

DIATOMITE

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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, and rarely black). It is very finely porous, very low in density (floating on water at least until saturated), and essentially chemically inert in most liquids and gases. It also has low thermal conductivity and a rather high fusion point. Diatomaceous earth and simply “D.E.” are common alternate names but they are more appropriate for the unconsolidated or less lithified sediment; many sediments and sedimentary rocks are somewhat diatomaceous. The deposits result from an accumulation in oceans or freshwater of amorphous silica (opal, $\text{SiO}_2 \cdot n\text{H}_2\text{O}$) comprising the cell walls of dead diatoms, which are microscopic single-cell aquatic plants (algae). The fossilized skeletal remains—a pair of symmetrical shells (frustules) that fit together like a pill box—vary in size from less than 1 micrometer to more than 1 millimeter but are typically 10 to 200 micrometers across and have a broad variety of delicate, lacy, perforated shapes from spheres and cylinders to discs, ladders, feathers, and needles. Each deposit has characteristic assemblages that have been used to identify the source of material for forensic purposes. There are more than 10,000 species of extinct and living diatoms. Some currently live in ice or hot springs as well as marshes or even on moist bark, but they are most abundant in sunlit water—fresh or salt—constantly being enriched with suitable nutrients and dissolved silica. Live cells are covered by a jelly, and masses appear as brownish water or films on stream bottoms. Extensive blooms of diatom algae in coastal waters have caused severe pollution, and some species produce domoic acid, a nerve poison that, if ingested, quickly causes death to many animals (Eureka, November 12, 1998, Diatoms ‘natures marbles’, accessed May 20, 1999, at URL <http://hjs.geol.uib.no/diatoms>).

Diatomite is also known as “kieselgur” (a German name compounded from the words for flint and earthy sediment in water) and as tripolite after a diatomite occurrence near Tripoli, Libya. Tripolite is used in some U.S. Government trade documents as a short term for a longer description of siliceous fossil meals and similar siliceous earths that is used more generally in the various tariff codes which cover diatomite. An impure (up to 30% clay) Danish variety is called moler.

Infusorial earth is sometimes confused with diatomaceous earth, but the former contains the skeletal remains of infusoria (ciliata) or radiolaria, both of which are minute aquatic single-cell animals (protozoa) that also have opaline silica shells (also

called tests); but mention of such deposits is not very common in the literature. Tripoli is often also confused with tripolite (i.e., diatomite) because it is also a lightweight, light-colored, very friable, very porous sedimentary rock that is a weakly consolidated aggregate of particles, but the particles are individual microcrystals of quartz rather than diatom shells. Also, tripoli is heavier and less absorbent than diatomite. Known U.S. deposits of tripoli (and the very similar “microcrystalline silica”) occur in Paleozoic or older (more than 240 million years old) limestones that contain chert layers obviously related to tripoli (Berg and Steuart, 1994, p. 1091-1095) and may have originally been diatomite deposits (Thurston, 1978, p. 122-123), whereas the oldest rocks in which abundant diatom skeletons have been found are believed to be Cretaceous, which at most are 140 million years old (Industrial Minerals, 1987).

Diatomite was apparently used by the ancient Greeks as an abrasive and in making lightweight building brick and blocks. In 535 A.D., blocks of diatomite were used for the 30-meter-diameter dome of the Church of St. Sophia in Istanbul, Turkey (Maurrasse, 1978, p. 263). In Western Europe, however, it only became of industrial interest in the mid-1800’s. One of the first uses was as cut blocks and bricks for heat insulation. In the 1860’s, pulverized diatomite became the preferred absorbent and stabilizer of nitroglycerine used by Alfred Nobel to make dynamite. In the United States, the first production of diatomite was in 1884 at a site in Maryland. By the late 1880’s, the huge, very pure deposit near Lompoc, Santa Barbara County, CA, became the focus of interest and has continued to dominate the world’s markets. Diatomite is now used principally as a filter aid. It also has many other applications as well: an absorbent for industrial spills and pet litter; a filler in a variety of products from paints to dry chemicals; an insulation material in sawn and molded shapes as well as loose granules; a mild abrasive in polishes; and a silica additive in cement and various other compounds.

Analysis of oven-dried samples of crude ore at many commercial operations typically shows 80% to over 90% silica (SiO_2) plus alumina (2%-4%, attributed mostly to clay minerals) and hematite (0.5%-2%), with an analytical ignition loss of 4%-6% of weight. Apparent oven-dry block density is 320 to 640 grams per liter (g/L) (compared to water at 1,000 g/L) with 80% to 90% voids. In-place ore contains from 10% to as much as 65% water (2% to 10% in the opaline structure). Dry crude rock can absorb 1.5 to more than 3 times its weight of water. Dry powdered natural rock has an apparent density of

¹Deceased.

80 to 250 g/L. The melting point of diatomite ranges from 1,000° C to 1,750° C (Durham, 1973, p. 192; Breese, 1994, p. 398).

Commercial diatomite products most commonly consist of fine-sized, irregular-shaped, porous, noncaking particles having a large surface area and a high liquid absorptive capacity. They are rather inert chemically (especially when iron is naturally low or altered in calcining), 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 customers' applications. Additionally there are shaped products, either sawn from natural solid material or molded from various-sized fragments and particles, normally dried or calcined, and often containing less than 75% diatomite. The shaped products have long been used as light-weight building material, especially in China (Lu, 1998, p. 54), and for insulation, primarily thermal, especially Danish moler (Harries-Rees, 1994, p. 35). Although sawn and molded shapes continue to be a significant portion of world diatomite production, particulate products are more widely used and can be tailored to fit desired uses by blending various grades of natural and calcined material. The rather uncommon range and combination of properties permits selection of those best suited for a specific application. The major category of use is as a filtration media of a great variety of grades for beverages (especially beer and wine), sugar and sweetener liquors, oils and fats, petroleum and chemical processing (including waste dry-cleaning fluids), pharmaceuticals, and water (potable, industrial process and waste, as well as swimming pool). A large and growing application is as an absorbent for industrial spills (e.g., oil and toxic liquids) and for pet litter. Another important broad category of use is as a filler, often serving dual purposes, such as an extender and/or flattening pigment in paints and coatings, a bulking and/or anticaking agent in granular materials, a multieffect component in plastics (including preventing films from sticking), and an extender and/or absorbent carrier for dry pesticides, pharmaceuticals, catalysts, and other chemicals. Other significant products include as insulation material in bulk (loose), and in calcium silicate and other insulation products as a component; a mild abrasive in polishes; and a silica additive in various compounds, including mortar and portland cement where it is also used for its pozzolanic properties. In 1993, worldwide use, including moler, was estimated to be almost one-half for filtration, more than one-quarter for fillers, one-sixth for insulation, and about one-tenth for absorption and other applications (Roskill Information Services Ltd., 1994, p. 3). Although lack of reliable data prevents a more-current estimate, available data does not indicate any major changes.

Commercial diatomite products are offered in a great variety of grades. Principal factors are the size, shape, overall arrangement and proportion of the various types of frustules (particularly the effect on filtration rate and product clarity, and absorptive capacity) and the content of silica and various impurities, such as certain minerals and chemicals (especially the form of iron, a major impurity), clay, sand, and organics. Additional specialized application specifications include

brightness/whiteness and abrasive hardness. Free crystalline silica content, although normally low, is also a specification required by some environmental regulations, particularly for calcined products. A major influence on the grade is the extent of processing within three broad classifications—naturally milled and dried; plain ("straight") calcined (to 1,000° C); and flux-calcined (to 1,200° C) by adding up to 10% of such sodium compounds, such as salt, soda ash, or sodium hydroxide. Calcining removes organics, increases filtration rate (i.e., surface area is reduced by fusing more delicate structures of particles and sintering them into small clusters, resulting in larger particle size and increased pore size), oxidizes iron to a less reactive form (which changes the buff-to-gray colors common in crude ore feed to pink or white), increases specific gravity, and increases particle hardness. Calcining also produces environmentally-undesirable free silica. Flux-calcining significantly intensifies those changes in the physical and chemical properties and makes a very white product that is desirable in some applications. Most filter grades are calcined.

Deposits of various purities occur in many parts of the world, and many are occasionally mined for only limited local or special markets. Estimated world reserves are 800 million metric tons (Mt), of which 250 Mt are in the United States (Antonides, 1999, p. 61). The total is equivalent to almost 400 times the current estimated annual world production of about 2 Mt (table 5.) The world reserve base was estimated by the U.S. Bureau of Mines in 1985 to be almost 2 billion metric tons (Meisinger, 1985, p. 250). A resource estimate based just on the dimensions of the deposits near Lompoc suggests they alone could meet the world's current needs for centuries. Data on reserves, defined as being currently economic using proven production practices among other qualifications (U.S. Bureau of Mines and U.S. Geological Survey, 1980, p. 2), however, are not readily available and are difficult to calculate because in addition to considerable variation in physical and chemical properties between and even within deposits, the particular potential use and proximity to a market are major considerations in determining economic viability.

Commercial deposits around the world are reported to be mostly freshwater lake (lacustrine) deposits of Miocene to Pleistocene age (i.e., formed 24 million to 100,000 years ago). The producing deposit that outcrops near Lompoc, reputed to be the world's largest, is a huge marine deposit of Miocene age. Although known marine occurrences generally appear to be larger than the lacustrine, a very large diatomite deposit is reported in China where all deposits were also described as being lacustrine (Lu, 1998, p. 53). The oldest marine occurrences are believed to be of Cretaceous age (i.e., formed 140 million to 65 million years ago), and any older occurrences would presumably have been changed into other forms of silica. The oldest lacustrine deposits are believed to be of Eocene age (i.e., 55 million to 38 million years old). There are younger deposits, some of which are currently developing. Worldwide, many deposits, especially the older marine type, have been found in uplifted coastal areas exposed to some volcanic effects (e.g., Pacific Rim from Chile to Japan). Lake deposits, especially in mountainous localities, also often show some

association with volcanic activity (e.g., Pacific Northwest), although lake deposits are presently forming in lowlands far removed from volcanic activity (e.g., Florida).

In the United States, California has other coastal marine deposits (undeveloped) and some interior lake deposits (few developed); Nevada has lake deposits (several developed); Arizona, Idaho, Oregon, and Washington each have several lake deposits (at least one developed in each State); Kansas has a deposit (last mined in the 1970's); Maryland and Virginia have low-purity marine deposits (no longer developed); Florida, New Hampshire, and New York have diatomaceous sediments in lake bogs (undeveloped); and several other States may have some deposits about which information is not readily available.

Outside the United States, many known deposits are on the Pacific Rim from Chile to British Columbia and from Japan, the Korean peninsula, and Eastern China to Southeast Asia and Australia. Others are in Eastern Africa, the Middle East, Eastern Europe, and Western Europe. Most deposits are estimated to be less than 5 Mt and only a very few are larger than 50 Mt, although most have limited production or prospects for development.

Exploration involves a normal sequence of first locating areas having appropriate stratigraphic horizons by using existing and/or new field mapping, aerial photography, and other remote imaging, as applicable; next, field searching for outcrops; and then sampling (chip, drill, or pit) as appropriate for analysis to decide if the potential quality and size are sufficient to do preliminary economic studies. If results are promising, then several campaigns of successively more-detailed sampling, eventually by trenching or other bulk sampling methods, are normally conducted. Such samples are needed for analysis to estimate the size and content of the deposit and for conducting processing and economic studies that are progressively more accurate and give greater certainty. Potential customers are frequently provided samples for testing and obtaining comments regarding commercial acceptability.

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 is suitable. To remove overburden and excavate ore, different combinations of rippers, dozers, scrapers, front-end loaders, power shovels, and dump trucks are used. Underground mining is not too uncommon outside the United States (e.g., Chile, China, and France) when it is considered better suited to deposit form and depth, topography, and other restraints. Usually, room-and-pillar methods are used, often with equipment similar to that used in open pits; in the smallest mines, hand tools are used. Explosives are not normally needed at surface or underground mines because of the rock's soft, friable nature. In Iceland, dredging is used to recover diatomaceous mud from the bottom of lakes. If the climate permits, the ore at many mines is stockpiled in the open to segregate it by grade and to reduce the normally high moisture content before delivering it to the processing facility.

Diatomite processing is usually done near the mine to reduce the cost of hauling up to 65% water, but the cost of delivering

energy (electric power and fuel) to the site is an offsetting consideration. Processing typically involves a series of crushing, drying, size-reduction, and calcining operations using heated air for conveying and classifying within the plant. Commonly, spiked rolls and hammer mills are used for primary crushing to minus 1.25 centimeters (cm), in order to limit damage to the diatomite structure. The heated air and multiple passes through special "milling" fans and air cyclones further dry, reduce in size, and classify the material. The cyclones not only classify for size but also remove undesirable components in the raw feed based on weight differences. Size reduction is designed to separate individual frustules without destroying their delicate structure. Fines, especially from baghouses used to remove particulates from the cyclone discharge waste or recycle air, are used mostly for filler-grade products; the coarser bottom discharge particles are used for filter grades. Calcining is normally done in rotary kilns to effect the physical and chemical changes previously mentioned. Plant operators take special precautions to overcome any free crystalline silica health hazards, particularly to the lungs, by containing dust within enclosures and requiring employees to use respirators. Although the generally high moisture in the ore reduces the free crystalline silica health hazards in mining areas, precautions are still taken.

Production cost allocations were reported for the United States in 1983 as 10% mining, 60% processing, and 30% packing and shipping (Breese, 1994, p. 405). A 1990 report stated energy costs were 25% to 30% of direct costs (Breese, 1994, p. 405). The proportion of the product that is calcined directly affects energy consumption.

For the United States, the diatomite production data used to prepare table 1 were collected by a survey sent to all known mine producers who voluntarily gave a 100% response as to the tonnage and value sold or used, which has historically been considered in these statistics to be production. The survey for 1998 covered 7 diatomite-producing companies with 13 individual mining areas and 12 processing facilities in California, Nevada, Oregon, and Washington. Major producers were Celite Corp. (Lompoc, CA, and Quincy, WA), Eagle-Picher Minerals Inc. (Lovelock and Fernley, NV, and Vale, OR), and Grefco Minerals, Inc. (Burney and Lompoc, CA, and Mina, NV). Smaller producers were Calveras Cement Co. (Burney, CA), CR Minerals Corp. (Fernley, NV), Moltan Co. (Fernley, NV), and Oil-Dry Production Co. (Christmas Valley, OR). California continued to be the leading producing State, followed by Nevada; together they accounted for more than 80% of the U.S. production in 1998. Lake-type deposits are the source of U.S. production except for the major marine deposit at Lompoc, CA.

The United States is the world's largest producer and consumer of diatomite. U.S. production sold or used by mining companies in 1998 decreased by about 6%, to 725,000 metric tons (t), and its value decreased by about 5%, to \$180 million f.o.b. plant, compared with the 1997 production sold or used which was 773,000 t, valued at \$189 million f.o.b. plant (table 1). Comparing 1998 data with those of 1993, tonnage increased by about 12%, and total value increased about 19%. The major products were various grades of calcined powders,

principally for filtration (table 2).

In 1998, industry activity included corporate changes and new ventures. Greco sold at least a significant part of its Lompoc diatomite reserves and mining rights to Celite and began dismantling its processing plant. CR Minerals was reportedly included in the sale of all the industrial mineral businesses of Canyon Resources Corporation to a Texas-based investment group for \$6 million (Yahoo, November 3, 1998, Canyon Resources sells industrial minerals business for \$6 million, accessed November 4, 1998, at URL http://biz.yahoo.com/prnews/981103/co_canyon_1). Eagle-Picher Minerals Inc. completed the addition of a second processing line at its Vale, OR facility in late 1997 and early in 1998 was part of an acquisition of its parent Eagle-Picher Industries Inc. by Granaria Holdings BV of the Netherlands (Industrial Specialties News, 1998). Several new ventures were also reported, but details are limited. Two were planned for the Harper Valley area of Oregon, west of Boise, ID, one of which is known to have begun mining operations. At least two others were being considered near Reno, NV, one of which is in California; the other may be ready for production. Overseas, Celite was apparently increasing production from its three joint ventures in China and acquired reserves in Chile and Peru to add to its extensive international holdings. A new 20,000-metric-ton-per-year mine was expected to be operational in Badgingara, north of Perth, Western Australia, by late 1998, according to owner Mallina Holdings Ltd, reputedly the holder of the country's largest diatomite deposits (Industrial Minerals, 1998a). In early 1998, Knight Piesold consultants were reported to be investigating a deposit in the Republic of Georgia, presumably for a joint venture of undisclosed United Kingdom and Georgian companies (Industrial Minerals, 1998b).

Consumption

In 1998, apparent domestic consumption of diatomite was 588,000 t, a 7% decrease from 635,000 t in 1997. That consumption figure is calculated from production sold or used based on the U.S. Geological Survey (USGS) survey, plus imports minus exports using trade data furnished by the U.S. Department of Commerce, and overlooks stocks data which are not available. The lack of stocks data may not be significant. The consumption figure is probably significantly too high and of limited usefulness, based on information from industry representatives. It is estimated that the export data may be less than 50% of actual exports, as further discussed in the Foreign Trade section below.

According to the USGS survey for 1998, total domestic and export quantities of diatomite sold or used by U.S. producers were distributed as follows, by application category: filter aid products, 467,000 t, which is calculated to be 5% less than the comparable figure for 1997; absorbents, 104,000 t, 3% less than for 1997; filler products, 84,000 t, 10% less than for 1997; and insulation products, 12,000 t, 40% less than for 1997. "Other" applications were down by 6% to 58,000 t, most of which was used in cement manufacturing. For 1998 as for several prior years, no entries were made for abrasives or lightweight

aggregate, the only additional specific categories on the USGS survey form. Comparing 1998 data with those of 1993, as a percentage of total use, filter use decreased slightly, filler and insulation uses remained about the same, and absorbent and "Other" uses (mostly for cement manufacture) increased slightly.

Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 1998, using USGS survey data, was \$249 per ton f.o.b. plant, a 2% increase compared with \$244 per ton in 1997 (table 3). Comparing 1998 data with those for 1997, the average value per ton for filter use was essentially unchanged, and the value for filler and absorbent use decreased by about 4% for each. In 1998, however, some producers of high-value insulation failed to sell or use any, resulting in a drop of 72% in the calculated average value for insulation products. The substantial increase in the quantity of unspecified high-value material, however, resulted in a rise of 236% in average value for "Other" uses. Comparing unit values for 1998 with those for 1993, in then-current dollars, the total average increased by about 7%, or \$15 per ton from \$233. The unit value of filter-grade products also increased by about 7%, and that of filler-grade products was essentially unchanged. Data on other grades were insufficient for accurate comparisons, although the unit value appeared to have increased for absorbent grades and to have decreased for insulation grades.

Foreign Trade

Export and import data presented herein is from the Bureau of Census and is of limited accuracy because of producer-reported inconsistencies, as well as lack of detail for the various materials specified in the 1998 Harmonized Tariff Schedule (HTS) of the United States issued by the U.S. International Trade Commission.

Exports of diatomite from the United States in 1998 were 138,000 t according to Census data that is equivalent to data published in previous years (table 4). This is less than 19% of all grades of domestic production sold or used as shown in the USGS survey and 1% less than 1997 exports. The data were issued as pertaining to HTS Code 2512 material, officially described as natural and straight-calcined diatomite, but industry sources indicate that at least some exports of flux-calcined material were classified under that code number by U.S. Customs employees. According to the HTS Explanatory Notes issued by the World Customs Organization (of which the United States is a signatory member), however, flux-calcined material is classified under another code (Code 3802.90.20.00) where, unfortunately, it can not be separately identified from activated clays. Similarly, heat-insulating mixtures and sawn and molded unfired shapes of diatomite are officially assigned to an "Other" data classification (Code 6806.90.00.90) that is not exclusively diatomite. Also, fired sawn and molded shapes of diatomite are covered in separate data (Code 6901) that is not exclusively diatomite.

Industry sources indicated that actual total exports of diatomite products could be estimated as a minimum of 300,000 t/yr, which is about 40% of domestic mine production sold or used in 1998, according to the USGS survey. Industry sources additionally suggested that 75% or more of exports are flux-calcined with the balance being mostly straight-calcined or natural products and only a small portion being the heat-insulating mixtures and shapes described in Codes 6806 and 6901.

Products went to 74 countries, according to Census data. Main export markets were Belgium (24,000 t), Canada (23,000 t), Germany (12,000 t), Japan (9,947 t), Australia (9,008 t), and the United Kingdom (7,004 t), making up more than 60% of the total exports reported. On the basis of available data, the average unit value of exported diatomite was \$316 per ton f.a.s. compared with values of \$305 per ton in 1997 and \$303 per ton in 1993. 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 816 tons coming from seven countries. France provided 75%, followed by Italy with 14%.

World Review

World production estimates, including those for China and Japan, remained essentially unchanged from those of 1997, after a gradual growth for the five prior years. For 1998, output was estimated to be 2.15 Mt, less than 1% below that of 1997 (table 5). With the large Chinese and Japanese production added to the data this year, adjustments were required in world ranking. In 1998, the major producers were the United States at 34%, followed by Denmark with more than 17% (all molar products), China with 16%, Japan with 9%, and France and the former Soviet Union countries (as a group) with slightly less than 4% each. Mexico, the Republic of Korea, and Spain were the next ranking producers.

Outlook

The diatomite market appears to remain mature and generally stable with industry representatives still expecting the next 5 years to be similar to the past 5 years. Some turmoil in structure of the domestic industry, however, seems to be pending, with new companies trying to enter the market and some additional mergers or buyouts being rumored. The past encroachments into filter applications by more-advanced technology (ceramic, polymeric, and carbon membranes) apparently are not of major concern to producers possibly because of cost factors, even though disposal of diatomite waste

is a problem not fully solved by recycling. The problem of free crystalline silica associated with diatomite, particularly when calcined, continues to be of concern but more as a part of normal business rather than as a crisis.

References Cited

- Antonides, L.E., 1999, Diatomite, in Mineral commodity summaries 1999: U.S. Geological Survey, p. 60-61.
- Berg, R.B., and Steuart, C.T., 1994, Tripoli, in Carr, D.D., and others, eds., Industrial minerals and rocks (6th ed.): Littleton, CO, Society for Mining, Metallurgy, and Exploration, p. 1091-1102.
- Breese, R.O.Y., 1994, Diatomite, in Carr, D.D., and others, eds., Industrial minerals and rocks (6th ed.): Littleton, CO, Society for Mining, Metallurgy, and Exploration, Inc., p. 397-412.
- Durham, D.L., 1973, Diatomite, in Brobst, D.A., and Pratt, W.P., eds., United States minerals resources: U.S. Geological Survey Professional Paper 820, p. 191-195.
- Harries-Rees, Karen, 1994, Diatomite: Industrial Minerals, no. 320, April, p. 31-43.
- Industrial Minerals, 1987, Diatomite: Industrial Minerals, no. 236, May, p. 22-39.
- 1998a, Diatomite project underway: Industrial Minerals, no. 366, March, p. 82.
- 1998b, U.K. company to revive 10m. tonne diatomite deposit: Industrial Minerals, no. 368, May, p. 11.
- Industrial Specialties News, 1998, Granaria plans international expansion for Eagle-Picher: Industrial Specialties News, v. 12, no. 5.
- Lu, Wen, 1998, Chinese industrial minerals: Surrey, UK, Industrial Minerals Information Ltd., p. 52-62.
- Maurrasse, Florentin, 1978, Diatomite, in Fairbridge, R.W., and Bourgeois, Joanne, eds., Encyclopedia of sedimentology: Stroudsburg, PA, Dowden, Hutchinson & Ross, Inc., p. 263 and 266.
- Meisinger, A.C., 1985, Diatomite, in Mineral facts and problems: U.S. Bureau of Mines Bulletin 675, p. 249-254.
- Roskill Information Services Ltd., 1994, Economics of diatomite 1994 (7th ed.): London, Roskill Information Services Ltd., 146 p.
- Thurston, D.R., 1978, Chert and flint, in Fairbridge, R.W. and Bourgeois, Joanne, eds., Encyclopedia of sedimentology: Stroudsburg, PA, Dowden, Hutchinson & Ross Inc., p. 119-124.
- U.S. Bureau of Mines and U.S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U.S. Geological Survey Circular 831, 5 p.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Diatomite. Ch. in Mineral Commodity Summaries, annual.²
- Diatomite. Ch. in Minerals Yearbook, annual.²

Other

- Industrial Minerals (monthly), Metal Bulletin plc, London.
- Diatomite. Ch. in Industrial Minerals HandyBook II (P.W. Harben), Metal Bulletin plc, London, 1995.

²Prior to January 1996, published by the U.S. Bureau of Mines

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

(Thousand metric tons and thousand dollars)

	1997	1998
Quantity	773	725
Value	\$189,000	\$180,000

1/ Data are rounded to three significant digits.

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

(Percent of U.S. production by tons)

	1997	1998
Absorbents	14	14
Fillers	12	12
Filtration	63	64
Insulation	3	2
Other 2/	8	8

1/ Includes exports.

2/ Includes silicate admixtures and unspecified uses.

TABLE 3
AVERAGE ANNUAL VALUE PER METRIC TON OF DIATOMITE, BY MAJOR USE 1/

	1997	1998
Absorbents	\$163.52	\$156.39
Fillers	297.56	285.87
Filtration	278.52	280.22
Insulation	127.38	35.77
Other 2/	65.16	153.53
Weighted average	243.99	248.82

1/ Based on unrounded data.

2/ Includes silicate admixtures and unspecified uses.

TABLE 4
U.S. EXPORTS OF DIATOMITE 1/ 2/

(Thousand metric tons and thousand dollars)

Year	Quantity	Value 3/
1997	140	42,600
1998	138	43,800

1/Harmonized Tariff System (HTS) Code 2512.00.00.00, natural and straight-calcined grades but in practice probably includes an undetermined quantity of flux-calcined product HTS

Code 3806.90.20.00, which code includes activated clays, without differentiation of diatomite

2/ Data are rounded to three significant digits.

3/ Free alongside ship (f.a.s.) U.S. customs value.

Source: Bureau of the Census.

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

(Thousand metric tons)

Country	1994	1995	1996	1997	1998 e/
Algeria	3 r/	4	4 e/	4 e/	4
Argentina	6	5	9	5 e/	5
Australia e/	11	11	11	11	20
Brazil (marketable)	17	14	14 e/	14 e/	14
Canada e/ 3/	10	10	10	10	10
Chile	10	11	12 r/	12 r/	12
China e/ 4/	230 r/	250 r/	300 r/	320 r/	350
Colombia e/	4	4	4	4	4
Costa Rica e/	7	7	8	8	8
Czech Republic	40	29	35	-- r/	--
Denmark 5/	285 r/	279 r/	270 r/	372 r/	375
France e/	90	80	85	80	80
Germany e/	52	50	-- r/	-- r/	--
Iceland	25	28 r/	26 r/	25 r/ e/	25
Iran e/ 6/	(7/)	(7/)	(7/)	(7/)	(7/)
Italy e/	25	25	25	25	25
Japan	184	175	194	194 e/	190
Kenya	1	(7/)	(7/)	(7/)	(7/)
Korea, Republic of	83	81	70	54 r/	50
Macedonia e/	5	5	5	5	5
Mexico	52	50	52	59 r/	60
Peru e/	35	35	35	35	35
Poland	3	2	2	2 e/	2
Portugal e/	2 8/	2	2	2	2
Romania	35	50	57 r/	24 r/	30
Spain e/ 9/	36	36	40	40	40
Thailand	6	6	2 r/	(7/)	1
U.S.S.R., former e/ 10/	120	110	100	90	80
United Kingdom e/	(7/)	--	--	--	--
United States 11/	646	722 e/	729	773	725 8/
Total	2,020 r/	2,080 r/	2,100 r/	2,170 r/	2,150

e/ Estimated. r/ Revised.

1/ World totals, U.S. data, and estimated data are rounded to 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 May 17, 1999.

3/ Includes an unknown quantity of fuller's earth.

4/ May not include building and insulating brick estimated as 150,000 metric tons (in 1994) to 200,000 metric tons (in 1998).

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 1/2 unit.

8/ Reported figure.

9/ Includes tripoli.

10/ U.S.S.R. dissolved in December 1991; however, information is inadequate to formulate reliable estimates for individual countries.

11/ Sold or used by producers.