

CLAYS

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The amount of clay sold or used by domestic producers decreased slightly to 42 million metric tons valued at \$1.67 billion in 1997. Production of ball clay, bentonite, fire clay, and kaolin increased while production of common clay and fuller's earth decreased. Common clays accounted for 58% of the tonnage and kaolin accounted for 62% of the value of clays produced in 1997. Imports of all clay types increased to 63,700 tons valued at \$23.2 million. Exports increased to 5.08 million tons valued at \$860 million. (*See table 1.*)

Legislation and Government Programs

Clay mining has an environmental impact because of the disturbance to the land. Overburden is moved and clays are removed, leaving a depression or pit. State laws usually require leveling or recontouring of the disturbed area and planting trees or grasses to prevent or minimize erosion. For processing, the impoundment of slimes and dust control are usually required. The rules for disposal of coarse tailings are similar to or included within those laws governing reclamation of the mined area.

An issue that has recently arisen concerns dioxins in ball clay deposits. The dioxins were brought to the attention of the Food and Drug Administration when elevated levels of dioxins were detected in poultry. The source was traced to ball clay, which was used as a flow control agent in the chicken feed. No apparent anthropogenic sources for the dioxins in the ball clay were detected. Studies currently are underway to determine if the dioxin could have occurred naturally (Food and Drug Administration, 1997).

Production

Approximately 240 companies operating 766 clay pits or quarries reported production in 1997; of these, 21 companies, many with multiple operations, accounted for approximately 50% of the tonnage and 74% of the value for all types of clay produced and sold or used. Clay production was reported in most States except Alaska, Delaware, Hawaii, Rhode Island, Vermont, and Wisconsin, and the District of Columbia and Puerto Rico. (*See table 2.*)

The 10 leading producer States, in descending order of tonnage, were Georgia, Wyoming, Alabama, North Carolina, Texas, Missouri, South Carolina, Ohio, California, and Tennessee. The 10 leading producing companies, in decreasing order of production, were Engelhard Corp. (fuller's earth and kaolin); American Colloid Co. (bentonite and fuller's earth); ECC International (kaolin); General Shale Products Corp. (common clay and shale); Holnam Inc. (common clay and shale); Thiele Kaolin Co. (kaolin); Dry Branch Kaolin Co. (kaolin); Solite Div., Big River Industries Inc. (common clay and shale); J.M. Huber Corp. (kaolin); and Livelite Corp. (common clay and shale).

Most clay mining in the United States was by open pit methods;

less than 1% of U.S. clay output was from underground mines. All of the underground production was in Ohio, where the clays are mainly underclays associated with coal.

Domestic production data for clays were developed by the U.S. Geological Survey from a voluntary survey of U.S. operations. Of the 681 survey forms issued, 481 were completed, representing 71% of the total clay and shale production sold or used shown in table 1. Production data for the nonrespondents were estimated from reported prior-year production levels adjusted by trends in the industry and other guidelines.

Ball Clay.—Six companies mined ball clay in 1997 from 32 quarries in 5 States. Two of the producers were large, diversified firms with widespread foreign and domestic mineral interests.

Production of domestic ball clay increased to 1.04 million tons valued at \$48.1 million. Tennessee supplied 63% of the Nation's output, followed by, in descending order of production, Kentucky, Texas, Mississippi, and Missouri. Although the data are withheld, production increased in Kentucky, Mississippi, and Texas and decreased in Missouri and Tennessee. Water-slurried ball clay was produced only in Tennessee. Air-float ball clay was produced in Kentucky, Mississippi, and Tennessee. Unprocessed clay was mined and then sold or used from mines in all five ball-clay-producing States. (*See table 3.*)

United Clays Inc. reported the installation of new blending and processing equipment at their facility in Huntingburg, IN. Beside processing ball clay, the facility also handles talc from the company's Texas operation and recycled tile from nearby tile plants (Watts Blake Beame & Co. PLC, WBB report and accounts 1997, accessed June 30, 1998, at URL <http://www.wbb.co.uk/page9.htm>).

Bentonite.—Eighteen companies produced bentonite from 57 quarries in 10 States. Six producers were large, diversified firms with international mineral operations or interests in other types of clay in the United States.

The quantity and value of all varieties of bentonite sold or used decreased to 4.02 million tons valued at \$169 million. Production of nonswelling bentonite decreased to 397,000 tons valued at \$13.5 million. Alabama led all States in the production of nonswelling bentonite, followed by Mississippi, Arizona, Texas, Utah, Nevada, and California.

Production of swelling bentonite increased to 3.63 million tons valued at \$156 million. Wyoming led all States in the production of swelling bentonite, followed by Montana, Utah, California, Oregon, Nevada, and Texas. (*See table 5.*)

American Colloid announced plans to build a blending plant in Indiana. The plant will produce custom blends of bentonite and other components for the foundry industry (European Chemical News, 1997).

Basic Resources Corp. has received most of the permits necessary to begin mining a calcium bentonite near Ephrata, WA. The deposit consists of a sequence of bentonite beds between basalt layers. Reserves are estimated to exceed 9 million tons. Production will be

approximately 36,000 tons per year, mainly for the production of agricultural pellets (North American Minerals News, 1997f).

Common Clay and Shale.—One hundred and seventy-four firms produced common clay and shale from 454 pits in 42 States and Puerto Rico in 1997. Most of these companies also were manufacturers of structural clay products such as clay pipe, drain tile, and sewer pipe; lightweight aggregates; and cement. More than 90% of the total production is used by the producer itself to manufacture structural clay products, aggregate, and cement or for civil engineering applications.

Domestic sales or use of common clay and shale increased to 24.5 million tons, valued at \$149 million. The major producing States were Alabama, North Carolina, Texas, Georgia, Ohio, South Carolina, Missouri, Arkansas, Indiana, and California, in descending order of tonnage. (See table 7.)

Fire Clay.—Fire clay producers were mostly refractories manufacturers that used the clays in firebrick and other refractories. Forty-nine quarries were operated in 1997 by 17 firms in 6 States.

Fire clay sold or used by domestic producers increased to 649,000 tons valued at \$9.45 million. Ohio was the leading producing State, followed by Missouri, California, Alabama, Kentucky, and New Mexico. (See table 9.)

Fuller's Earth.—Seventeen companies produced fuller's earth from 30 quarries in 12 States. Ten of the mines were in the attapulgite-type fuller's earth areas of Florida and Georgia; these two States accounted for all of the domestic attapulgite production. Most producers were small, independent firms, but five were large, diversified corporations with international mineral interests.

Production of fuller's earth decreased to 2.37 million tons valued at \$255 million. Production of attapulgite-type fuller's earth was 707,000 tons valued at \$90 million in 1997. Over one-half of this production came from Georgia, followed by Florida and Nevada. Production in Nevada was of sepiolite-type fuller's earth.

Production of montmorillonite-type fuller's earth was 1.66 million tons valued at \$165 million. Montmorillonite-type fuller's earth was produced in Mississippi, Illinois, Missouri, California, Georgia, Florida, Kansas, Virginia, Tennessee, Texas, and Utah, in decreasing order of production. (See table 11.)

Engelhard Corp. finalized its purchase of the Floridin Co. from U.S. Borax Inc. Engelhard has shifted its sorbent granular attapulgite production from its Attapulugus, GA plant to Floridin's Quincy, FL plant. Engelhard will continue to produce slurry products at its Attapulugite plant. As part of the sale of Floridin, ITC Inc. acquired the Floridin product line and trademarks. Lime Mountain Co. purchased Industrial Mineral Ventures (IMV), a division of Floridin. IMV produces sepiolite, bentonite, and saponite from mines in Nevada (Chemical Week, 1997; North American Minerals News, 1997c).

Kaolin.—Thirty firms mined kaolin from 120 quarries in 11 States. Domestic production was 9.41 million tons valued at \$1.04 billion. Georgia was the largest kaolin producer, followed by South Carolina, Alabama, Arkansas, California, North Carolina, Florida, Texas, Nevada, Tennessee, and Pennsylvania, in decreasing order of production. (See table 13.)

Approximately 50% of the kaolin produced was water-washed, followed by calcined (18%), delaminated (15%), airfloat (14%), and unprocessed kaolin (3%). (See table 14.) Production of low-temperature (pigment) and high-temperature (refractory) calcined kaolin was 784,000 and 909,000 tons, respectively. (See table 15.)

Kaolin production in Georgia was 8.30 million tons valued at \$981 million. Approximately 56% of the production was sold as water-washed, followed by delaminated (17%), calcined (15%), airfloat (10%), and unprocessed (2%). (See table 16.) Production in South Carolina was 447,000 tons valued at \$29 million, most of which was airfloat or unprocessed. (See table 18.)

Engelhard Corp. increased capacity on its hydrous kaolin processing line at its middle Georgia facility. The expansion is part of a 4-year, \$142 million program designed to improve its kaolin-based paper coatings business (Chemical Market Reporter, 1997).

Thiele Kaolin Co. began construction of a new calciner at its Sandersville, GA plant. The new calcining facility will increase the company's calcining capacity to 100,000 tons per year. The calcined products will be destined primarily for the paper industry. The company also will build a slurry plant in Wisconsin Rapids, WI. Initial output will be 100 tons per day and the plant will serve surrounding paper mills (North American Minerals News, 1997g).

Nord Resources Corp. sold its subsidiary, Nord Kaolin Co., to Dry Branch Kaolin Co. With the purchase, Dry Branch acquired 31 million tons of kaolin reserves in Georgia, gained access to Nord's Norplex hybrid pigment products, and added an additional 300,000-ton-per-year capacity to its own existing capacity of 1.2 to 1.3 million tons per year of water washed and calcined kaolin (Industrial Minerals, 1997g).

Cytec Industries Inc. sold its kaolin reserves and calcining facility in Georgia to GEO Specialty Chemicals Inc. The reserves, located near Andersonville, GA, include 30 million tons of kaolin, bauxitic clay, and bauxite. The calcining facility has a capacity of 146,000 tons per year. The products are used for alum manufacture, high and low alumina refractories, and paint fillers (Industrial Minerals, 1997c).

Consumption

Ball Clay.—The principal domestic ball clay markets were floor and wall tile, pottery, and sanitaryware. (See table 4.) Consumption increased approximately 11% in 1997. The largest increases were in sales for floor and wall tile. Increases in ball clay sales for the past 4 to 5 years have resulted from the expanding home building market with its demands for sanitaryware and tile.

Bentonite.—Major markets for bentonite were drilling mud, foundry sand, iron ore pelletizing, and pet waste absorbents. Consumption increased about 7% in 1997, mainly on the strength of sales for animal feed, civil engineering and sealing, drilling mud, filtering and clarifying of oils and greases, foundry sand, and paint markets. Total sales of bentonite for iron ore pelletizing (domestic and export) were 590,000 tons versus 685,000 tons in 1996, a 14% decline. (See table 6.)

With regard to the sales of swelling versus nonswelling bentonite, most of the data were concealed to avoid disclosing company proprietary data. More than 95% of the bentonite sold for pet waste absorbent and more than 90% for adhesives applications was the swelling variety. For animal feed applications, more than 80% of bentonite sold was the swelling variety. Approximately two-thirds of the bentonite sold for ceramics was swelling bentonite and essentially all of the bentonite used in drilling mud applications was the swelling variety. Swelling bentonite accounted for almost 90% of the bentonite sold for filler and extender applications. More than two-thirds of the bentonite sold for foundry sand applications was

swelling bentonite. Most of the bentonite sold for filtering, clarifying, and decolorizing applications was of the nonswelling variety. Bentonite sold for pelletizing iron ore was exclusively swelling bentonite. More than 90% of the bentonite used for civil engineering, waterproofing and sealing was swelling bentonite. The major domestic uses for swelling bentonite were drilling mud, foundry sand, pet waste absorbent, iron ore pelletizing, waterproofing and sealing, and animal feed, in decreasing order of consumption. Major export markets were in foundry sand, drilling mud, and iron ore pelletizing applications. The major domestic uses for nonswelling bentonite were in foundry sand, filtering, clarifying, and decolorizing of oils and greases, miscellaneous civil engineering applications, animal feed, absorbents, and drilling mud, in decreasing order of consumption. Exports were limited to foundry sand.

Common Clay and Shale.—Common clay was used most frequently in the manufacture of heavy clay products such as building brick, flue linings, sewer pipe, drain tile, structural tile, and terra cotta; portland cement clinker; and lightweight aggregate. (See table 8.) Consumption of common clay and shale decreased about 6% in 1997. The largest losses were made in sales for civil engineering and sealing, cement, and miscellaneous heavy clay products.

Fire Clay.—Fire clays were used in refractory products such as firebrick and block, grogs and calcines, high-alumina brick and specialties, saggars, refractory mortars and mixes, and ramming and gunning mixes. Fire clays also were used to produce such items as brick and pottery.

Consumption of fire clay increased approximately 29% in 1997 to 649,000 tons. Major markets for fire clay were common brick, firebrick, refractory mortar and cement, grogs and calcines, and pottery, in decreasing order of consumption. (See table 10.) Increased sales for the production of common brick accounted for the bulk of the increase in overall sales of fire clay.

Fuller's Earth.—The major uses for attapulgite-type and montmorillonite-type of the fuller's earths were as pet waste absorbents, oil and grease absorbents, pesticide carriers, and flow control agents in animal feed, in decreasing order of consumption. (See table 12.) Overall consumption of fuller's earth decreased 9% in 1997. Sales of attapulgite-type fuller's earth decreased 19% in 1997 primarily because of the sale and subsequent split of Floridin operations and products between Engelhard Corp. and ITC Inc. Overall sales of montmorillonite-type fuller's earth decreased 4% in tonnage. However, sales for oil and grease absorbents, drilling mud applications, and miscellaneous floor and wall tile markets increased. Consumption of montmorillonite-type fuller's earth declined for most of the remaining markets. Most of the sales losses were in the export, pesticide carriers, and pet waste absorbent markets.

With regard to the sales of attapulgite-type fuller's earth versus montmorillonite-type fuller's earth, most of the data were concealed to avoid disclosing company proprietary data. Major markets for attapulgite were pet waste absorbents, oil and grease absorbents, pesticide carriers, ceramic tile, fertilizer carriers, drilling mud, gypsum products, cement clinker, animal feed, and adhesive applications, in decreasing order of consumption. Major markets for montmorillonite-type fuller's earth were pet waste absorbents, oil and grease absorbents, pesticide carriers, and fertilizer carrier applications, in decreasing order of consumption.

Attapulgite sales account for less than one-third and one-quarter of the fuller's earth sold for oil and grease absorbents and pet waste absorbents, respectively. Attapulgite accounted for all of the sales

for adhesive, asphalt tile, cement, drilling mud, gypsum products, paint, tile, and miscellaneous refractories and less than 20% of animal feed sales. More than 75% of the fertilizer sales were attapulgite. More than one-half of the fuller's earth used as pesticide carriers was montmorillonite and most of the fuller's earth sold for filtering, clarifying, and decolorizing oils and greases was attapulgite.

Kaolin.—The major markets were for paper coating, paper filler, refractories, fiberglass, paint, catalyst, rubber, and chemical manufacture, in decreasing order of consumption. (See table 20.) Consumption increased approximately 3% in 1997. The largest gains from a tonnage standpoint were made in fiber glass (about an 8% gain), paper coating (6%), paper filler (7%), paint (14%), and refractories (11%). Major domestic markets for kaolin from Georgia were paper coating, paper filling, refractories, fiber glass, and paint, in decreasing order of consumption. Major gains were made in paper coating (4%), paper filler (7%), paint (13%), and refractories (8%). Losses were reported in rubber and export markets. The major market for kaolin from South Carolina was rubber, followed by catalyst, fiber glass, common brick, face brick, roofing granules, adhesives, paper coating and filler, pesticide carriers, and firebrick, in decreasing order of consumption. Gains made in the rubber and fiberglass sales were offset by losses in sales to the common brick and export markets. (See tables 17 and 19.)

Absorbent Uses.—Absorbent uses for clays were about 2.44 million tons, a decrease of 4% from that of 1996. Fuller's earth accounted for more than 70% of the clay used for absorbent purposes, followed by bentonite (more than 20%), and kaolin (less than 1%). (See tables 6 and 12.) Pet waste absorbents accounted for approximately 85% of absorbent consumption, followed by oil and grease absorbents (11%), and miscellaneous absorbent applications (4%).

Ceramics.—All varieties of clays were used in ceramics. Demand for clay in the manufacture of ceramics, ranging from china to sanitaryware to tile to roofing granules, was approximately 1.81 million tons, an increase of 12% from that of 1996. The largest ceramics market was in ceramic floor and wall tile (40% of the market), followed by sanitaryware (15%), catalyst (13%), roofing granules (10%), pottery (9%), quarry tile (4%), electrical porcelain (1.8%), fine china (1.6%), and glaze applications (0.5%). Ball clay accounted for 38% of the clay used in ceramics, followed by common clay and shale (31%) and kaolin (26%). Small amounts of bentonite, fire clay, and fuller's earth also were used in the manufacture of ceramics. With regard to individual ceramics markets, ball clay dominated the electrical porcelain, glazing, pottery, and sanitaryware markets. Common clay and shale was the predominant clay used in roofing granules. Kaolin dominated the catalyst, crockery, and fine china markets. Common clay and shale and ball clay were the predominant clays used in floor and wall tile manufacture. (See tables 4, 8, 10, and 20.)

Construction.—Common clays and shales were used to manufacture a wide variety of construction materials such as expanded aggregates, hydraulic cement, and structural clay products.

Expanded Clay and Shale.—Approximately 3.99 million tons of clays was used in the production of lightweight aggregate. Nearly all of the clay used to manufacture lightweight aggregate was common clay and shale. Lightweight aggregates were used in concrete block, structural concrete, and highway surfacing, in decreasing order of consumption. (See tables 8 and 21.)

Hydraulic Cement.—Clays provide the alumina and silica

required to manufacture hydraulic cements. Approximately 5.96 million tons of clays was consumed, a 17% decrease from that of 1996. Common clays, kaolin, fuller's earth, and fire clay, in decreasing order of consumption, were used in the manufacture of portland cement clinker. More than 99% of the clay consumed by the cement industry was common clay and shale. (See tables 8 and 20.)

Metakaolin, which is kaolin that has been calcined over a controlled temperature range, can be used in cement to improve the life of the concrete, reduce permeability, and improve resistance to chemical attack. The metakaolin is used as a pozzolan, partially replacing some of the portland cement in the mix. The metakaolin reacts with lime produced by the portland cement hydration reaction, converting the lime to a cementitious product that increase the density and fills channels in the concrete (Gypsum, Lime, & Building Products, 1997).

Structural Clay Products.—Approximately 13.5 million tons of clays was used in the manufacture of structural clay products such as building brick, roofing tile, and sewer pipe. Common and face brick accounted for 98% of this total. Other markets, in decreasing order of consumption, were flue linings, flower pots, sewer pipe, drain tile, structural tile, terra cotta, and roofing tile. Approximately 97% of the clay used in these applications was common clay and shale. (See tables 8, 20, and 22.)

Surface pigments can be used to expand product lines for brick manufacture. The pigments typically are oxides of iron, manganese, zinc, titanium, tin, cobalt, and zirconium. The color is determined by the stability of the oxide during firing, the kiln atmosphere, the firing temperature, and source of the individual pigments. Sometimes the pigments are mixed with inert and reactive fillers to produce colors normally not associated with the pure oxide compounds. By using pigments, the manufacturer can produce unique finishes, use inferior color quality clays if necessary, and produce more uniform product colors (Barber, 1997).

The U.S. Bureau of the Census reported domestic shipments of 7.71 billion building and face bricks valued at \$1.34 billion, an increase from 7.62 billion bricks in 1996. Shipments of clay floor and wall tile were 59.2 million square meters valued at \$874 million compared with 54 million square meters in 1996. Shipments of vitrified clay and sewer pipe fittings were 134,000 tons valued at \$44.4 million, a 7% decrease from that of 1996. The increase in shipments of brick and tile is corroborated by statistics on housing starts; the Bureau of the Census estimated that the seasonally adjusted annual rate for privately owned housing starts in December was 1.52 million units in 1997, compared with 1.35 million units in 1996.

Drilling Mud.—Reported demand for clays in drilling muds (domestic and exports) was 837,000 tons, a 38% increase from that of 1996. This magnitude of increase is partially corroborated by the higher domestic rotary drill rig count for 1997 (Oil & Gas Journal, 1997). The sizable increase in exports of drilling grade bentonite also suggests healthy oil drilling markets. Swelling-type bentonite remained the principal clay used in drilling mud mixes (more than 90%). Fuller's earth, used mostly in saltwater drilling techniques, accounted for less than 10% of the total. Some ball clay and kaolin also were used in drilling mud applications. (See tables 6 and 12.)

Fillers, Extenders, and Binders.—Approximately 5.61 million tons of clays was used as fillers, extenders, and binders, an increase of 11% from that of 1996. Clays are used in a wide variety of

products, such as adhesives, flooring products, paint, paper, and rubber. Paper coating and filling accounted for 70% of the filler and extender market consumption, followed by paint (6%), pesticides (6%), animal feed (4%), rubber (4%), and wallboard production (2%). Asphalt emulsion, fertilizer carrier, plastic, gypsum products, asphalt tile, textile, medical (pharmaceutical and cosmetic), vinyl flooring, and ink each account for less than 1% of the fillers and extenders markets, in decreasing order of consumption.

Kaolin accounted for approximately 84% of the clay used in filler and extender applications, followed by fuller's earth (7%), common clay and shale (4%), bentonite (3%), ball clay (1%), and trace amounts of fire clay. (See tables 4, 6, 12, and 20.) Ball clay dominated the asphalt emulsion market. Bentonite was the predominant clay used for ink applications. Common clay was the predominant clay used in wallboard production. Fuller's earth was the predominant clays used in fertilizer, gypsum product, and pesticide applications. Kaolin dominated the adhesive, paint, paper, plastics, rubber, textile, and vinyl flooring markets. Bentonite, fuller's earth, and kaolin were the major clays used in asphalt tile. Bentonite and fuller's earth were the predominant clays in animal feeds and medical, pharmaceutical, and cosmetic applications.

Bentonite is used in paints as rheological additives. Having a large particle diameter-to-thickness ratio and a negative charge on the surface and positive charge on the edges, smectites act as thixotropic agents. They thicken the paint to prevent settling under low shear conditions. When stirred, the edge to surface bonding of the bentonite is disrupted and the viscosity of the paint is reduced. The result is a paint that has a high solids content while remaining pourable. Another advantage is that flow and leveling properties also are improved in some paints. Smectite has been used to replace attapulgite and cellulose thickeners in many water-based paints (Brennan, 1997).

Glass.—Approximately 479,000 tons of kaolin was consumed in the manufacture of fiberglass and mineral wool. This was an increase of 8% from that of 1996. (See table 20.)

Iron Ore Pelletizing.—Domestic demand decreased to 536,000 tons in 1997. This represents a decrease of 20% of bentonite reported as domestic sales. Total sales (including exports) were 598,000 tons, approximately 12% less than in 1996. This corresponds to a slight decline in the production of pelletized iron ore for blast furnaces. Demand also may be lower due to improved pelletizing properties of new bentonite products and different pelletizing characteristics of the iron ore mined during the year. At least one iron ore pelletizer noted that pelletized ore also faced competition from the use of steel scrap in minimills, iron ore agglomerates, and steel slab imports. All of the clay used in pelletizing was bentonite. (See table 6.)

Paper Products.—Kaolin accounted for essentially all of the clay used for paper coating (3 million tons) and all of the clay used for paper filling (918,000 tons). Sales for both markets increased 7% over that of 1996. (See table 20.) Small amounts of fuller's earth were used in paper coating applications.

The paper industry recovered somewhat from the downturn that occurred in late 1995 and early 1996 with growth rates expected to be approximately 3% per year (Burns, 1997). Monthly capacity utilization rates for paper and products ranged from 87% to 91% in 1997. This compares with monthly rates of 85.5% to 90% in 1996.

Kaolin-based pigments are widely used by the paper industry. The standard hydrous kaolin-based product finds uses in number 3 and 4

coated woodfree papers and number 4 and 5 coated groundwood papers. In contrast, the premium hydrous kaolin-based pigments are used in number 1 and 2 coated woodfree paper. Delaminated grades are used in high quality, art-type paper and calcined grades are particularly valuable as more cost-effective opacifiers than other pigments. To meet the needs of the paper industry, the kaolin industry has made several advances. These include tighter control on particle size distributions, reduction of impurities and improvements in brightness, whiteness and rheological properties and development of co-pigments (Jeffries, 1997).

Refractories.—Approximately 2.94 million tons of clays was used for the manufacture of refractories, a 13% increase from that of 1996. The largest markets were foundry sand (31%), grogs and calcines (30%), refractory mortar and cement (14%), firebrick (9%), high alumina brick (1%), and high alumina specialties (less than 1%). The market percentages for refractories must be used with caution for all but the foundry sand and refractory mortar and cement categories because of the uncertainty in the data for specific market destinations.

Ball clay, bentonite, common clay and shale, fire clay, fuller's earth, and kaolin accounted for 2%, 31%, 21%, 12%, less than 1%, and 33%, respectively, of the refractories markets. Fire clay dominated the firebrick market, bentonite dominated the foundry sand market, and kaolin dominated the grog, calcine, high alumina brick, kiln furniture, and plug, tap, and wad markets. Common clay dominated the refractory mortar and cement market. (*See tables 4, 6, 8, 10, and 20.*)

Production data for refractories manufactured in 1997 are not available at this time from the U.S. Bureau of the Census. For 1996, the Bureau reported shipments of clay refractories to be valued at \$944 million in 1996, a slight increase from those of 1995. Shipments of clay refractory brick and shapes were 815,000 tons (280 million bricks) valued at \$559 million. This can be broken out into fire clay brick and shapes at 386,000 tons (128 million bricks) valued at \$209 million; high alumina brick and shapes, 371,000 tons (100 million bricks) valued at \$286 million; and insulating brick and shapes, 57,400 tons (51.9 million bricks) valued at \$64.3 million. Shipments of unshaped clay refractories were 648,000 tons valued at \$330 million. This is broken out into refractory mortars, 48,200 tons valued at \$25.4 million; plastic refractories, 144,000 tons valued at \$76.8 million; castable refractories, 292,000 tons valued at \$166 million; and fire clay gunning mixes, 164,000 tons valued at \$61.7 million. Approximately 194,000 tons of miscellaneous refractories valued at \$24 million also were sold in 1996.

Prices

Ball Clay.—The average value for ball clay reported by domestic producers was \$46.34 per ton. The average values for imported and exported ball clay were \$317.13 and \$64.86 per ton, respectively.

Bentonite.—The average value reported by domestic producers for nonswelling bentonite was \$33.91 per ton. The average value for swelling bentonite was \$42.92 per ton. The average value for all types of bentonite was \$42.03 per ton. The average value of imported bentonite was \$371.33 per ton. The average value of exported bentonite was \$99.67 per ton.

Common Clay and Shale.—The average value for all common clay and shale produced in the United States and Puerto Rico was \$6.09 per ton. The average value of clay and shale used in

lightweight aggregate was \$14.63 per ton.

Fire Clay.—The average value for fire clay reported by domestic producers was \$14.57 per ton. The average of imported fire clay was \$1,144.93 per ton. The average value of exported fire clay was \$105.65 per ton. The unit value of domestically produced fire clay decreased because of increased sales for lower value applications such as brick manufacture.

Fuller's Earth.—The average value of attapulgite-fuller's earth reported by domestic producers was \$127.28 per ton. The average value of montmorillonite-fuller's earth was \$99.02 per ton. The average value of all types of fuller's earth was \$107.45 per ton. The average value of imported fuller's earth was \$133.88 per ton. The average value of exported fuller's earth was \$112.05 per ton.

Kaolin.—The average value of kaolin was \$120.19 per ton for all kaolin grades. The average value for airfloat kaolin was \$54.44 per ton; for high-temperature calcined (refractory grade) kaolin, \$17.74; for low-temperature calcined (pigment grade) kaolin, \$322.64; for all types of calcined kaolin, \$158.90 per ton; for delaminated kaolin, \$101.63 per ton; for water-washed kaolin, \$116.99 per ton; and for unprocessed kaolin, \$23.97 per ton. The average value of the imported kaolin was \$239.14 per ton. The average value of exported kaolin was \$172.48 per ton. Prices for paper-grade kaolin products declined, resulting in lower unit values for pigment-grade, delaminated, and water-washed kaolin in 1997.

Foreign Trade

Ball Clay.—Ball clay exports increased to 91,000 tons valued at \$5.90 million, according to the Bureau of the Census. (*See table 23.*) Domestic ball clay producers reported that 146,000 tons of ball clay was exported in 1997. The discrepancy observed between the export tonnage reported by the U.S. Bureau of the Census and that reported by producers probably results from a combination of factors. One reason is that the producers often do not control the final sale and movement of the clays, as when a mineral broker is involved. Some clays originally destined for export may be sold domestically and vice versa without the knowledge of the producer. Another reason is that some clay may be exported under an export code other than that corresponding to ball clay to the U.S. Bureau of the Census.

Ball clay exports were used mainly for floor and wall tile production and sanitaryware production. Other markets include asphalt emulsions, china, dinnerware, and miscellaneous refractory and filler and extender applications.

In 1996, imports were 823 tons of ball clay valued at \$261,000. (*See table 24.*)

Bentonite.—Bentonite exports increased to 850,000 tons valued at \$84.7 million. Domestic bentonite producers reported exports of 544,000 tons. The discrepancy between producer and U.S. Bureau of Census appears to result from producers including most of the exports destined for Canadian and Mexican markets (approximately 195,000 tons) under domestic sales. Also see the discussion under ball clay concerning discrepancies between export data reported by producers and those reported by the U.S. Bureau of the Census. (*See tables 6 and 23.*)

Bentonite imports consisted mainly of untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite were 7,560 tons valued at \$2.81 million. Imports of chemically activated material were 18,600 tons valued at \$10.3 million. (*See table 24.*)

Fire Clay.—Approximately 222,000 tons of fire clay valued at \$23.5 million was exported. Sixty-nine tons of fire clay valued at \$79,000 was imported in 1997. (See tables 23 and 24.)

Fuller's Earth.—Approximately 144,000 tons of fuller's earth valued at \$16.1 million was exported. Domestic producers reported more than 44,000 tons of exports in 1997. Again, the discrepancy between producer and U.S. Bureau of the Census data is partially explained by the fact that producers apparently include much of the exports destined for Canada and Mexico (approximately 65,000 tons) under domestic sales. Several of producers manufacture commercial products such as pet waste absorbent and commercial absorbents that may have been reported under export classifications other than fuller's earth. Also see the discussion under ball clay concerning discrepancies between export data reported by producers and those reported by the U.S. Bureau of the Census. (See table 12.) Approximately 3,530 tons of decolorizing and fuller's earth valued at \$473,000 was imported in 1997. (See tables 12, 23, and 24.)

Kaolin.—The U.S. Bureau of the Census reported that 3.38 million tons of kaolin valued at \$583 million was exported in 1997. Producers reported exports of 2.39 million tons. Most of the kaolin destined for Canadian and Mexican markets (approximately 800,000 tons) appears to have been reported under domestic consumption. Also, discrepancies between producer and Bureau of the Census data are similar to the situation with ball clay. (See tables 20 and 23.) Kaolin imports increased to 30,400 tons valued at \$7.27 million. (See table 24.)

World Review

World production of bentonite was approximately 9.68 million tons, fuller's earth production was estimated to be 3.45 million tons, and kaolin production was about 39.1 million tons. The United States continued to be the leading producer of all three clay types, followed by the former U.S.S.R. for bentonite, Germany for fuller's earth, and Uzbekistan for kaolin. Spain led all countries in the production of sepiolite. (See tables 25, 26, and 27.)

Australia.—CRA Ltd. completed a 3-year exploration program for high whiteness kaolin. The company located several promising locations in the Wickiepin District (Industrial Minerals, 1997k).

Commercial Minerals Ltd. purchased Australian Bentonite from Cudgen R.Z., Ltd. The purchase included the 60,000-ton-per-year mine and a 120,000-ton-per-year mill. Commercial Minerals also operates a bentonite mine in New South Wales (Industrial Minerals, 1997b).

Australian Kaolin NL proceeded with the development of a kaolin deposit in Queensland. The company initially expects to produce 75,000 tons and 100,000 tons annually of calcined kaolin and hydrous kaolin, respectively. Production is expected to begin in 1998 (Industrial Minerals, 1997h).

Brazil.—Companhia de Pesquisas de Recursos Minerais, the State geological survey, announced plans to auction its kaolin deposit in Rip Capim. The deposit contains approximately 560 million tons of kaolin reserves. The move is an effort by Brazil to privatize its holdings (Industrial Minerals, 1997a).

Kaolin deposits in Brazil are remarkably similar to those in Georgia. Both are sedimentary deposits, laid down in fluvial deltaic and foreshore environments. Deposition was followed by subsequent intense weathering by ground water. As in Georgia, there are hard kaolins (finer grained) and soft kaolins (consisting of books of

kaolin). The coarse kaolin was likely to have been at least partially recrystallized during the weathering process (Pickering and Linkous, 1997).

Canada.—ECC International announced plans to build a kaolin slurry plant in Port Hawkesbury, Nova Scotia. The plant will receive dry kaolin from ECC's operations in England. The plant will supply 140,000 tons annually for the paper market (North American Mineral News, 1997b).

Bruneau Minerals Inc. continued testing of its kaolin deposit in St. Jovite, Quebec. The 5.4-million-ton deposit consists of brown kaolin containing no alkali. The kaolin will probably be marketed for cement and concrete manufacture (North American Minerals News, 1997a).

China.—ECC International announced a joint venture with Fujian Jiuzhou Longyan Kaolin Clay Co. to produce ceramic-grade kaolin. Production capacity of the operation will be 100,000 tons per year with an estimated 50-year reserve of kaolin (American Ceramic Society Bulletin, 1997).

Volclay International and Jianping Redhill Bentonite Co. formed a joint venture, which now operates as Beijing Prosperity Clay & Construction Materials. The venture will focus on the foundry sand, oil drilling, construction, and cat litter markets in the Pacific Rim area (Industrial Minerals, 1997j).

Watts Blake Bearne & Co. PLC entered into a joint venture with Jianbei (Group) Co. Ltd. to produce ball clay near Qingyuan, Guangdong Province. The new venture will serve the growing Chinese ceramics market. Production is scheduled to begin in 1998 (Watts Blake Bearne & Co. PLC, What's new at WBB, accessed June 30, 1998, at URL <http://www/wbb.co.uk/page10.htm>).

India.—Volclay International finalized a joint venture with Ashapura Minechem Ltd. The venture will operate as Ashapura Volclay Ltd. and manufacture and sell value-added bentonitic products (Industrial Minerals, 1997j).

Italy.—Süd-Chemie AG acquired 50% of Laviosa Minerals SpA's ownership in Società Sarda di Bentonite SpA. Under the agreement, one mine and two plants were transferred to Süd-Chemie. The 180,000-ton-per-year mine is located in northwest Sardinia and the plants are located in Oristano and Sant'Antioco, southwestern Sardinia (Industrial Minerals, 1997e).

Mexico.—Volclay de Mexico SA de CV built a new blending facility at its Gomez Palacio operation. The facility, which is highly automated, prepares blends of bentonite and coal for its foundry customers. The foundry market is believed one of the major growth areas for the Mexican bentonite industry. There has been increased investment in the foundry industry and major plant expansions in the past 2 years. This has resulted in large part because of the large growth in the automobile manufacturing industry in Mexico (North American Minerals News, 1997e; Nebergall, 1997).

Spain.—Tolsa SA agreed to purchase the Iboughardian bentonite mine from the Bureau de Recherches et de Participations Minières. The mine is near Nador and has reserves of 600,000 tons (Industrial Minerals, 1997i).

Guzman Minerales SA and Stephan Schmidt KG formed a joint venture to mine and process clay for the tile and sanitaryware market (Industrial Minerals, 1997f).

Laporte PLC sold its subsidiary, Minas de Gador SA, to a Spanish investment bank. Minas de Gador has a production capacity of 130,000 tons per year of bentonite and saponite. The sale is part of a reorganization that Laporte is currently undergoing (Industrial

Minerals, 1997d).

Thailand.—Volclay Siam Ltd. Co. built a bentonite processing plant in Rayong. Volclay International, the parent company of Volclay Siam, will provide technical support and assist with new product development (Industrial Minerals, 1997j).

Turkey.—Kalemaden Endüstriyel Sanayii ve Ticaret A.Ş. completed a processing facility for kaolin and other ceramic-grade clays. The plant will supply clay for engobe, glaze, and sanitaryware markets (Asian Ceramics, 1997).

Research

Research was conducted on the use of montmorillonite to improve the properties of polymers. Tests showed increases in tensile strength, tensile modulus, flexural strength, and flexural modulus. In addition, the polymers exhibited better resistance to heat distortion and were less flammable (lower heat release rates). A purified montmorillonite is produced for this application by separating the montmorillonite from a bentonite sample and modifying its surface to make it organophilic. The fine grain size of the montmorillonite improves its dispersion in the polymer. The attached organic molecules on the montmorillonite improve its bonding with the polymer. Courser, untreated clay particles are dispersed throughout the polymer as clusters of platelets rather than individual platelets and tend to behave as immiscible components, resulting in two distinct phases. (Chemical & Engineering News, 1997; North American Minerals News, 1997d).

Bentonite which has been surface treated with quaternary amines such as alkyl di-methyl ammonium halide effectively removed oils and other organic compounds from water treatment systems. The amines rendered the bentonite lipophilic and hydrophobic, permitting it to absorb up to 50 weight-percent of organics (Chemical Engineering, 1997).

Outlook

The outlook for the domestic clay industry looks promising with modest growth expected for the next couple of years. The U.S. economy has been growing over the past 6 or 7 years with an accompanying growth in industrial manufacturing, housing, and other industries that consume clays. The strength of the economy should ensure that clay markets remain strong for several years to come.

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TABLE 1
SALIENT U.S. CLAY STATISTICS 1/ 2/

(Thousand metric tons and thousand dollars)

	1993	1994	1995	1996	1997
<u>Domestic clays sold or used by producers:</u>					
Quantity	40,700	42,000	43,100	43,100	42,000
Value	\$1,470,000	\$1,590,000	\$1,730,000	\$1,710,000	\$1,670,000
<u>Exports:</u>					
Quantity	4,150	4,620	4,680	4,830	5,080
Value	\$670,000	\$739,000	\$812,000	\$825,000	\$860,000
<u>Imports for consumption:</u>					
Quantity	39	36	35	45	64
Value	\$17,600	\$14,900	\$16,000	\$21,000	\$23,200

1/ Excludes Puerto Rico.

2/ Data are rounded to three significant digits, where applicable.

TABLE 2
CLAYS SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 1997, BY STATE 1/ 2/

(Thousand metric tons and thousand dollars)

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total	Total value
Alabama	--	W	2,590	W	--	W	2,590	25,400
Arizona	--	W	W	--	--	--	W	W
Arkansas	--	--	979	--	--	W	979	1,400
California	--	29	937	W	W	75	1,040	13,700
Colorado	--	--	258	--	--	--	258	1,970
Connecticut	--	--	48	--	--	--	48	90
Florida	--	--	W	--	W	W	W	W
Georgia	--	--	1,820	--	576	8,300	10,700	1,060,000
Illinois	--	--	100	--	W	--	100	533
Indiana	--	--	947	--	--	--	947	2,040
Iowa	--	--	287	--	--	--	287	976
Kansas	--	--	545	--	W	--	545	2,500
Kentucky	W	--	865	7	--	--	872	3,910
Louisiana	--	--	556	--	--	--	556	9,060
Maine	--	--	W	--	--	--	W	W
Maryland	--	--	287	--	--	--	287	1,010
Massachusetts	--	--	W	--	--	--	W	W
Michigan	--	--	712	--	--	--	712	3,750
Minnesota	--	--	W	--	--	--	W	W
Mississippi	W	W	502	--	388	--	890	31,600
Missouri	W	--	1,050	291	W	--	1,340	8,400
Montana	--	W	W	--	--	--	W	W
Nebraska	--	--	279	--	--	--	279	1,090
Nevada	--	W	--	--	W	W	W	W
New Jersey	--	--	W	--	--	--	W	131
New Mexico	--	--	32	1	--	--	33	185
New York	--	--	477	--	--	--	477	12,100
North Carolina	--	--	2,460	--	--	W	2,460	11,900
North Dakota	--	--	56	--	--	--	56	W
Ohio	--	--	1,210	301	--	--	1,510	9,910
Oklahoma	--	--	653	--	--	--	653	4,430
Oregon	--	W	W	--	--	--	W	W
Pennsylvania	--	--	839	--	--	W	839	2,740
South Carolina	--	--	1,080	--	--	447	1,520	31,900
South Dakota	--	--	182	--	--	--	182	W
Tennessee	659	--	W	--	W	W	659	27,400
Texas	W	W	2,150	--	W	35	2,190	21,200
Utah	--	W	299	--	W	--	299	4,510
Virginia	--	--	830	--	W	--	830	3,160
Washington	--	--	165	--	--	--	165	715
West Virginia	--	--	151	--	--	--	151	323
Wyoming	--	3,340	W	--	--	--	3,340	140,000
Total	1,040	4,020	24,500	649	2,370	9,410	42,000	1,670,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

1/ Excludes Puerto Rico.

2/ Data are rounded to three significant digits; may not add to totals shown.

TABLE 3
BALL CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Airfloat		Water-slurried		Unprocessed		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1996:								
Tennessee	255	13,900	187	8,270	236	6,870	679	29,000
Other 2/	118 r/	6,990 r/	(3/)	(3/)	139	5,920	257 r/	12,900 r/
Total	373 r/	20,800 r/	187	8,270	375	12,800	935 r/	41,900 r/
1997:								
Tennessee	252	13,400	157	6,960	249	7,120	659	27,400
Other 2/	178	13,000	--	--	202	7,650	379	20,700
Total	430	26,400	157	6,960	451	14,800	1,040	48,100

r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes Kentucky, Mississippi, Missouri, and Texas.

3/ Included with "Unprocessed."

TABLE 4
BALL CLAY SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1996	1997
Filler, extenders, binders 2/	74,900 r/	78,600
Floor and wall tile	223,000	315,000
Miscellaneous ceramics 3/	45,500	26,500
Pottery	118,000	102,000
Refractories 4/	78,900	68,500
Sanitaryware	207,000	219,000
Miscellaneous 5/	59,800 r/	82,800
Exports 6/	129,000	146,000
Total	935,000 r/	1,040,000

r/ Revised.

1/ Data are rounded to three significant digits, may not add to totals shown.

2/ Includes animal feed, asphalt emulsions, pesticides, rubber, and other filler, extenders and binders.

3/ Includes catalysts, electrical porcelain, fine china/dinnerware, glazes, and miscellaneous ceramics.

4/ Includes firebrick, blocks, and shape, high-alumina brick and specialties, and miscellaneous refractories.

5/ Includes brick (common), waterproofing seals, drilling mud, and other unknown uses.

6/ Includes ceramics and glass, fillers, extenders and binders, floor and wall tile, miscellaneous refractories, and other unknown uses.

TABLE 5
BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Nonswelling		Swelling		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1996:						
California	W	W	W	W	148	13,900
Colorado	1	19	--	--	1	19
Mississippi	145	4,480	--	--	145	4,480
Nevada	W	W	W	W	6	580
Oregon	W	W	W	W	33	1,530
Wyoming	--	--	3,030	98,400 r/	3,030	98,400 r/
Other 2/	315	17,400	251	13,500 r/	566	15,000 r/
Total	461	21,900	3,280	112,000	3,740	134,000
1997:						
California	W	W	W	W	29	3,420
Colorado	--	--	--	--	--	--
Mississippi	W	W	W	W	W	W
Nevada	W	W	W	W	W	W
Oregon	--	--	W	W	W	W
Wyoming	--	--	3,340	140,000	3,340	140,000
Other 2/	397	13,500	283	15,900	651	25,900
Total	397	13,500	3,630	156,000	4,020	169,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other " or "Total."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes Alabama, Arizona, Montana, Texas, and Utah.

TABLE 6
BENTONITE SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1996	1997
Domestic:		
Absorbents:		
Pet waste absorbents	607,000	604,000
Other absorbents	90,500	W
Adhesives	11,200	15,100
Animal feed	65,200	110,000
Ceramics (except refractories) 2/	W	W
Drilling mud	572,000	789,000
Filler and extender applications 3/	33,500	41,300
Filtering, clarifying, decolorizing: minerals oils and greases, vegetable oils, desiccants (1997)	W	82,400
Foundry sand	772,000	901,000
Pelletizing (iron ore) 4/	674,000	536,000
Miscellaneous refractories and kiln furniture 5/	16,700	7,800
Miscellaneous 6/	242,000	126,000
Waterproofing and sealing	227,000	267,000
Total	3,310,000	3,480,000
Exports:		
Drilling mud	102,000	150,000
Foundry sand	278,000	293,000
Other 7/	46,400	101,000
Total	426,000	544,000
Grand total	3,740,000	4,020,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes floor and wall tile, and pottery.

3/ Includes medical, pharmaceutical, cosmetics, paint, pesticides and related products, plastics, asphalt emulsions and tiles, ink, and miscellaneous fillers and extenders applications.

4/ Excludes shipments to Canada. Total sales were 685,000 tons in 1996 and 598,000 tons in 1997.

5/ Includes kiln furniture (1996), plugs, taps, wads, and miscellaneous refractories.

6/ Includes chemical manufacturing, filtering and clarifying oils, heavy clay products, and other unknown uses.

7/ Includes absorbents, waterproofing and sealing, fillers and extenders, and pelletizing refractories, and miscellaneous refractories.

TABLE 7
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons and thousand dollars)

State	1996		1997	
	Quantity	Value	Quantity	Value
Alabama	2,290	17,100	2,590	25,400
Arkansas	939	2,390	979	1,400
California	1,340	12,600	937	10,300
Georgia	1,660	11,200	1,820	11,600
Indiana	1,510	3,500	947	2,040
Kansas	548	2,250	545	2,500
Kentucky	823	3,680	865	3,910
Michigan	652	3,410	712	3,750
Mississippi	534	3,610	502	3,500
Missouri	849	3,250	1,050	4,140
New York	652	14,000	477	12,100
North Carolina	2,400	12,400	2,460	11,900
Ohio	1,960	7,450	1,210	5,600
Oklahoma	799	4,090	653	4,430
Pennsylvania	753	2,420	839	2,740
South Carolina	1,260	4,860	1,080	2,850
Texas	2,290	15,000	2,150	13,600
Virginia	883	3,220	830	3,160
Other 3/	4,060	17,500	3,820	24,700
Total	26,200	144,000	24,500	149,000

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Excludes Puerto Rico.

3/ Includes all other States except; Alaska, Delaware, Hawaii, Idaho, Nevada, New Hampshire (1997), Rhode Island, Vermont, and Wisconsin.

TABLE 8
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY USE 1/ 2/

(Metric tons)

Use	1996	1997
Ceramics and glass 3/	142,000	158,000
Civil engineering and sealing	279,000	W
Floor and wall tile:		
Ceramic	293,000	318,000
Other 4/	61,900	57,700
Heavy clay products:		
Brick, extruded	11,300,000	10,900,000
Brick, other	1,730,000	1,940,000
Drain tile and sewer pipe	123,000	56,800
Flowerpots	47,400	W
Flue linings	45,200	59,900
Structural tile	21,500	W
Other 5/	505,000	122,000
Lightweight aggregate:		
Concrete block	2,450,000	2,550,000
Highway surfacing	245,000	278,000
Structural concrete	887,000	740,000
Miscellaneous 6/	471,000	429,000
Portland and other cements	7,000,000	5,720,000
Refractories 7/	519,000	619,000
Miscellaneous 8/	117,000	513,000
Total	26,199,488	24,466,984

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Miscellaneous."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Excludes Puerto Rico.

3/ Includes pottery and roofing granules.

4/ Includes quarry tile and miscellaneous floor and wall tiles.

5/ Includes flower pots (1997), roofing tile, structural tile, terra cotta, and miscellaneous clay products.

6/ Includes miscellaneous lightweight aggregates.

7/ Includes firebrick, blocks and shapes, grogs and calcines, mortar and cement, and miscellaneous refractories.

8/ Includes asphalt emulsions, civil engineering and sealing (1997), pelletizing (iron ore) (1996), exports, and other unknown uses.

TABLE 9
FIRE CLAY SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons and thousand dollars)

State	1996		1997	
	Quantity	Value	Quantity	Value
Alabama	52	2,800	W	W
Missouri	223	3,220	291	4,270
Ohio	103	3,230	301	4,310
Other 3/	127	1,450	57	874
Total	505	10,700	649	9,450

W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Refractory uses only.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Includes Arkansas (1996), California, Kentucky (1997), Montana (1996), New Mexico, Oklahoma (1996), and South Carolina (1996).

TABLE 10
FIRE CLAY SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1996	1997
Ceramics and glass 2/	W	W
Heavy clay products and lightweight aggregates 3/	78,800	W
Refractories:		
Firebrick, block and shapes	166,000	176,000
Other refractories 4/	188,000	168,000
Miscellaneous	72,800	306,000
Exports	W	--
Total	505,000	649,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes pottery.

3/ Includes portland cement, terra cotta, and other unknown uses.

4/ Includes common brick, flue linings (1996), foundry sand, grogs and calcines, mortar and cement, plug, tap and wad, terra cotta (1997) and other unknown uses.

TABLE 11
FULLER'S EARTH SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Attapulgitite		Montmorillonite		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1996:						
Florida	377	58,900	(2/)	(2/)	377	58,900
Georgia	739	89,200	(2/)	(2/)	739	89,200
Southern States 3/	--	--	504	38,500	504	38,500
Western States 4/	(5/)	(5/)	981	91,100	981	91,100
Total	1,120	148,000	1,490	130,000	2,600	278,000
1997:						
Florida	(5/)	(5/)	W	W	W	W
Georgia	576	70,500	(2/)	(2/)	576	70,500
Southern States 3/	--	--	840	101,000	840	101,000
Western States 4/	(5/)	(5/)	955	83,300	955	83,300
Total	576	70,500	1,800	184,000	2,370	255,000

W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Included with "Attapulgitite."

3/ Includes Florida (1997), Mississippi, Tennessee, and Virginia.

4/ Includes California, Illinois, Kansas, Missouri, Nevada, Texas, and Utah.

5/ Included with "Montmorillonite."

TABLE 12
FULLER'S EARTH SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1996	1997
Absorbents:		
Oil and grease absorbent	258,000	274,000
Pet waste absorbent	1,530,000	1,470,000
Miscellaneous absorbent	W	W
Animal feed	89,600	113,000
Drilling mud	24,000	W
Fertilizers	48,900	42,500
Fillers, extenders, binders 2/	76,600	73,000
Filtering, clarifying, decolorizing, animal, mineral, vegetable oils, and greases	8,170	5,930
Pesticides and related products	261,000	176,000
Miscellaneous 3/	145,000	173,000
Exports 4/	164,000	44,000
Total	2,600,000	2,370,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes adhesives, asphalt tiles, gypsum products, medical, pharmaceutical and cosmetics (1996), paint, paper coating (1997), plastics (1996), asphalt emulsions, textiles, and other unknown uses.

3/ Includes catalysts (oil-refining), roofing granules, chemical manufacturing (1996), portland cement, refractories, waterproofing and sealing (1997), and other unknown uses.

4/ Includes absorbents, fillers, extenders and binders, floor and wall tiles, refractories, and other unknown uses.

TABLE 13
KAOLIN SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	1996		1997	
	Quantity	Value	Quantity	Value
Arkansas	161	W	W	W
Florida	35	3,760	W	W
Georgia	8,040	1,050,000	8,300	981,000
South Carolina	442 r/	21,400 r/	447	29,000
Other 2/	494 r/	23,400	617	26,900
Total	9,180 r/	1,100,000 r/	9,410	1,040,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other or Total."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes Alabama, California, Colorado, Minnesota (1996), Nevada, North Carolina, Pennsylvania, Tennessee, Texas, and items indicated by symbol W.

TABLE 14
KAOLIN SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY KIND 1/

(Thousand metric tons and thousand dollars)

Kind	1996		1997	
	Quantity	Value	Quantity	Value
Airfloat	1,210 r/	66,200 r/	1,320	71,900
Calcined 2/	1,670	309,000	1,690	269,000
Delaminated	1,520	191,000	1,440	146,000
Unprocessed	450	8,430	296	7,090
Water-washed	4,340	525,000	4,670	546,000
Total	9,180 r/	1,100,000 r/	9,410	1,040,000

r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes pigment-grade and refractory-grade calcined kaolin.

TABLE 15
CALCINED KAOLIN SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY STATE 1/

(Thousand metric tons and thousand dollars)

State	High-temperature		Low-temperature	
	Quantity	Value	Quantity	Value
1996:				
Alabama and Georgia	858	13,900	670	285,000
Other 2/	99	4,190	38	6,580
Total	957	18,100	708	291,000
1997:				
Alabama and Georgia	W	W	742	244,000
Other 2/	W	W	41	8,550
Total	909	16,100	784	253,000

W Withheld to avoid disclosing company proprietary data; included with "Total."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes Arkansas, California, Colorado (1996), Nevada, Pennsylvania, South Carolina, and Texas.

TABLE 16
GEORGIA KAOLIN SOLD OR USED
BY PRODUCERS, BY KIND 1/

(Thousand metric tons and thousand dollars)

Kind	1996		1997	
	Quantity	Value	Quantity	Value
Airfloat	832	38,300	849	37,800
Calcined 2/	1,270	293,000	1,200	244,000 3/
Delaminated 4/	1,500	191,000	1,440	146,000
Unprocessed	133	5,220	190	W
Water-washed	4,300	523,000	4,630	545,000
Total	8,040	1,050,000	8,300	981,000

W Withheld to avoid disclosing company proprietary data; included with "Total."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes pigment-grade and refractory-grade calcined kaolin.

3/ Excludes value for high-temperature; included in "Total."

4/ May include some sales of water-washed kaolin in 1996.

TABLE 17
 GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY USE 1/ 2/

(Metric tons)

Use	1996	1997
Domestic:		
Ceramics and glass:		
Catalysts (oil-refining)	W	W
Electrical porcelain	5,930	W
Fiber glass	418,000	429,000
Roofing granules	9,660	W
Sanitaryware	64,200	W
Other 3/	234,000	319,000
Fillers, extenders, and binder:		
Adhesives	78,400	71,100
Paint	262,000	296,000
Paper coating	2,800,000	2,980,000
Paper filling	847,000	905,000
Plastic	31,000	33,600
Rubber	112,000	84,500
Other 4/	86,500	98,400
Heavy clay products 5/	20,900	46,600
Refractories 6/	523,000	565,000
Undistributed 7/	150,000	137,000
Total	5,650,000	5,970,000
Exports:		
Paint	66,300	72,800
Paper coating 8/	2,000,000	2,010,000
Paper filling 8/	142,000	105,000
Rubber	8,570	7,020
Undistributed 9/	185,000	138,000
Total	2,400,000	2,330,000
Grand total	8,040,000	8,300,000

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed."

1/ Includes high-temperature calcined, low-temperature calcined, and delaminated.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Includes crockery/earthenware, fine china/dinnerware, glazes, glass and enamels, pottery, and miscellaneous ceramics.

4/ Includes asphalt emulsion, asphalt tile, fertilizers, gypsum products, medical, pharmaceutical and cosmetics, pesticides and related products, textiles and miscellaneous fillers, extenders and binders, and ink.

5/ Includes brick (common and face), portland cement, and miscellaneous clay products.

6/ Includes firebrick, blocks and shapes, grogs and calcines, high-alumina specialties, kiln furniture, and miscellaneous refractories.

7/ Includes chemical manufacturing, civil engineering and sealings, drilling mud, filtering, clarifying, and decolorizing, floor and wall tiles, pet waste absorbents, and other unknown uses.

8/ Some export sales may be included under Domestic sales.

9/ Includes fiber glass, sanitaryware, ink, miscellaneous fillers, extenders and binders, and other unknown uses.

TABLE 18
SOUTH CAROLINA KAOLIN SOLD OR USED BY PRODUCERS,
BY KIND 1/

(Thousand metric tons and thousand dollars)

Kind	1996		1997	
	Quantity r/	Value	Quantity	Value
Airfloat	276	20,000 r/	390	27,500
Unprocessed 2/	166	1,460	57	1,540
Total	442	21,400 r/	447	29,000

r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes pigment-grade calcined kaolin.

TABLE 19
SOUTH CAROLINA KAOLIN SOLD OR USED
BY PRODUCERS, BY KIND AND USE 1/

(Metric tons)

Kind and use	1996	1997
Adhesives	W	14,800
Animal feed and pet waste absorbent	W	W
Ceramics 2/	18,900 r/	24,400
Fertilizers, pesticides and related products	5,220	W
Fiber glass	W	W
Paper coating and filling	8,290	W
Plastics	W	5,290
Rubber	119,000 r/	133,000
Refractories 3/	10,200	10,300
Other uses 4/	253,000 r/	201,000
Exports 5/	27,400 r/	57,500
Total	442,000 r/	447,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other uses."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes crockery and earthenware (1996), fine china/dinnerware, floor and wall tile, pottery, roofing granules, and sanitaryware (1997).

3/ Includes refractory calcines and grogs, firebrick, blocks and shapes, refractory mortar and cement (1996), and high-alumina refractories.

4/ Includes brick (face and common), catalysts (oil refining), asphalt emulsion, asphalt tile (1997), gypsum products, and unknown uses.

5/ Includes paint, paper filling, and rubber.

TABLE 20
KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1996	1997
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	212,000	227,000
Electrical porcelain	12,300	13,700
Fine china and dinnerware	26,400	19,800
Floor and wall tile	31,800	33,400
Pottery	25,700	27,100
Roofing granules	21,300	22,900
Sanitaryware	72,100	53,700
Miscellaneous	100,000	66,700
Chemical manufacture	W	W
Civil engineering	7,780	6,930
Glass fiber, mineral wool	458,000	496,000
Filler, extender, binder:		
Adhesive	93,700 r/	85,900
Fertilizer	W	5,200
Medical, pharmaceutical cosmetic	W	W
Paint	288,000	329,000
Paper coating	2,810,000	2,990,000
Paper filling	854,000	918,000
Pesticide	16,700	19,000
Plastic	36,300	38,900
Rubber	231,000 r/	218,000
Miscellaneous	94,500 r/	114,000
Heavy clay products:		
Brick, common and face	214,000	105,000
Portland cement	W	71,000
Refractories:		
Firebrick, block and shapes	565,000	13,700
Groggs and calcines	173,000	867,000
High alumina brick, specialties, kiln furniture	86,800	45,700
Foundry sand, mortar, cement, miscellaneous refractories	78,000	73,300
Miscellaneous applications	231,000	163,000
Total	6,740,000 r/	7,020,000
Exports:		
Ceramics	179,000	129,000
Foundry sand, grogs and calcines; other refractories	W	W
Paint	66,300	72,800
Paper coating	2,000,000	2,010,000
Paper filling	142,000	105,000
Rubber	35,800	64,600
Miscellaneous	19,900	10,500
Total	2,440,000	2,390,000
Grand total	9,180,000 r/	9,410,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous" or "Miscellaneous applications."

1/ Data are rounded to three significant digits; may not add to totals shown.

TABLE 21
COMMON CLAY AND SHALE USED IN LIGHTWEIGHT AGGREGATE PRODUCTION IN THE UNITED STATES BY STATE 1/

(Thousand metric tons and thousand dollars)

State	Concrete block	Structural concrete	Highway surfacing	Other	Total	Total value e/
1996:						
Alabama and Arkansas	792	103	21	67	983	13,200
California	141	104	--	76	321	7,540
Florida and Indiana	153	36	--	60	249	1,650
Kansas, Kentucky, Louisiana	295	128	--	86	509	1,180
Mississippi and Missouri	15	1	2	116	134	1,560
New York	265	235	--	--	500	13,200
North Carolina	301	52	--	--	353	4,050
Oklahoma, Ohio, Pennsylvania	187	26	--	--	213	1,430
Texas	49	157	222	31	459	2,520
Utah and Virginia	255	45	--	35	335	4,850
Total	2,450	887	245	471	4,060	51,200
1997:						
Alabama and Arkansas	926	104	25	--	1,060	15,600
California e/	141	104	--	76	321	7,540
Florida and Indiana	190	42	--	--	232	1,470
Kansas, Kentucky, Louisiana	334	70	30	160	594	8,380
Missouri	--	--	--	128	128	1,690
New York	201	152	--	--	354	11,300
North Carolina e/	300	52	--	--	353	4,050
Oklahoma and Ohio	211	14	--	--	224	1,240
Texas e/	49	157	222	31	459	2,520
Utah and Virginia	194	45 e/	--	35 e/	274	4,680
Total	2,550	740	277	430	3,990	58,400

e/ Estimated.

1/ Data are rounded to three significant digits; may not add to totals shown.

TABLE 22
COMMON CLAY AND SHALE USED IN BUILDING BRICK
PRODUCTION IN THE UNITED STATES, BY STATE 1/ 2/

(Thousand metric tons and thousand dollars)

State	1996		1997	
	Quantity	Value	Quantity	Value
Alabama	860	2,160	917	2,030
Arkansas	448	375	449	464
California	288	1,390	254	1,160
Colorado	295	2,190	240	1,880
Connecticut, New Jersey, 3/ New York 3/	287	1,370	243	971
Georgia	1,250	8,950	1,410	9,410
Illinois	128	634	92	W
Indiana and Iowa	383	1,180	365	1,110
Kentucky 3/ and Tennessee 3/	760	2,080	816	2,350
Maryland and West Virginia 4/	277	706	271	884
Mississippi and Missouri	541	2,210	507	2,230
North Carolina	1,940 r/	7,310	1,980	5,960
Ohio	835	3,990	573	2,470
Oklahoma	445	2,260	405	2,690
Pennsylvania	654	2,140	646	2,020
South Carolina	819	3,290	922	2,180
Texas	1,120	7,840	1,020	5,580
Virginia	671	2,030	689	2,180
Other 5/	966	3,860	1,040	4,580
Total	13,000	56,000	12,800	50,100

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Includes extruded and other brick.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Extruded brick only.

4/ Includes other brick only.

5/ Includes Arizona, Kansas, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Nebraska, New Mexico, North Dakota, Oregon (1996), Utah, Washington, and Wyoming.

TABLE 23
U.S. EXPORTS OF CLAYS IN 1997, BY COUNTRY 1/

(Thousand metric tons and thousand dollars)

Country	Ball clay		Bentonite		Fire clay		Fuller's earth	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	1	26	(2/)	683	(2/)	47	(2/)	122
Australia	(2/)	3	7	1,240	3	1,050	--	--
Belgium	2	40	1	583	3	192	(2/)	19
Brazil	(2/)	5	23	3,390	(2/)	102	(2/)	25
Canada	--	--	256	16,400	5	884	96	8,000
Finland	1	56	(2/)	108	--	--	--	--
France	7	126	41	1,960	(2/)	49	(2/)	33
Germany	(2/)	8	14	1,340	3	333	(2/)	14
Indonesia	--	--	6	1,450	1	143	--	--
Italy	--	--	(2/)	356	2	156	3	613
Japan	4	127	202	17,400	28	2,600	(2/)	34
Korea, Republic of	(2/)	5	18	5,330	5	657	(2/)	6
Malaysia	(2/)	6	16	1,240	--	--	9	1,370
Mexico	27	1,640	31	2,510	69	5,380	1	124
Netherlands	(2/)	25	45	4,010	71	8,160	17	1,720
Singapore	--	--	17	2,050	--	--	1	180
South Africa	--	--	1	358	1	59	(2/)	15
Taiwan	7	707	29	5,220	19	2,110	--	--
Thailand	--	--	21	1,920	(2/)	54	(2/)	47
United Kingdom	(2/)	3	58	5,480	3	280	2	361
Venezuela	12	1,210	22	2,650	(2/)	74	1	289
Other	30	1,920	42	9,040	9	1,110	14	3,170
Total	91	5,900	850	84,700	222	23,500	144	16,100
	Kaolin		Clays, n.e.c. 3/		Total			
	Quantity	Value	Quantity	Value	Quantity	Value		
Argentina	15	2,760	3	1,380	20	5,020		
Australia	15	8,700	4	3,860	29	14,900		
Belgium	38	10,200	2	1,990	46	13,100		
Brazil	6	1,660	4	3,530	33	8,710		
Canada	701	81,100	196	30,600	1,250	137,000		
Finland	305	50,400	(2/)	756	307	51,300		
France	7	1,850	2	1,760	57	5,780		
Germany	23	9,060	9	3,710	50	14,500		
Indonesia	70	14,500	3	2,330	80	18,400		
Italy	141	20,500	3	1,390	149	23,000		
Japan	869	174,000	26	15,300	1,130	209,000		
Korea, Republic of	163	27,000	6	6,850	192	39,800		
Malaysia	4	1,210	2	1,260	31	5,080		
Mexico	182	18,900	9	3,020	318	31,500		
Netherlands	307	46,100	16	13,000	456	73,100		
Singapore	4	988	3	3,210	25	6,430		
South Africa	15	3,370	4	1,940	20	5,740		
Taiwan	146	20,600	14	3,800	215	32,500		
Thailand	18	4,100	4	2,380	43	8,500		
United Kingdom	62	8,060	26	20,400	151	34,500		
Venezuela	22	5,480	16	5,140	73	14,800		
Other	268	73,400	38	19,100	403	108,000		
Total	3,380	583,000	390	147,000	5,080	860,000		

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Also includes chamotte or dinas earth, activated clays and earths, and artificially activated clays.

Source: Bureau of the Census.

TABLE 24
U.S. IMPORTS FOR CONSUMPTION OF CLAY IN 1997, BY KIND 1/

Kind	Quantity (metric tons)	Value (thousands)
China clay or kaolin:		
Brazil	17,400	\$2,760
China	3,230	621
New Zealand	1,380	873
United Kingdom	8,030	2,720
Other	342	290
Total	30,400	7,270
Fire clay:		
Canada	25	17
France	23	37
United Kingdom	13	4
Other	8	22
Total	69	79
Decolorizing earths and fuller's earth:		
Canada	3,290	342
France	220	109
Netherlands	2	11
Switzerland	20	11
Total	3,530	473
Bentonite:		
Canada	1,190	348
Japan	1,640	156
Mexico	978	223
United Kingdom	2,740	1,600
Other	953	478
Total	7,560	2,810
Common blue clay and other ball clay:		
Germany	30	30
United Kingdom	793	231
Total	823	261
Other clay:		
Canada	629	254
Italy	194	73
South Africa	519	728
United Kingdom	1,140	494
Other	245	494
Total	2,720	2,040
Chamotte or dina's earth: Denmark		
	33	14
Artificially activated clay and activated earth:		
Austria	751	992
Canada	985	727
Germany	1,110	1,660
Mexico	14,600	4,920
Other	1,110	2,010
Total	18,600	10,300
Grand total	63,700	23,200

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 25
BENTONITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1993	1994	1995	1996	1997 e/
Algeria 4/	20,833	20,215	17,088 r/	17,200 r/	17,000
Argentina	96,706	313,407 r/	111,011 r/	134,588 r/	140,000
Armenia	50 e/	100 e/	110	2,750	2,750
Australia e/ 4/	35,000	35,000	35,000	35,000	35,000
Bosnia and Herzegovina e/	800	800	800	800	800
Brazil (beneficiated)	113,180 r/	144,950 r/	150,000 r/	186,000 r/	180,000
Bulgaria	78,000	76,300	125,800	118,212	120,000
Burma	200	795	2,655	2,600 e/	2,500
Chile	989	1,213	684 r/	1,191 r/	1,200
Croatia	10,000 e/	10,391	7,327	9,728	7,331 5/
Cyprus	51,689	46,530	49,487 r/	70,600 r/	71,000
Czech Republic	63,000	65,000	54,000	59,000	110,000 5/
Egypt	6,013	2,379	1,930 r/	2,210 r/	2,200
France e/	6,000	7,000	--	--	--
Georgia e/	13,000	13,000	13,000	13,000 5/	12,000 5/
Germany	473,102	499,000 r/	529,000 r/	491,000 r/	500,000
Greece	677,578	697,773	1,115,119	973,517 r/	950,000
Guatemala e/	12,300	4,408 5/	4,500	4,500	4,500
Hungary	9,404	14,700	22,792	15,376	14,848 5/
Indonesia	13,707	14,409	26,057	26,000 e/	25,000
Iran 6/	53,667 r/	71,759 r/	54,798 r/	85,000 e/	85,000
Italy	327,000	386,000	591,000 r/	475,000 r/	500,000
Japan	517,389	484,115	478,056	468,728	487,670 5/
Macedonia e/	35,000	30,000	30,000	30,000	30,000
Mexico	94,600	100,000 e/	72,599	69,810 r/	111,503 5/
Morocco	10,811	24,919	29,308	39,680 r/	49,633 5/
Mozambique e/	100	3,349 5/	3,000	3,000	3,000
New Zealand (processed)	1,613	930	3,699	13,734 r/	14,000
Pakistan	7,991	11,180	5,759	15,290	12,000
Peru	10,250	27,682	26,961	18,592	18,600
Philippines	5,050	3,415 r/	7,636 r/	8,000 r/ e/	8,000
Poland	19,800	19,900	6,300 r/	8,000 r/	10,000
Romania	50,000 e/	41,056	42,277	43,543 r/	27,133 5/
Serbia and Montenegro	110	215	192	95	100
South Africa 7/	50,441	71,773	70,927	48,076	30,615 5/
Spain	162,405	179,233	172,265 r/	151,155 r/	150,000
Tanzania e/	70	70	70	75 r/	75
Turkey	456,597	516,187	602,499	600,000 e/	600,000
Turkmenistan e/	50,000	50,000	50,000	50,000	50,000
U.S.S.R. e/ 8/	1,600,000	1,300,000	1,300,000	1,200,000	1,100,000
United States	2,870,000	3,290,000	3,820,000	3,740,000	4,020,000 5/
Zimbabwe 7/	113,470 r/	169,097	169,823 r/	185,953 r/	170,000
Total	8,120,000 r/	8,750,000 r/	9,800,000 r/	9,420,000 r/	9,680,000

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.

2/ Table includes data available through July 15, 1998.

3/ In addition to the countries listed, Canada and China are believed to produce bentonite, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

4/ Includes bentonitic clays.

5/ Reported figure.

6/ Year beginning March 21 of that stated.

7/ May include other clays.

8/ Dissolved in December 1991; however, information is inadequate to formulate reliable estimates for individual countries, except Armenia, Georgia, and Turkmenistan.

TABLE 26
FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1993	1994	1995	1996	1997 e/
Algeria	3,229	4,550	4,500 e/	4,500 e/	4,500
Argentina e/	1,600	1,600	1,600	1,500	1,500
Australia (attapulgit) e/	15,000	15,000	15,000	15,000	15,000
Germany (unprocessed) e/	670,000	498,000	600,000	600,000	600,000
Italy	30,000 e/	24,000 r/	34,000 r/	26,000 r/	30,000
Mexico	36,068	21,377	15,755	41,800 r/	51,430 4/
Morocco (smectite)	38,680	22,782	15,027	16,623	17,000
Pakistan	20,941	15,335	12,862	13,415	14,000
Senegal (attapulgit) e/	119,000	119,000	120,000	120,000	100,000
South Africa (attapulgit)	7,030	10,230	8,049	14,318	9,017 4/
Spain (attapulgit)	98,336	91,124	94,266 r/	94,000 r/	94,000
United Kingdom 5/	187,100	134,000	132,300	143,000 r/ e/	140,000
United States 6/	2,450,000	2,640,000	2,640,000	2,600,000	2,370,000
Total	3,680,000	3,600,000	3,690,000	3,690,000 r/	3,450,000

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.

2/ Excludes centrally planned economy countries and former such countries, some of which presumably produce fuller's earth, but for which no information is available. Table includes data available through July 9, 1998.

3/ In addition to the market economy countries listed, France, India, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

4/ Reported figure.

5/ Salable product.

6/ Sold or used by producers.

TABLE 27
KAOLIN: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1993	1994	1995	1996	1997 e/
Algeria	12,586	16,984	24,068	24,000 e/	25,000
Argentina	42,052	50,471	39,860 r/	64,241 r/	60,000
Australia (includes ball clay) e/	180,000	200,000	210,000	210,000	220,000
Austria (marketable)	64,381	65,000	57,000	60,000 e/	60,000
Bangladesh 4/	7,500	3,283	6,541	7,000 e/	7,200
Belgium e/	300,000	300,000	300,000	300,000	300,000
Bosnia and Herzegovina e/	3,000	3,000	3,000	3,000	3,000
Brazil (beneficiated)	916,048 r/	1,037,570 r/	1,067,109 r/	1,105,000 r/	1,100,000
Bulgaria	111,000	115,000	115,000 e/	115,000 e/	115,000
Burundi e/	5,000	5,000	1,000	1,000	1,000
Chile	66,939	73,081	10,845 r/	13,452 r/	13,000
Colombia (includes common clay)	2,097,491	6,700,000	7,300,000	7,300,000 r/ e/	7,500,000
Czech Republic	2,336,000	2,706,000 r/	2,800,000 r/	2,798,000 r/	2,982,000 5/
Denmark (sales) e/	3,500	3,500	3,500	3,000	3,000
Ecuador	12,000	6,883	8,000	7,000 e/	7,000
Egypt	184,004	180,000 e/	293,381 r/	115,409 r/	120,000
Eritrea	XX	5,231	3,200 r/ e/	2,620	2,500
Ethiopia e/ 6/	500	8 r/ e/	15 r/ e/	15 r/ e/	15
France (marketable)	295,000 e/	327,000	345,000	326,000 r/	330,000
Germany	981,000 e/	1,631,000	1,925,000 r/	1,800,000 r/	1,800,000
Greece	89,473 r/	117,254	68,682 r/	60,453 r/	65,000
Guatemala e/	3,000	3,000	3,100	3,100	3,200
Hungary (processed)	15,000	5,000	4,847	5,000 e/	5,000
India:					
Processed	129,271	134,002 r/	160,689 r/	183,268 r/	190,000
Saleable crude	518,629	548,467 r/	552,128 r/	557,778 r/	550,000
Indonesia	42,365	53,236	14,373	15,000 e/	16,000
Iran	254,413	227,650 r/	265,591 r/	250,000 e/	250,000
Israel e/	40,000 5/	40,000	40,000	40,000	40,000
Italy: Kaolinitic earth e/	15,000	7,000	10,000	10,000	9,000
Japan	110,318	138,412	182,122	141,230	110,915 5/
Korea, Republic of	2,328,921	2,675,485	2,792,139	2,501,600 r/	2,688,489 5/
Madagascar e/	1,000	1,200	1,545 5/	1,500	1,500
Malaysia	249,852	252,628	211,182	209,562	187,411 5/
Mexico	216,000	193,034	221,685	253,971 r/	552,840 5/
New Zealand	26,543	40,720	13,662	26,325 r/	26,000
Nigeria e/	1,300	105,000	105,000 r/	105,000 r/	110,000
Pakistan	37,179	47,894	30,746	54,860	55,000
Paraguay e/	74,000	74,000	66,300 5/	74,000	65,000
Peru	5,100	5,100	8,445	14,295	14,300
Poland (washed)	47,900	52,600 r/	53,000	71,700 r/	70,000
Portugal	178,285 r/	181,933 r/	180,000 r/ e/	180,000 r/ e/	180,000
Romania	50,000 e/	47,566	49,024	45,199 r/	29,169 5/
Serbia and Montenegro:					
Crude	37,627	69,927	56,926	55,000 e/	55,000
Washed	4,800	7,110	4,900	5,000 e/	5,000
Slovakia	25,000	24,100	13,300	23,240	24,000
Slovenia: e/					
Crude	10,000	10,000	10,000	10,000	10,000
Washed	4,000	4,000	4,000	7,000	7,000
South Africa	147,349	131,863	146,587	146,496	140,218 5/
Spain (marketable): 7/ Crude and washed	284,382	337,339	316,074 r/	315,000 r/ e/	315,000
Sri Lanka	7,000 e/	7,500 e/	16,000 r/	7,700 r/	7,600
Sweden e/	100	100	100	100	100
Taiwan e/	100,000	100,000	100,000	100,000	100,000
Thailand (beneficiated)	397,330	417,064	460,629	553,770 r/	367,000
Turkey	210,356	179,775	489,635	490,000 r/ e/	500,000
Ukraine	1,100,000 e/	1,015,000	950,000	900,000 e/	850,000
United Kingdom (sales) 8/	2,577,160	2,653,918	2,585,881	2,281,000 r/	2,400,000
United States 9/	8,830,000	8,770,000	9,480,000	9,120,000	9,410,000 5/

See footnotes at end of table.

TABLE 27--Continued
 KAOLIN: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1993	1994	1995	1996	1997 e/
Uzbekistan e/	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000
Venezuela	22,000	10,345	3,020	7,542 r/	8,225 5/
Vietnam e/	800	1,000	1,000	1,000	1,000
Zimbabwe	90 e/	462	57	-- r/	--
Total	31,300,000 r/	37,600,000 r/	39,700,000 r/	38,600,000	39,600,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through July 9, 1998.

3/ In addition to the countries listed, China, Morocco, and Suriname may also have produced kaolin, but information is inadequate to make reliable estimates of output levels.

4/ Data for year ending June 30 of that stated.

5/ Reported figure.

6/ Data for year ending July 7 of that stated.

7/ Includes crude and washed kaolin and refractory clays not further described.

8/ Dry weight.

9/ Kaolin sold or used by producers.