwan (2,548 t), Vietnam (2,525 t), Russia (2,460 t), and Korea (2,102 t). These 10 countries accounted for 65% of the total exports reported. Based on available trade data from the U.S. International Trade Commission, the average unit value free alongside ship of exported diatomite was $467 per ton in 2009 compared with $448 per ton in 2008, an increase of 4% (table 4). Import data for diatomite show that 1,257 t came from 24 countries in 2009. Italy was the leading source with 448 t (36%), Mexico with 422 t (34%), the Netherlands with 206 t (16%), France with 57 t (5%), and Australia with 41 t (3%). These five countries provided 93% of the imports to the United States in 2009.

World Review

The estimated world production of diatomite in 2009 was 1.87 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 1.87 Mt. About 250 Mt, or 25% of the estimated 1 Gt of world reserves, is in the United States (Crangle, 2010). 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. Estimating 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; Crangle, 2010).

The five leading diatomite producers in 2009 were, in decreasing order of production, the United States, China, Denmark, Mexico, and Japan. The United States continued to be the leading producer, consumer, and exporter of diatomite, and accounted for 31% of total world production, followed by China with 24%, Denmark with 12% (all moler products), and Mexico and Japan, each with 6%. Smaller amounts of diatomite were mined in 22 additional countries.

Outlook

Despite the economic downturn in 2009 and a decrease in overall production, diatomite prices increased from those in 2008. The economic stability of the mineral commodity was largely owing to its use as a filtration medium, where its demand remains strong, particularly in the filtration of human blood plasma and other biotechnical applications. Likewise, the encroachment of more advanced filter applications, including carbon membranes, ceramics, and polymers, were not a concern in 2009. 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 and widespread use of diatomite in filtration. A prolonged economic recession, however, could lead to further production declines.

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. The use of uncalcined diatomite has replaced its calcined counterpart in some markets. Adequate supplies of diatomite, owing to the large domestic and world reserves, coupled with small or no changes in demand, will probably remain available 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)

	2008	2009
Domestic production, sales:		
Quantity	764	575
Value	171,000	147,000

[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)

	2008	2009
Absorbents	9	10
Cement[2]	33	24
Fillers	8	9
Filtration	48	55
Insulation	2	2
Other[3]	(4)	(4)

[1]Includes exports.
[2]As ingredient in portland cement.
[3]Includes abrasives, lightweight aggregates, and unspecified uses.
[4]Less than ½ unit.

TABLE 3

AVERAGE VALUE PER METRIC TON OF DIATOMITE,

BY MAJOR USE[1]

	2008	2009
Absorbents	41	41
Cement[2]	9	7
Fillers	412	421
Filtration	380	375
Insulation	50	50
Other[3]	3,600	1,960
Weighted average	224	255

[1]Rounded estimates.

[2]As ingredient in portland cement.

[3]Includes 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]
2008	151	67,700
2009	88	41,100

[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 value.

Source: U.S. Census Bureau.

TABLE 5

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

(Thousand metric tons)

Country	2005	2006	2007	2008	2009
Algeria	2 [3]	2	2 [3]	2	2
Argentina	34 [3]	39 [3]	50 [3]	37 [r, 3]	40
Australia	20	20	20	20	20
Brazil, marketable	8	9 [3]	6 [3]	6 [r, 3]	6 [p]
Chile	16 [3]	19 [3]	25 [3]	25 [r, 3]	20
China	410	420	420	440	440
Colombia	-- [r]	-- [r]	-- [r]	-- [r]	--
Commonwealth of Independent States[4]	80	80	80	80	80
Costa Rica	1 [r, 3]	3 [r, 3]	4 [r, 3]	4 [r, 3]	4
Czech Republic	38	53	19	31 [r]	--
Denmark[5]	234	235	230	230	225
Ethiopia[6]	(7) [3]	-- [r, 3]	-- [r]	-- [r]	--
France	75	75	75	75	75
Germany	2 [r]	2 [r]	2 [r]	2 [r]	2
Iceland	29	28	28	28	26
Iran[8]	1	2	(7) [r]	(7) [r]	(7)
Italy	25	25	25	25	25
Japan	130 [r, 3]	130	120	115	110
Kenya	(7) [3]	(7)	(7) [r, 3]	(7) [r, 3]	(7)
Korea, Republic of	2 [3]	3 [3]	2 [3]	3 [r, 3]	3
Macedonia	5	5	5	5	5
Mexico	62 [3]	63 [3]	63 [3]	83 [3]	116 [3]
Mozambique	1 [r]	1 [r]	1 [r, 3]	(7) [r, 3]	(7)
Peru	35	35	22 [r, 3]	12 [r, 3]	10 [3]
Poland	1	1	1	1	1
Portugal	(7)	(7)	(7)	(7)	(7)
Romania	1 [3]	2 [3]	2 [r]	-- [r]	--
Spain[9]	44 [r]	52 [r]	50 [r]	50 [r]	50
Thailand	1 [3]	1 [3]	1 [3]	4 [r, 3]	2
Turkey	44 [3]	45 [3]	33 [3]	30	30
United States[10]	653 [3]	799 [3]	687 [3]	764 [3]	575 [3]
Total	1,960 [r]	2,150 [r]	1,970 [r]	2,070 [r]	1,870

[p]Preliminary. [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 March 29, 2010.

[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]Year ending July 7 of that stated.

[7]Less than ½ unit.

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

[9]Includes tripoli.

[10]Sold or used by producers.