### **CLAY AND SHALE**

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Companies in the United States mined six types of clays—ball clay, bentonite, common clay and shale, fire clay, fuller's earth, and kaolin. Ball clays consist primarily of kaolinite with minor to major amounts of chlorite, illite, organic materials, smectite minerals, and quartz. Bentonites comprise smectite minerals (usually montmorillonite) with minor amounts of biotite, feldspars, and quartz. Common clay and shale contain chlorite and illite as major components. Fire clay comprises mainly diaspore, halloysite, and/or kaolinite. Fuller's earth consists primarily of attapulgite, calcium-rich montmorillonite, and quartz. In many countries, all calcium-rich montmorillonite clays, including calcium-rich bentonite, are called fuller's earth, and attapulgite is grouped under specialty clays. Kaolin comprises primarily kaolinite or kaolin-group minerals. Mica, quartz, rutile, and smectite minerals are a few other components of kaolin deposits. Absorption qualities, clarification properties, color, firing characteristics, mineral composition, and plasticity are a few of the characteristics used to distinguish between the different clay types.

The amount of clay sold or used by domestic producers in 2003 was 40 million metric tons (Mt) valued at \$1.66 billion (table 1). Common clay and shale accounted for 58% of the tonnage, and kaolin accounted for 57% of the value (tables 2, 7, 13). Imports of clays were 279,000 metric tons (t) valued at \$51.2 million. Exports were 5.13 Mt valued at \$859 million (table 1).

Major markets, including exports, for ball clay were floor and wall tile (31%), sanitaryware (20%), and pottery and other ceramics (19%); for bentonite, absorbents (25%), foundry sand bond (25%), drilling mud (22%), and iron ore pelletizing (15%); for common clay and shale, brick (55%), cement (19%), and lightweight aggregate (16%); for fire clay, refractory products (79%); for fuller's earth, absorbents (76%); and for kaolin, paper coating and filling (64%).

#### **Legislation and Government Programs**

The U.S. Environmental Protection Agency (EPA) finalized its maximum achievable control technology (MACT) regulation for the refractory industry. The standard requires the refractory industry to achieve one of two options—total hydrocarbons emissions of 20 parts per million or a reduction in hydrocarbon emissions of 95%. Affected continuous kilns must limit hydrogen fluoride emissions to 0.019 kilogram per megagram (kg/Mg) of uncalcined clay or reduce emissions by 90%. For hydrogen chloride, emissions are limited to 0.091 kg/Mg of uncalcined clay or a reduction of 30% in emissions. For new batch kilns, hydrogen fluoride and hydrogen chloride emissions must be reduced by at least 90% and 30%, respectively, of emissions by brick kilns with dry lime scrubbers (U.S. Environmental Protection Agency, 2003b).

The EPA also finalized its MACT regulation for brick and structural clay manufacturing. Existing large tunnel kilns, new or reconstructed small tunnel kilns, small kilns expanded to large capacity, and dry limestone absorber-controlled kilns must limit hydrogen fluoride emissions to 0.029 kg/Mg of uncalcined clay or reduce emissions by 90%. For hydrogen chloride, emissions are limited to 0.13 kg/Mg of uncalcined clay or a reduction of 30%. Particulate emissions are limited to 0.21 kg/Mg of fired product. New or reconstructed large tunnel kilns must limit hydrogen fluoride emissions to 0.029 kg/Mg of uncalcined clay or reduce emissions by 90%. For hydrogen chloride, emissions are limited to 0.028 kg/Mg of uncalcined clay or a reduction of 85%. Particulate emissions are limited to 0.06 kg/Mg of fired product (U.S. Environmental Protection Agency, 2003a).

#### **Production**

In 2003, about 240 companies operated approximately 810 clay and shale pits or quarries. The largest 20 companies, many with multiple operations, accounted for 50% of the tonnage and 79% of the value for all types of clay produced and sold or used. Clay production was reported in all States except Alaska, Delaware, Hawaii, Idaho, New Hampshire, Rhode Island, Vermont, and Wisconsin (table 2). For States not reporting production, clay probably was extracted for construction uses by companies not participating in the U.S. Geological Survey (USGS) canvass of the clay and shale industry.

The 10 leading producer States, in decreasing order of tonnage, were Georgia, Wyoming, Alabama, Texas, North Carolina, Missouri, California, Ohio, South Carolina, and Virginia. The 10 leading producer companies, in alphabetical order, were American Colloid Co. (bentonite); Big River Industries, Inc. (common clay and shale); Engelhard Corp. (bentonite, fuller's earth, and kaolin); General Shale Products Corp. (common clay and shale); Holnam, Inc. (common clay and shale); J.M. Huber Corp. (kaolin); Imerys (ball clay and kaolin); Oil-Dri Corp. (fuller's earth); Solite Corp. (common clay and shale); and Thiele Kaolin Co. (kaolin).

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 underground production was in Ohio where the clays are mainly underclays associated with coal.

Domestic production data for clays were developed by the USGS from a voluntary survey of U.S. operations. Responses to the survey and company data available from other sources accounted for approximately 60% of the total clay and shale sold or used quantity listed in table 1. The bulk of the nonrespondents were producers of common clay and shale. Production data for the nonrespondents were estimated from

reported prior year production levels adjusted by trends in the industry and other guidelines.

Ball Clay.—In 2003, 4 companies mined ball clay from 54 pits in 4 States. Production of domestic ball clay was estimated to be 1.31 Mt valued at \$56.2 million (table 3). Sales of unprocessed or shredded ball clay increased as this has become an increasingly popular product for ceramic manufacturers. Sales of airfloat ball clay also increased in response to demand by the ceramics industry. Tennessee supplied 59% of the Nation's output, followed by, in descending order of tonnage, Texas, Kentucky, and Mississippi. One producer reported a small amount of production in Indiana, but this was fire clay rather than ball clay. Water-slurried ball clay was produced in Kentucky and Tennessee, Airfloat ball clay was produced in Kentucky, Tennessee, and Texas. Shredded (unprocessed) ball clay was produced in all four States.

Franklin Industries, Inc. acquired H.C. Spinks Clay Co. Inc. Spinks Clay mined and processed ball clay near Gleason, TN. Franklin Industries viewed the purchase as a means of diversifying its product line. The company already was involved in the production of chemical-grade limestone and calcium carbonate for a variety of filler and extender applications (Industrial Minerals, 2003c).

*Bentonite.*—In 2003, 24 companies produced bentonite from approximately 105 pits in 11 States. About 3.94 Mt valued at \$177 million of bentonite was sold or used (table 5). Production of nonswelling bentonite was 238,000 t valued at \$9.84 million. Alabama led all States in the production of nonswelling bentonite, followed by, in descending order of tonnage, Mississippi, Arizona, Nevada, California, and Colorado.

Production of swelling bentonite was 3.70 Mt valued at \$167 million. Wyoming still led all States in the production of swelling bentonite, followed by Montana, Utah, Texas, California, Oregon, and Nevada.

Common Clay and Shale.—In 2003, 162 companies produced common clay and shale from approximately 450 pits in 41 States and Puerto Rico. In States not reporting production, common clay and shale probably was mined and sold for construction uses by companies not participating in the USGS canvass of the clay and shale industry.

Domestic sales or use of common clay and shale was 23.1 Mt valued at \$131 million (table 7). The major producing States, in descending order of tonnage, were North Carolina, Texas, Alabama, Ohio, Georgia, California, Oklahoma, and South Carolina.

Hanson Building Materials America (a subsidiary of Hanson PLC) completed its integration of seven U.S. brick manufacturers into Hanson Brick North America. With the integration, Hanson Brick now operates 22 plants in Kentucky, Michigan, North Carolina, South Carolina, Texas, and Canada. The combined companies will produce 1.6 billion bricks per year (Hanson Brick North America, 2003).

*Fire Clay.*—Fire clay producers were mostly refractory product manufacturers that used the clays in firebrick and other refractory products. In 2003, 7 firms in 3 States operated 45 pits. Fire clay sold or used by domestic producers was 400,000 t valued at \$10.2 million (table 9). Missouri was the leading producing State, followed by, in descending order of tonnage, South Carolina and Ohio.

The refractory industry continued to consolidate to be more competitive in current markets and to address asbestos liability issues. ANH Refractories (formerly RHI America, a subsidiary of RHI AG) sold off equipment from operations in California, Ohio, and Pennsylvania. Assets of National Refractories and Minerals Corp. were sold under terms of Chapter 11 of the U.S. Bankruptcy Code in late 2002. Resco Products Inc. acquired specific brands, formulations, intellectual property, and the inventory of products manufactured at National Refractories and Minerals' Mexico, MO, and Columbiana, OH, plants, excluding high-duty and superduty brick products. The company also acquired portions of the high-alumina brick products from National Refractories and Minerals' Wellsville, MO, plant. Allied Mineral Products, Inc. completed its acquisition of National Refractories and Minerals' Chicago Fire Brick Co. in Illinois and Wellsville Fire Brick Co. in Missouri. Allied purchased the monolithic refractory product formulas, brand names, company names, and trademarks (Industrial Minerals, 2003g).

Fuller's Earth.—In 2003, 16 companies produced fuller's earth (attapulgite and montmorillonite varieties) from 45 pits in 11 States. Production of fuller's earth was reported by producers to be 3.60 Mt valued at \$346 million (table 11). This tonnage probably includes crude ore and stocks (more information can be found in the "Montmorillonite" portion of the "Production" section in this report). The fuller's earth deposits grade from attapulgite-rich in Florida to montmorillonite-rich further northward in Georgia. Only those clays with attapulgite as the major clay component are classified as attapulgite. These basically are the gellant-grade fuller's earths in Florida and the southernmost part of Georgia. Going northward into Georgia, the attapulgite content of the fuller's earth declines, and montmorillonite becomes the dominant clay present. This is classified under montmorillonite although it contains minor to trace amounts of attapulgite.

The attapulgite variety of fuller's earth was mined from eight pits in the Florida Panhandle and southwestern Georgia. Only Engelhard in Iselin, NJ, and Zemex Corp. in Toronto, Ontario, Canada, mined attapulgite in the United States at yearend 2003. An unspecified portion of the production by Engelhard was sold by ITC, Inc. under the terms of a U.S. Department of Justice agreement, making, in essence, three producers of attapulgite. Attapulgite production was 244,000 t valued at \$29.9 million. Georgia led in the production of attapulgite, followed by Florida.

Production of the montmorillonite variety of fuller's earth was 3.36 Mt valued at \$316 million. Some of the reported production probably was crude ore and some probably had not entered into commerce by yearend. Actual sales of montmorillonite probably were about 2.9 Mt rather than 3.36 Mt. Montmorillonite was produced, in decreasing order of tonnage, in Georgia, Mississippi, Missouri, Virginia, Illinois, California, Florida, Tennessee, Kansas, and Texas. Production increased in Georgia, Illinois, and Virginia.

Sepiolite, although not a fuller's earth, was produced in Nevada. Sepiolite is included in the total for fuller's earth so as to avoid disclosing company proprietary data.

South American cement and minerals producer Cementos Pacasmayo S.A.A. agreed to purchase, through one of its subsidiaries, all outstanding shares in Zemex for \$100 million.

Zemex is a diversified producer of industrial minerals, including attapulgite and kaolin, in North America (Zemex Corp., 2003).

*Kaolin.*—In 2003, 24 firms mined kaolin from approximately 100 pits in 10 States. Domestic production was 7.68 Mt valued at \$939 million (table 13). The leading producer State was Georgia, followed by, in descending order of tonnage, Alabama, South Carolina, California, Arkansas, North Carolina, Texas, Nevada, Florida, and Tennessee.

Of the 7.68 Mt mined, 4.01 Mt was water washed, 1.39 Mt was calcined, 1.13 Mt was delaminated, 943,000 t was airfloat, and 202,000 t was unprocessed (table 14). Of the calcined kaolin, 796,000 t valued at \$237 million was pigment-grade (low-temperature calcined kaolin). Some production of pigment-grade calcined kaolin in Texas was concealed to avoid disclosing company proprietary data. The remainder was refractory-grade (high-temperature calcined kaolin) (table 15).

Kaolin production in Georgia was 6.61 Mt valued at \$884 million. Approximately 3.94 Mt of Georgia kaolin production was sold as water washed, 1.13 Mt was delaminated, 883,000 t was calcined (high- and low-temperature calcined kaolin), 593,000 t was airfloat, and 59,300 t was unprocessed (table 16). Production in South Carolina was 355,000 t valued at \$21.7 million (table 18).

Imerys undertook a reduction in workforce and idled equipment at its Dry Branch facility in Georgia. The facility will continue to produce kaolin for adhesive, caulk, ceramic, paint, plastic, rubber, and sealant applications without any anticipated loss of market share (Industrial Specialties News, 2003; Imerys, 2004).

Oglebay Norton Co. announced that it would sell its mica operations in New Mexico and North Carolina as part of its strategy to reduce its long-term debt. The company produced kaolin as a coproduct of its mica operation in Spruce Pine, NC (Oglebay Norton Co., 2003).

Alchemy Ventures Ltd. changed its name in 2003 to iminerals Inc. The company continued its evaluation of the Helmer-Bovill deposit in Latah, ID. The company was interested in recovering feldspar, kaolin, and quartz from the deposit (i-minerals Inc., 2003§¹).

Atlas Minerals Co. continued its work on the Dragon Mine site in Juab County, UT. The company found additional halloysite beds while conducting repair work on the mineshaft (Atlas Mining Co., 2003§).

Utah Clay Technology Inc. announced the sale of its kaolin assets to four of the company's directors after its decision to reorganize and pursue other business ventures. The purchase will include the company's kaolin mining and development business. Utah Clay had been investigating kaolin deposits south of Salt Lake City, UT, since about 1994 (Utah Clay Technology Inc., 2003).

#### Consumption

By type of clay, consumption was as follows: **Ball Clay.**—The principal domestic ball clay markets, in

decreasing order, were floor and wall tile, sanitaryware, and miscellaneous ceramics (table 4). Sales and use, including exports, were 1.31 Mt. Sales to all domestic markets increased except for pottery. Increased sales for asphalt tile and gypsum products accounted for most of the increase in sales of fillers and extenders. Increased sales for crockery, dinnerware, fiberglass, and glaze applications accounted for most of sales increase in miscellaneous ceramics.

*Bentonite.*—Sales and use were estimated to be 3.94 Mt (table 6). Major domestic markets for bentonite were pet waste (987,000 t), drilling mud (790,000 t), foundry sand (763,000 t), and iron ore pelletizing (530,000 t). Total sales (domestic and exports) of bentonite were approximately 989,000 t for foundry sand bond (about 92% was swelling bentonite), 993,000 t for pet waste absorbent (more than 99% was swelling bentonite), 847,000 t for drilling mud (essentially all swelling bentonite), and 597,000 t for pelletizing iron ore (all swelling bentonite).

Data for other bentonite markets were concealed to avoid disclosing company proprietary data. However, swelling bentonite accounted for more than 90% of the bentonite sold for absorbents, animal feed, civil engineering, drilling mud, foundry sand, miscellaneous chemical manufacture applications, pelletizing iron ore, waterproofing, and water treatment and more than 70% of the bentonite sold for miscellaneous filler and extender applications. More than 60% of the bentonite sold for clarifying, decolorizing, and filtering of oils and greases was the nonswelling variety. Nonswelling bentonite was used mainly for desiccant, ink, pesticides, pharmaceuticals, and plastic applications.

The major domestic markets for swelling bentonite, in decreasing order, were pet waste absorbents, drilling mud, foundry sand, iron ore pelletizing, and sealing and waterproofing. Major export markets for swelling bentonite, in decreasing order, were foundry sand, iron ore pelletizing, and drilling mud applications. The major domestic uses for nonswelling bentonite, in descending order of tonnage, were foundry sand bond; miscellaneous absorbents; clarifying, decolorizing, and filtering of oils and greases; animal feed; miscellaneous refractory products; miscellaneous fillers and extenders; drilling mud; water treatment; pet waste absorbent adhesives; and sealing and waterproofing.

Common Clay and Shale.—Common clay and shale was used most frequently in the manufacture of heavy clay products, such as building brick, drain tile, flue linings and terra cotta; lightweight aggregate; portland cement; sewer pipe; and structural tile (table 8). Consumption of common clay and shale increased slightly to 23.1 Mt in 2003. Brick manufacture remained the largest market for common clay and shale, followed by, in descending order of tonnage, portland cement, and lightweight aggregate. Privately owned housing starts, not seasonally adjusted, increased to 1.85 million units in 2003 from 1.70 million units in 2002 (U.S. Department of Commerce, 2004§).

*Fire Clay.*—Fire clays were used in grogs and calcines; highalumina brick and specialties; ramming and gunning mixes; refractory products, such as firebrick and block; mortars and mixes; and saggers. Fire clays also were used to produce such items as brick and pottery.

<sup>&</sup>lt;sup>1</sup>References that include a section mark (§) are found in the Internet References Cited section.

Consumption of fire clay was 400,000 t in 2003 (table 10). Major markets for fire clay, in descending order of tonnage, were kiln furniture, refractory mortar and cement, miscellaneous refractory products, common brick, portland cement, grogs and calcines, and firebrick.

Fuller's Earth.—The major domestic uses for attapulgite and montmorillonite varieties of fuller's earth, in descending order of tonnage, were pet waste absorbents; oil and grease absorbents; portland cement manufacture; pesticides; animal feed; drilling mud; clarifying, decolorizing, and filtering of oils and greases; miscellaneous absorbents; fertilizer carriers; refractory products; miscellaneous fillers and extenders; paint; asphalt tile; textiles, and adhesives (table 12). Consumption of fuller's earth was reported by producers to be 3.60 Mt in 2003, although sales probably were nearer to 3.2 Mt (more information can be found in the "Fuller's Earth" portion of the "Production" section of this report).

Sales of montmorillonite were reported to be 3.36 Mt in 2003 but probably were nearer 2.9 Mt (table 11). Major domestic markets for montmorillonite, in descending order of tonnage, were pet waste absorbents; oil and grease absorbents; portland cement; pesticide carrier; animal feed; clarifying, decolorizing, and filtering of oils and greases; miscellaneous refractory applications; miscellaneous absorbents; fertilizer carrier, and paint. Sales for pet waste absorbent accounted for most of the increase in sales for 2003. Although reported to be 2.4 Mt, sales for pet waste absorbent probably were nearer to 2.0 Mt based on current markets. The largest export market was pet waste absorbent.

Sales of attapulgite reported by producers were 244,000 t in 2003 (table 11). Most of the sales data were concealed to avoid disclosing company proprietary data. Major markets for attapulgite, in decreasing order, were drilling mud; absorbents; fertilizer carrier; asphalt emulsion; animal feed; gypsum products; paper coating; miscellaneous filler and extender applications; paint; miscellaneous refractory; textile; clarifying, decolorizing, and filtering of mineral oils and greases; asphalt tile; ceramic floor tile; cosmetic, medical, pharmaceutical applications; and adhesives.

Sales of the montmorillonite variety of fuller's earth accounted for more than 80% of sales of fuller's earth for animal feed; portland cement manufacture; clarifying, decolorizing, and filtering of oils and greases; oil and grease absorbents; pesticide carriers; pet waste absorbents; and exported products. Attapulgite accounted for all of the sales for asphalt emulsion; asphalt tile; cosmetic, medical, and pharmaceutical applications; drilling mud; gypsum products; paint; textiles; miscellaneous filler and extender applications; and miscellaneous refractory products.

*Kaolin.*—Consumption of kaolin decreased to 7.68 Mt in 2003. The major domestic markets for kaolin, in descending order of tonnage, were paper coating and filler, refractory products, paint, fiberglass, catalyst, and rubber (table 20). Major domestic markets for kaolin from Georgia, in descending order by tonnage, were paper coating, paper filling, fiberglass, paint, refractory products, and catalyst manufacture (table 17). Major domestic markets for kaolin from South Carolina, in descending order of tonnage, were rubber, catalyst, brick, fiberglass,

adhesives, and roofing granules (table 19). The major export market for kaolin from South Carolina was rubber applications.

By application, consumption of clays was as follows:

Absorbent Uses.—Sales reported by producers for absorbent uses were about 3.82 Mt. Fuller's earth accounted for about 74% of the clay used for absorbents, followed by bentonite and kaolin. Pet waste absorbents accounted for 89% of absorbent consumption, followed by oil and grease absorbents and miscellaneous absorbent applications. Increased sales for pet waste absorbents accounted for most of the increase in 2003.

Ceramics.—All varieties of clays were used in ceramics. Demand for clay in the manufacture of ceramics, ranging from china to sanitaryware to roofing granules, was 1.96 Mt. The largest ceramics market was ceramic floor and wall tile (41%), followed by sanitaryware (18%), roofing granules (12%), catalyst (11%), fine china (4%), pottery (3%), and quarry tile (3%). Ball clay accounted for 44% of the clay used in ceramics, followed by common clay and shale (33%) and kaolin (23%). Small amounts of bentonite also were used in the manufacture of ceramics. Ball clay dominated the crockery, electrical porcelain, glazing, and sanitaryware markets. Common clay and shale was the predominant clay used in quarry tile and roofing granules. Kaolin dominated the catalyst market. Ball clay and common clay and shale were the predominant clays used in pottery and floor and wall tile manufacture, and ball clay and kaolin dominated the fine china markets.

The recovering economy and low interest rates continued to spur the growth in new home construction in the United States. Manufacturers reported increased sales of sanitaryware in 2002. While new home builders focused on the price of sanitaryware, consumers considered quality and design rather than price when remodeling. Manufacturers expected growth in markets in China and the United States. Markets in Central Europe and Japan appear to be declining with downturns in construction activity (Grahl, 2003).

In 2003, apparent consumption of clay floor and wall tile in the United States was 268 million square meters valued at \$2.55 billion. Domestic producers shipped 62 million square meters of clay floor and wall tile valued at \$812 million in 2003 compared with 60 million square meters valued at \$825 million in 2002. Exports were 2.69 million square meters valued at \$27.4 million. Imports of clay floor and wall tile were 207 million square meters valued at \$1.75 billion (U.S. Census Bureau, 2003a-c, 2004a).

The International Trade Administration reported that approximately 26.8 million square meters valued at \$180 million of glazed and unglazed ceramic tile with sides measuring less than 7 centimeters was imported compared with 24.5 million square meters valued at \$171 million in 2002. Brazil, Italy, and Spain were the major sources of imported tile.

Imports of ceramic baths, bidets, flush tanks, lavatories, sinks, water closet bowls, and other ceramic sanitary fixtures increased in 2003. The U.S. Census Bureau reported imports to be 24.9 million units compared with 21.1 million units in 2002 (U.S. International Trade Commission, 2004§). China and Mexico were the major sources of imported sanitaryware.

*Construction.*—Common clays and shales were used to manufacture a wide variety of construction materials, including

expanded aggregates, hydraulic cement, and structural clay products.

**Drilling Mud.**—Bentonite sales (domestic and exports) for drilling mud applications were 899,000 t (842,000 t sold domestically and 57,200 t exported). Swelling-type bentonite accounted for most of the clay used in drilling mud. Fuller's earth and a small tonnage of kaolin also were used in drilling mud applications. The average monthly number of rotary rigs in Canada and the United States operating in 2003 was 1,300 compared with 958 in 2002 (Baker Hughes Inc., 2004b§).

*Fiberglass.*—Sales, including exports, to the fiberglass and mineral wool industry were 357,000 t. Nearly all the clay used for fiberglass was kaolin. While industry statistics are not available on fiberglass production, industrial sand (ground and unground) used for the production of fiberglass was 1.51 Mt compared with 1.43 Mt in 2002 (T.P. Dolley, physical scientist, U.S. Geological Survey, written commun., September 9, 2004).

Fillers, Extenders, and Binders.—Clays are used as fillers, extenders, and binders in a wide variety of products, such as adhesives, flooring products, paint, paper, and rubber. About 4.91 Mt of clays was sold for use as fillers, extenders, and binders in the United States. An additional 2.21 Mt of clays was exported for filler and extender applications. Paper coating and filling accounted for 69% of domestic sales, followed by paint (7%), animal feed (4%), rubber (4%), pesticide carrier (3%), and adhesives (2%). Asphalt emulsion; asphalt tile; cosmetic, medical, pharmaceutical; fertilizer carrier; gypsum products; ink; plastic; textile; and wallboard applications each accounted for less than 2% of the fillers and extenders markets.

Kaolin accounted for approximately 85% of the clay used in domestic filler and extender applications, followed by fuller's earth (9%), bentonite (2%), ball clay (2%), and common clay and shale (2%). Bentonite was the predominant clay used for ink, as well as cosmetic, medical, and pharmaceutical applications; fuller's earth dominated in animal feed, asphalt emulsion, and fertilizer and pesticide applications. Kaolin was the predominant clay used for adhesives, gypsum products, paint, paper, plastics, and rubber markets.

Increased use of plastics has resulted in the increased consumption of minerals as fillers and extenders. Approximately 12 Mt of mineral fillers was used worldwide in 2002. The major filler minerals were carbonates, kaolin, mica, talc, and wollastonite. Ground and synthetic carbonates account for the bulk of the filler market. In Europe, carbonates are used primarily in polyvinyl chloride (PVC) products (860,000 t), followed by polyethylene (PE) products (130,000 t), and polypropylene (PP) products (80,000 t). Kaolin was used in PVC (13,000 t), polyamide (PA) (5,000 t), PE (2,000 t), and PP (1,000 t) products. About 5,000 t of mica was used in PP products, followed by 3,000 t in PA products. Talc was used mainly in PP products (125,000 t), followed by PE and PA (5,000 t each) products. Wollastonite was used in PP (5,000 t) and PA (3,000 t) products (Hohenberger, 2003).

Research on nanoclays, mainly smectite and hectorite, has been conducted for more than a decade, but markets still are limited. Two of the larger potential markets are automotive polymers and flame retardant applications. Two desirable automobile polymer markets are polyolefin and PP products. Consumption for

automotive polymers is projected to be 10,000 to 25,000 metric tons per year (t/yr) by 2005 in North America. For flame retardant applications, the nanoclay acts as an extender and displaces some of the more expensive flame retardant chemicals in the product. Potential sales could approach 40,000 t/yr. Use of nanoclays as a barrier in polyethylene terephthalate bottles is another market that is being investigated for its growth potential (Harris, 2003).

The U.S. Census Bureau (2004b) reported shipment of paint and coatings for 2003 to be 1.34 billion gallons (5.07 billion liters) valued at \$16.1 billion. Of this amount, architectural paints, the major market for paint-grade fillers, was 781 million gallons (2.96 billion liters) valued at \$7.63 billion.

**Expanded Clay and Shale.**—Approximately 3.71 Mt of clay and shale was used in the production of lightweight aggregates (table 21). Nearly all the clay used to manufacture lightweight aggregates was common clay and shale. Lightweight aggregates were used in concrete block, structural concrete, and highway surfacing, in decreasing order of consumption.

Hydraulic Cement.—Clays provide the alumina and silica required to manufacture hydraulic cements. In 2003, approximately 4.68 Mt of clays was consumed. In descending order of tonnage, common clay and shale, fuller's earth, kaolin, fire clay, and bentonite clay were used in the manufacture of portland cement clinker. About 92% of the clay consumed by the cement industry was common clay and shale.

*Iron Ore Pelletizing.*—Sales reported by producers were 597,000 t (530,000 t used domestically and 67,200 t exported). Swelling bentonite was the only type of clay used for this application.

Structural Clay Products.—Approximately 13.8 Mt 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 about 94% of this total. Other markets, in descending order of tonnage, were terra cotta, drain tile, flue linings, flower pots, roofing tile, sewer pipe, and structural tile. About 99% of the clay used to manufacture structural clay products was common clay and shale. Small amounts of ball clay, bentonite, fire clay, and kaolin also were used.

In 2003, domestic producers shipped 8.54 billion building and face bricks valued at \$1.83 billion. About 151,000 units of vitrified clay sewer pipe and fittings valued at \$51.2 million were shipped in 2003 (U.S. Census Bureau, 2004a).

**Paper Products.**—Kaolin accounted for almost all the clay sales used for paper coating (2.45 Mt sold domestically and 1.97 Mt exported) and essentially all the clay used for paper filling (438,000 t sold domestically and 91,300 t exported). A small amount of bentonite and fuller's earth also were sold for paper applications.

**Refractory Products.**—Producers reported that 1.71 Mt of clays was used for the domestic manufacture of refractory products in 2003 (2.48 Mt with foundry sand included). Foundry sand accounted for 31% of domestic sales and nearly all of exports. Other refractory markets for clays were firebrick; grogs and calcines; high-alumina brick and kiln furniture; plug, tap, and wad products; and refractory mortar and cement. About 231,000 t was exported for refractory applications.

Bentonite accounted for 997,000 t of refractory sales (771,000 t used domestically and 226,000 t exported), followed

by kaolin (760,000 t used domestically and exported), common clay and shale (523,000 t used domestically with no exports), fire clay (317,000 t used domestically with no exports), ball clay (66,600 t used domestically and exported), and fuller's earth (38,300 t used domestically and exported).

Data on U.S. refractory production and shipments were not available for 2003. The U.S. Census Bureau (2003d) reported shipments of clay refractory products to be \$829 million in 2002 compared with \$774 million in 2001. In 2002, 639,000 t (235 million bricks) valued at \$423 million of clay refractory bricks and shapes was shipped by U.S. manufacturers. This is subdivided into fire clay brick and shapes, shipments of 284,000 t (90.3 million bricks) valued at \$130 million; highalumina brick and shapes, 326,000 t (116 million bricks) valued at \$256 million; and insulating brick and shapes, 28,700 t (29 million bricks) valued at \$37.1 million. Shipments of unshaped clay refractory products were 599,000 t valued at \$335 million. This is subdivided into refractory bonding mortar shipments of 129,000 t valued at \$61.9 million; plastic refractory products, 115,000 t valued at \$70.4 million; castable refractory products, 264,000 t valued at \$167 million; and fire gunning mixes, 91,000 t valued at \$35.9 million. Approximately 155,000 t of miscellaneous refractory products valued at \$50 million and \$21.4 million of other unknown types of clay refractory products also were sold in 2002.

#### **Prices**

In general, clay and shale prices were relatively unchanged. Many producers, particularly in the fuller's earth and kaolin industries, have been affected by high fuel costs and added energy surcharges to some of their products. The kaolin industry has been able to increase prices on some of its products because of demand relative to supply. Domestic producers removed about 1.5 Mt of capacity during the past few years. Increases ranged from 3% to 8% for the various kaolin products (Van Savage, 2003).

**Ball Clay.**—The average value for ball clay reported by domestic producers was \$42.93 per metric ton. The average values for imported and exported ball clay were \$91.19 per ton and \$60.66 per ton, respectively.

Average prices for ball clay, United Kingdom, free on board (f.o.b.), air-dried, shredded, bulk, were \$40 to \$105 per ton; refined, noodled, bulk, \$88 to \$112 per ton; and pulverized, bagged, \$129 to \$209 per ton. Average prices for ball clay, Germany, f.o.b., dried and ground, bulk, were \$52 to \$141 per ton, and shredded, bulk, \$15 to \$61 per ton (Industrial Minerals, 2002)

**Bentonite.**—The average value reported by domestic producers for nonswelling bentonite was \$41.33 per ton. The average value for swelling bentonite was \$45.26 per ton. The average value for all bentonite was \$45.02 per ton. The average value of imported bentonite was \$236.40 per ton. The average value of exported bentonite was \$122.21 per ton.

The price, ex-works, Wyoming, crude, bulk, rail cars, was \$26 to \$63 per ton; foundry grade, bagged, rail cars, \$50 to \$76 per ton; and American Petroleum Institute (API)-grade, bagged, rail cars, \$43 to \$53 per ton. The price for bentonite, India, crushed,

dried, loose in bulk, was \$30 to \$40 per ton for API-grade; \$32 to \$40 per ton for pet litter grade; and \$40 to \$45 per ton for foundry grade (Industrial Minerals, 2003h).

Common Clay and Shale.—The average value for all common clay and shale produced in the United States and Puerto Rico was \$5.69 per ton. The average value of clay and shale used in lightweight aggregate was \$14.33 per ton. The value for lightweight aggregate is an estimate of the clay value. Average prices for lightweight aggregate produced from clay and shale ranged from \$30 to \$50 per ton for most applications.

*Fire Clay.*—The average value for fire clay reported by domestic producers was \$25.46 per ton. The average of imported fire clay was \$508.30 per ton. The average value of exported fire clay was \$96.03 per ton.

Fuller's Earth.—The average value of attapulgite-type fuller's earth was \$122.50 per ton. The average value of montmorillonite-type fuller's earth was \$94.00 per ton. The average value of all fuller's earth was estimated to be \$95.92 per ton. The average value of imported fuller's earth was \$10.81 per ton. The average value of exported fuller's earth was \$183.92 per ton.

The price of attapulgite, ex-plant, Georgia, 40% to 100% less than 325 mesh, truck load, was \$220 to \$550 per ton; granular processed, 40% to 100% less than 4/8 mesh, truck load, \$193 to \$550 per ton; granular, 6/30 mesh, truck load, \$132 to \$220 per ton; and granular, 6/30 mesh, gel grade, bagged, \$358 per ton to \$772 per ton (Industrial Minerals, 2002).

*Kaolin.*—The average value of kaolin was \$122.37 per ton for all kaolin grades. The average value for airfloat was \$56.28 per ton; refractory-grade (high-temperature calcined), \$31.80 per ton; pigment-grade (low-temperature calcined), \$297.78 per ton; all types of calcined, \$184.45 per ton; delaminated, \$126.78 per ton; and water washed, \$119.05 per ton. The average value of the imported kaolin was \$155.16 per ton. The average value of exported kaolin was \$162.79 per ton.

The price, ex-works, Georgia, filler, bulk, was \$80 to \$100 per ton; coating, bulk, \$85 to \$185 per ton; sanitaryware-grade, bagged, \$65 to \$75 per ton; tableware-grade, bagged, \$125 per ton; and calcined, bulk, \$320 to \$375 per ton (Industrial Minerals, 2003h).

#### **Foreign Trade**

**Ball Clay.**—Ball clay exports increased to 139,000 t valued at \$8.43 million, according to the U.S. Census Bureau (table 23). Domestic ball clay producers reported that 152,000 t of ball clay was exported in 2003 (table 4). Imports were 13,300 t of ball clay valued at \$1.2 million (table 24).

**Bentonite.**—Bentonite exports were almost unchanged at 721,000 t valued at \$88.1 million (table 23). Domestic bentonite producers reported exports of 392,000 t (table 6). The large discrepancy between data reported by producers and the U.S. Census Bureau may result from producers including most of the exports destined for Canadian and Mexican markets (255,000 t) under domestic sales. Sales through U.S. mineral brokers, where producers do not know if the bentonite is used domestically or exported, could also explain part of the discrepancy.

Bentonite imports consisted mainly of untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite were 12,700 t valued at \$3.01 million. Imports of chemically activated material were 21,000 t valued at \$9.43 million (table 24).

*Fire Clay.*—Approximately 285,000 t of fire clay valued at \$27.4 million was exported (table 23). Imports amounted to 482 t valued at \$245,000 (table 24).

*Fuller's Earth.*—Approximately 48,300 t of fuller's earth valued at \$8.83 million was exported (table 23). Approximately 2,590 t of decolorizing earth and fuller's earth valued at \$28,000 was imported (table 24).

*Kaolin.*—The U.S. Census Bureau reported that 3.52 Mt valued at \$574 million was exported (table 23). Producers reported exports of 2.36 Mt (table 20). Much of the 790,000 t of kaolin destined for Canada, particularly for its paper markets, probably was reported under domestic consumption.

Kaolin imports increased to 224,000 t valued at \$34.7 million (table 24). Approximately 93% was imported from Brazil, followed by the United Kingdom. Imports from Brazil were primarily for paper coating applications, and those from the United Kingdom were primarily for paper filler applications.

#### **World Review**

World production of bentonite was approximately 10.2 Mt, fuller's earth production was estimated to be 4.75 Mt, and kaolin production was 41 Mt (tables 25-27). The world production data for kaolin also contain common clay from Colombia, ball clay for Australia, and crude kaolin ore for many other countries. Sales of processed kaolin were estimated to be about 27.7 Mt, after excluding 8.4 Mt for Colombia, 4 Mt for Uzbekistan, 600,000 t for Iran, 200,000 t for Egypt, and 100,000 t for Australia. Under fuller's earth, Spain should also be listed as producing about 900,000 t of sepiolite, in addition to the attapulgite production. The United States continued to be the leading producer of all three varieties of clays, followed by Greece and countries of the Commonwealth of Independent States (CIS) for bentonite; Germany for fuller's earth; and the Republic of Korea (likely crude ore tonnage), the United Kingdom (sales), Brazil (sales), Germany (processed ore), Uzbekistan (crude ore), and the Czech Republic for kaolin. Spain led all countries in the production of sepiolite.

Growth in Asian bentonite industries offers opportunities for Asian and foreign producers. United States producers continued to be successful in Asian markets through acquisitions, exports, or joint ventures. While China and other Asian countries offer cost advantages, United States producers have sought to compete with quality and consistency. The largest growth in the near future in Asian markets was predicted to be for bleaching earth, foundry sand, oil drilling mud, paper, pet litter, and rheological applications (Crossley, 2003).

Australia.—Kendall Resources Ltd. determined that its kaolin deposit along the Kendall River in Cape York, Queensland, contained about 300 Mt of resources. The kaolin layers averaged about 12 meters in thickness with a shallow overburden. The crude ore brightness was 82% to 88%, and the brightness for processed kaolin was 88% to 90%. Kendall

Resources and Sigma Resources Ltd. also investigated other kaolin deposits along the Kendall River and deposits north of the Archer River (Industrial Minerals, 2003b)

*Brazil.*—Imerys announced the completion of the capacity expansion of its Rio Capim Caulim facility. The expansion began in 2002, with capacity being increased to 850,000 t/yr from 600,000 t/yr (Imerys, 2004, p. 109).

Para Pigmentos SA (PPSA) and Caulim da Amazônia SA (CADAM) also announced production capacity expansions. These two companies will increase capacities to 1 million metric tons per year (Mt/yr) from 600,000 t/yr and to 1 Mt/yr from 800,000 t/yr, respectively. PPSA has already initiated its expansion program. CADAM expected to complete its expansion by 2007 (Moore, 2003).

**Bulgaria.**—S&B Industrial Minerals S.A. of Greece announced that it had acquired 96.8% of the shares of Bentonit AD. Bentonit mined and processed bentonite near Kurdzali in southern Bulgaria. Proven reserves were 7.3 Mt. Its plant had a capacity of 200,000 t/yr. S&B Industrial Minerals sought to strengthen its presence in oil drilling and pet litter markets and enhance its presence in southeastern Europe and the CIS (S&B Industrial Minerals S.A., 2003).

China.—Elementis plc acquired a bentonite operation near Nanjing to produce organoclays for expanding Asian markets. The company was nearing completion of expansion and upgrade of the plant facilities. Elementis Specialties (a subsidiary of Elementis) produces organoclays for rheological applications (Elementis plc, 2003).

Engelhard Corp. acquired portions of Anpeak Kaolin Co. Ltd. for \$12.1 million. Anpeak Kaolin produces calcined kaolin for Asian markets. The plant, which can produce 30,000 t/yr of calcined kaolin, was built in 2002 in Shanxi Province. Markets for their product include coatings, paper, plastics, and rubber (Engelhard Corp., 2004, p. 56; Mining Engineering, 2003).

India.—Star Bentonite Group formed a joint venture with Italy's Laviosa Chimica Mineraria SpA. The venture, operating as Star Laviosa Bentonite Co., will focus its sales on specialty milled bentonite products for civil engineering, drilling mud, foundry sand, and other markets in Indian and nearby markets. Laviosa Bentonite expected the Far East and Middle East to represent the leading markets, with Indonesia and Thailand offering the greatest growth (Industrial Minerals, 2003d).

*Russia.*—Joint Stock Company (JSC) Bentonit neared completion of a processing plant in Kurgan Oblast. Design capacity will be 50,000 t/yr of bentonite and 50,000 t/yr of ball clay. An existing mine in the Ketovsky District will supply the plant with bentonite. The company will focus on drilling mud and foundry sand markets (Industrial Minerals, 2003e).

**Senegal.**—Spain's Sepiol SA acquired a 51% stake in Senegal Mines, Senegal's second leading attapulgite producer. The company produced about 35,000 t/yr from mines south of Dakar in 2002. Sepiol intends to increase capacity to 100,000 t/yr to satisfy European demand for attapulgite-based pet litter (Industrial Minerals, 2003a).

*Turkey.*—Ünye Madencilik Ltd. signed an agreement with Odyssey Resources, Ltd. of Toronto to develop bentonite and kaolin deposits in the Fatsa region of northern Turkey. Odyssey Resources mined gold and base metals in that region and sought

to utilize the clay overburden. Ünye Madencilik agreed to assess the feasibility of developing the study by November 2004 (Industrial Minerals, 2003f).

#### Outlook

The economy improved slightly in 2003, and economic experts anticipated continued growth, albeit slow, for the near future. The gross domestic product increased for many of the industry sectors affecting clays, such as agriculture, construction, and manufacturing of durable goods during the past 2 years after a decline during the recessionary period in 2001 (U.S. Bureau of Economic Analysis, 2004). Construction-oriented markets for clay-based products, such as brick, lightweight cement, ceramic tile, and whiteware, remained strong. This was expected to result in a steady demand for ball clay and common clay for the next few years. Demand for clay-based construction products also was expected to be bolstered by reconstruction efforts in the wake of several hurricanes that struck the east coast and the Gulf Coast of the United States in 2004.

Other markets for clays, such as foundry sand bond (bentonite), pelletizing iron ore (bentonite), and oil and grease absorbent (bentonite and fuller's earth), probably would remain near current levels owing to increased activity by the iron ore and metal manufacturing industries during the past couple of years. Concerns over oil supplies appeared to have resulted in increased drilling for oil in the United States (Baker-Hughes Inc., 2004a§). This was expected to result in increased sales of bentonite for drilling mud applications. Sales for pet litter markets were relatively unchanged in the past few years so that the market for the bentonite probably would increase only slightly in the next few years. The paper industry continued to stagnate; this, along with foreign competition, probably would continue to affect domestic and foreign kaolin sales for paper-filler and coating markets in the near future (China Clay Producers Association, 2004).

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 $\label{eq:table 1} \textbf{TABLE 1} \\ \textbf{SALIENT U.S. CLAY STATISTICS}^{1,\,2}$ 

(Thousand metric tons and thousand dollars)

	1999	2000	2001	2002	2003
Domestic clays sold or used by producers:					
Quantity	42,200	40,800	39,600	39,300	40,000
Value	1,570,000	1,520,000	1,510,000	1,580,000	1,660,000
Exports:					
Quantity	4,800	5,260	4,970	4,960	5,130
Value	823,000	896,000	836,000	817,000	859,000
Imports for consumption:					
Quantity	90	96	148	217	279
Value	23,000	34,900	33,900	39,400	51,200
1					

<sup>&</sup>lt;sup>1</sup>Excludes Puerto Rico.

TABLE 2 CLAYS SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2003, BY STATE  $^{\rm 1,\,2}$ 

(Thousand metric tons and thousand dollars)

			Common					
	Ball		clay and	Fire	Fuller's		Gran	d total
State	clay	Bentonite	shale	clay	earth	Kaolin	Quantity	Value
Alabama		125 e	1,920			W	2,050	27,800
Arizona		W	W				W	W
Arkansas			897			W	897	1,410
California		23	1,240		W	W	1,260	21,600
Colorado		W	259				259	1,580
Connecticut			52				52	143
Florida			94 <sup>e</sup>		W	31	125	4,530
Georgia			1,280		1,570	6,610	9,460	1,050,000
Illinois			179		W		179	1,010
Indiana	W		385				385	767
Iowa			256				256	763
Kansas			632		W		632	10,000
Kentucky	W		983				983	3,770
Louisiana			670				670	1,690
Maine			49 <sup>e</sup>				49	125
Maryland			269				269	550
Massachusetts			36 <sup>e</sup>				36	321
Michigan			588				588	3,050
Minnesota			20				20	22
Mississippi	W	W	524		534		1,060	44,700

See footnotes at end of table.

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

## TABLE 2--Continued CLAYS SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2003, BY STATE $^{\!1,2}$

(Thousand metric tons and thousand dollars)

			Common					
	Ball		clay and	Fire	Fuller's		Gran	nd total
State	clay	Bentonite	shale	clay	earth	Kaolin	Quantity	Value
Missouri			970	307	W		1,280	10,900
Montana		181 <sup>e</sup>	W				181	14,900
Nebraska			133 6				133	338
Nevada		6			28 e	W	34	4,690
New Jersey			W				W	W
New Mexico			36				36	209
New York			644				644	8,080
North Carolina			2,190			W	2,190	15,400
North Dakota			W				W	W
Ohio			1,440	W			1,440	7,430
Oklahoma			1,160				1,160	2,390
Oregon		W	W				W	W
Pennsylvania			750				750	2,240
South Carolina			1,060	W		355	1,420	24,400
South Dakota			213				213	W
Tennessee	766		304		92 <sup>e</sup>	W	1,160	38,900
Texas	W	W	2,110		27 <sup>e</sup>	W	2,130	11,300
Utah		W	300				300	3,270
Virginia			958		W		958	2,530
Washington			W				W	W
West Virginia			142				142	376
Wyoming		3,420	25				3,440	148,000
Total	1,310	3,940	23,100	400	3,600	7,680	40,000	1,660,000

<sup>&</sup>lt;sup>e</sup>Estimated. W Withheld to avoid disclosing company proprietary data; included in "Grand total." -- Zero.

 ${\bf TABLE~3}\\ {\bf BALL~CLAY~SOLD~OR~USED~BY~PRODUCERS~IN~THE~UNITED~STATES,~BY~STATE}^1$ 

(Thousand metric tons and thousand dollars)

	Airfl	oat	Water-sl	urried	Unproc	essed	Grand	total
State	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
2002:								
Tennessee	248	12,400	194	8,350	217	7,320	660	28,100
Other <sup>2</sup>	196	11,500	W	W	W	W	459	18,900
Total	444	24,000	194	8,350	217	7,320	1,120	47,000
2003:								
Tennessee	312	15,800	197	8,460	257	9,140	766	33,400
Other <sup>2</sup>	268	14,800	W	W	W	W	543	22,800
Total	580	30,500	197	8,460	257	9,140	1,310	56,200

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

<sup>&</sup>lt;sup>1</sup>Excludes Puerto Rico.

<sup>&</sup>lt;sup>2</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes Indiana, Kentucky, Mississippi, and Texas.

 ${\it TABLE~4} \\ {\it BALL~CLAY~SOLD~OR~USED~BY~PRODUCERS~IN~THE~UNITED~STATES,~BY~USE}^1 \\$ 

#### (Metric tons)

Use	2002	2003
Fillers, extenders, binders <sup>2</sup>	25,100	85,800
Floor and wall tile	395,000	409,000
Miscellaneous ceramics <sup>3</sup>	169,000	230,000
Pottery	23,100	21,000
Refractories <sup>4</sup>	63,100	66,600
Sanitaryware	246,000	267,000
Miscellaneous <sup>5</sup>	52,200	78,100
Exports <sup>6</sup>	146,000	152,000
Total	1,120,000	1,310,000

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown. <sup>2</sup>Includes adhesives (2003), animal feed, asphalt tile, asphalt emulsions, gypsum (2003), paper filling (2003), pesticides and related products (2003), plastics (2003), rubber, and other fillers, extenders, and binders.

 ${\bf TABLE~5}$  BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE  $^1$ 

#### (Thousand metric tons and thousand dollars)

	Nonsw	Nonswelling		Swelling		Grand total	
State	Quantity	Value	Quantity	Value	Quantity	Value	
2002:					-		
Wyoming			3,340	145,000	3,340	145,000	
Other <sup>2</sup>	354	14,000	273	20,800	627	34,800	
Total	354	14,000	3,620	166,000	3,970	180,000	
2003:							
Wyoming			3,420	148,000	3,420	148,000	
Other <sup>2</sup>	238	9,840	285	19,700	523	29,600	
Total	238	9,840	3,700	167,000	3,940	177,000	
Zero.							

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>3</sup>Includes catalysts, electrical porcelain, fiberglass, fine china/dinnerware, glass, mineral wool, roofing granules (2003), and miscellaneous ceramics.

<sup>&</sup>lt;sup>4</sup>Includes firebrick, blocks, shapes, high-alumina specialties (2003), and kiln furniture.

<sup>&</sup>lt;sup>5</sup>Includes heavy clay products, waterproofing seals, and other unknown uses.

<sup>&</sup>lt;sup>6</sup>Includes ceramics and glass and floor and wall tile.

<sup>&</sup>lt;sup>2</sup>Includes Alabama, Arizona, California, Colorado, Georgia, Mississippi, Montana, Nevada, Oregon, Texas, and Utah.

 ${\bf TABLE~6} \\ {\bf BENTONITE~SOLD~OR~USED~BY~PRODUCERS~IN~THE~UNITED~STATES,~BY~USE}^I$ 

#### (Metric tons)

Use	2002	2003
Domestic:		
Absorbents:	_	
Pet waste absorbents	899,000	987,000
Other absorbents	W	W
Adhesives	2,100	5,610
Animal feed	42,400	52,400
Ceramics (except refractories) <sup>2</sup>	W	W
Drilling mud	762,000	790,000
Filler and extender applications <sup>3</sup>	45,700	41,300
Filtering, clarifying, decolorizing	127,000	W
Foundry sand	762,000	763,000
Pelletizing (iron ore) <sup>4</sup>	536,000	530,000
Miscellaneous refractories	W	W
Miscellaneous <sup>5</sup>	117,000	378,000
Waterproofing and sealing	269,000	W
Total	3,560,000	3,550,000
Exports:		
Drilling mud	59,200	57,200
Foundry sand	244,000	226,000
Other <sup>6</sup>	106,000	108,000
Total	408,000	392,000
Grand total	3,970,000	3,940,000

W Withheld to avoid disclosing company proprietary data; included with "Domestic, miscellaneous."

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)

	200	02	2003		
State	Quantity	Value	Quantity	Value	
Alabama	2,020	24,600	1,920	24,000	
Arkansas	921	2,280	897	1,410	
California	1,030	21,400	1,240	19,100	
Georgia	1,310	5,500	1,280	4,430	
Indiana	429	1,240	385	767	
Kansas	642	4,280	632	10,000	
Kentucky	925	4,740	983	3,770	
Michigan	499	884	588	3,050	
Mississippi	496	2,210	524	2,050	
Missouri	1,050	3,930	970	3,660	
New York	641	7,990	644	8,050	
North Carolina	2,420	11,900	2,190	10,900	
Ohio	1,310	7,820	1,440	7,430	
Oklahoma	1,030	2,250	1,160	2,390	
C C	- C 4 - 1- 1 -				

See footnotes at end of table.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits, may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes catalysts and pottery.

<sup>&</sup>lt;sup>3</sup>Includes asphalt tiles (2003), cosmetics, ink, medical, miscellaneous fillers and extenders applications, paint, paper coating, paper filling (2003), pesticides and related products (2003), pharmaceuticals, and plastics.

 $<sup>^4</sup>$ Excludes shipments to Canada. Total sales in North America were 603,000 metric tons (t) in 2002 and 600,000 t in 2003.

<sup>&</sup>lt;sup>5</sup>Includes chemical manufacturing, heavy clay products, and other unknown uses.

<sup>&</sup>lt;sup>6</sup>Includes absorbents, fillers and extenders, miscellaneous refractories, pelletizing, and other unknown uses.

## TABLE 7--Continued COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY ${\rm STATE}^{1,2}$

(Thousand metric tons and thousand dollars)

	20	2002		2003		
State	Quantity	Value	Quantity	Value		
Pennsylvania	779	2,560	750	2,240		
South Carolina	1,020	3,360	1,060	2,660		
Texas	2,160	21,200	2,110	8,890		
Virginia	827	3,320	958	2,530		
Other <sup>3</sup>	3,510	16,900	3,370	14,200		
Total	23,000	148,000	23,100	131,000		

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8 COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE  $^{1,\,2}$ 

#### (Metric tons)

Use	2002	2003
Ceramics and glass <sup>3</sup>	174,000	207,000
Civil engineering and sealing	W	12,500
Floor and wall tile:		
Ceramic	387,000	342,000
Other <sup>4</sup>	115,000	99,600
Heavy clay products:		
Brick, extruded	11,300,000	11,300,000
Brick, other	1,500,000	1,480,000
Drain tile and sewer pipe	39,000	(5)
Flowerpots	46,000	43,100
Flue linings	47,700	146,000
Structural tile	(5)	(5)
Terra cotta		272,000
Other <sup>6</sup>	110,000	354,000
Lightweight aggregate:		
Concrete block	2,370,000	2,250,000
Highway surfacing	364,000	344,000
Structural concrete	908,000	799,000
Miscellaneous <sup>7</sup>	361,000	320,000
Portland and other cements	3,950,000	4,350,000
Refractories <sup>8</sup>	795,000	523,000
Miscellaneous <sup>9</sup>	556,000	285,000
Total	23,000,000	23,100,000

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

<sup>&</sup>lt;sup>2</sup>Excludes Puerto Rico.

<sup>&</sup>lt;sup>3</sup>Includes all other States except Alaska, Delaware, Hawaii, Idaho, Nevada, New Hampshire, Rhode Island, Vermont, and Wisconsin.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Excludes Puerto Rico.

<sup>&</sup>lt;sup>3</sup>Includes pottery and roofing granules.

<sup>&</sup>lt;sup>4</sup>Includes quarry tile and miscellaneous floor and wall tiles.

<sup>&</sup>lt;sup>5</sup>Withheld to avoid disclosing company proprietary data; included with "Heavy clay products, other."

<sup>&</sup>lt;sup>6</sup>Includes drain tile (2003), flower pots, roofing tile, sewer pipe (2003), structural tile, and miscellaneous clay products.

<sup>&</sup>lt;sup>7</sup>Includes miscellaneous lightweight aggregates.

<sup>&</sup>lt;sup>8</sup>Includes firebrick, blocks and shapes, mortar and cement, plugs, taps, wads, and miscellaneous refractories.

<sup>&</sup>lt;sup>9</sup>Includes exports; miscellaneous civil engineering and sealings; miscellaneous fillers, extenders, and binders; wallboard; and other unknown uses and uses indicated with symbol W.

## TABLE 9 FIRE CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE<sup>1</sup>

(Thousand metric tons and thousand dollars)

	200	2002		2003		
State	Quantity	Value	Quantity	Value		
Missouri	340	7,360	307	7,230		
Other <sup>2</sup>	106	3,110	93	2,950		
Total	446	10,500	400	10,200		

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

 ${\rm TABLE~10}$  FIRE CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY  ${\rm USE}^1$ 

#### (Metric tons)

Use	2002	2003
Heavy clay products and lightweight aggregates <sup>2</sup>	W	W
Refractories:		
Firebrick, block, shapes	20,400	W
Other refractories <sup>3</sup>	312,000	317,000
Miscellaneous <sup>4</sup>	114,000	83,300
Total	446,000	400,000

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

 ${\rm TABLE~11}$  FULLER'S EARTH SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE  $^{\rm I}$ 

#### (Thousand metric tons and thousand dollars)

	Attapu	Attapulgite <sup>2</sup>		Montmorillonite		Grand total	
State	Quantity	Value	Quantity	Value	Quantity	Value	
2002:							
Georgia	W	W	W	W	979	93,800	
Southern States <sup>3</sup>	W	W	835	75,300	835	75,300	
Western States <sup>4</sup>	W	W	W	W	736	54,800	
Total	218	26,800	2,510	219,000	2,730	246,000	
2003:							
Georgia	W	W	W	W	1,570	158,000	
Southern States <sup>3</sup>	$\mathbf{W}$	W	W	W	1,110	100,000	
Western States <sup>4</sup>	W	W	W	W	932	87,000	
Total	244	29,900	3,360	316,000	3,600	346,000	

W Withheld to avoid disclosing company proprietary data; included with "Southern States" or "Grand total."

<sup>&</sup>lt;sup>2</sup>Includes California (2002), Ohio, and South Carolina.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes common brick, portland cement, and terra cotta.

<sup>&</sup>lt;sup>3</sup>Includes foundry sand, grogs and calcines, kiln furniture (2003), mortar and cement, and miscellaneous refractories.

<sup>&</sup>lt;sup>4</sup>Includes animal feed (2002), ceramics and glass, pottery (2002), miscellaneous lightweight aggregates (2002), and other unknown uses (2002).

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Primarily gellant-grade fuller's earth. More information can be found in the "Fuller's Earth" portion of the "Production" section of this report.

<sup>&</sup>lt;sup>3</sup>Includes Florida, Mississippi, Tennessee, and Virginia.

<sup>&</sup>lt;sup>4</sup>Includes California, Illinois, Kansas, Missouri, Nevada, and Texas.

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

#### (Metric tons)

Use	2002	2003
Absorbents:		
Oil and grease absorbent	409,000	353,000
Pet waste absorbent	1,580,000	2,400,000
Animal feed	81,500	113,000
Fertilizers	139,000	49,600
Fillers, extenders, binders <sup>2</sup>	58,800	53,200
Filtering, clarifying, and decolorizing animal, mineral, and vegetable oils and greases	63,300	66,200
Pesticides and related products	102,000	134,000
Miscellaneous <sup>3</sup>	264,000	408,000
Exports <sup>4</sup>	30,900	31,800
Total	2,730,000	3,600,000

Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 13 KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE  $^{\rm I}$ 

#### (Thousand metric tons and thousand dollars)

	20	2002		03
Use	Quantity	Value	Quantity	Value
Georgia	6,830	893,000	6,610	884,000
South Carolina	374	21,400	355	21,700
Other <sup>2</sup>	806	36,600	712	33,700
Total	8,010	951,000	7,680	939,000

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 14 KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY  $\rm KIND^1$ 

#### (Thousand metric tons and thousand dollars)

	20	2002		3
Kind	Quantity	Value	Quantity	Value
Airfloat	943	52,500	943	53,100
Calcined <sup>2</sup>	1,550	284,000	1,390	256,000
Delaminated	1,070	124,000	1,130	144,000
Unprocessed	185	1,770	$202^{-3}$	9,260 3
Water washed	4,260	489,000	4,010	478,000
Total	8,010	951,000	7,680	939,000

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes adhesives, asphalt emulsions (2003), asphalt tiles, gypsum products, medical, pharmaceuticals and cosmetics, paints, paper coating (2003), textiles, and other unknown uses.

<sup>&</sup>lt;sup>3</sup>Includes drilling mud, portland cement, refractories, roofing granules, and other unknown uses.

<sup>&</sup>lt;sup>4</sup>Includes absorbents; fillers, extenders, and binders; floor and wall tiles; and refractories (2003).

<sup>&</sup>lt;sup>2</sup>Includes Alabama, Arkansas, California, Florida, Nevada, North Carolina, Tennessee, and Texas.

<sup>&</sup>lt;sup>2</sup>Includes pigment- and refractory-grade calcined kaolin.

<sup>&</sup>lt;sup>3</sup>Includes a small amount of pigment-grade.

TABLE 15 CALCINED KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE  $^{\rm I}$ 

(Thousand metric tons and thousand dollars)

	Refractor	y-grade	Pigmen	Pigment-grade	
State	Quantity	Value	Quantity	Value	
2002:					
Georgia	W	W	786	255,000	
Other <sup>2</sup>	W	W	40	8,850	
Total	721	20,600	826	264,000	
2003:					
Georgia	W	W	796	237,000	
Other <sup>2</sup>	W	W			
Total	591	18,800	796	237,000	

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

 ${\it TABLE~16}$  GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY  ${\it KIND}^1$ 

(Thousand metric tons and thousand dollars)

2002		200	3
Quantity	Value	Quantity	Value
593	28,000	593 <sup>e</sup>	28,000 e
888	258,000	883	239,000
1,070	124,000	1,130	144,000
59	609	59 <sup>e</sup>	609 e
4,220	483,000	3,940	472,000
6,830	893,000	6,610	884,000
	Quantity  593  888  1,070  59  4,220	Quantity         Value           593         28,000           888         258,000           1,070         124,000           59         609           4,220         483,000	Quantity         Value         Quantity           593         28,000         593 °           888         258,000         883           1,070         124,000         1,130           59         609         59 °           4,220         483,000         3,940

<sup>&</sup>lt;sup>e</sup>Estimated

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes Alabama, Arkansas, California, South Carolina, and Texas.

 $<sup>^{1}\</sup>mathrm{Data}$  are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes pigment- and refractory-grade calcined kaolin.

### ${\rm TABLE~17}$ GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY ${\rm USE}^{1,2}$

#### (Metric tons)

Use	2002	2003
Domestic:		
Ceramics and glass:	_	
Catalysts (oil-refining)	152,000	W
Fiberglass	265,000	265,000
Roofing granules	20,100	20,100
Sanitaryware	77,000	76,900
Other <sup>3</sup>	46,200	45,700
Fillers, extenders, binders:	_	
Adhesives	52,700	51,500
Paint	261,000	253,000
Paper coating	2,530,000	2,440,000
Paper filling	449,000	437,000
Plastic	45,400	43,800
Rubber	61,000	59,500
Other <sup>4</sup>	92,400	90,400
Heavy clay products <sup>5</sup>	17,400	W
Refractories <sup>6</sup>	258,000	239,000
Undistributed <sup>7</sup>	54,700	270,000
Total	4,380,000	4,290,000
Exports:		
Paint	85,000	82,600
Paper coating <sup>8</sup>	2,040,000	1,970,000
Paper filling <sup>8</sup>	93,900	91,300
Rubber	6,970	6,700
Undistributed <sup>9</sup>	221,000	171,000
Total	2,450,000	2,320,000
Grand total	6,830,000	6,610,000

W Withheld to avoid disclosing company proprietary data; included under "Domestic, undistributed."

<sup>&</sup>lt;sup>1</sup>Includes airfloat, high- and low-temperature calcined delaminated, water washed, and unprocessed kaolin.

<sup>&</sup>lt;sup>2</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>3</sup>Includes electrical porcelain, fine china/dinnerware, pottery, and miscellaneous ceramics.

<sup>&</sup>lt;sup>4</sup>Includes animal feed, asphalt tile, fertilizers, gypsum products, medical, pharmaceuticals and cosmetics, pesticides and related products, textiles, and miscellaneous fillers, extenders, and binders.

<sup>&</sup>lt;sup>5</sup>Includes brick (common and face), portland cement, and miscellaneous clay products.

<sup>&</sup>lt;sup>6</sup>Includes firebricks, blocks and shapes, grogs and calcines, high-alumina specialties, kiln furniture, and miscellaneous refractories.

<sup>&</sup>lt;sup>7</sup>Includes absorbents, chemical manufacturing, floor and wall tiles, catalysts (oil-refining) (2003), heavy clay products (2003), waterproofing seals, and other unknown uses.

<sup>&</sup>lt;sup>8</sup>Some export sales may be included under domestic sales.

<sup>&</sup>lt;sup>9</sup>Includes adhesives, catalysts (oil-refining), fiberglass, sanitaryware; miscellaneous fillers, extenders, and binders; portland cement; and miscellaneous refractories (2003).

### ${\it TABLE~18}\\ {\it SOUTH~CAROLINA~KAOLIN~SOLD~OR~USED~BY~PRODUCERS,~BY~KIND}^1\\$

#### (Thousand metric tons and thousand dollars)

	2002	2	2003		
Kind	Quantity	Value	Quantity	Value	
Airfloat	307	20,000	355 <sup>2</sup>	21,700 2	
Unprocessed <sup>3</sup>	68	1,350	W	W	
Total	375 r	21,400	355	21,700	

<sup>&</sup>lt;sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data; included in "Airfloat."

 ${\it TABLE~19}\\ {\it SOUTH~CAROLINA~KAOLIN~SOLD~OR~USED~BY~PRODUCERS,~BY~KIND~AND~USE}^1$ 

#### (Metric tons)

Kind and use	2002	2003
Adhesives	14,700	20,200
Ceramics <sup>2</sup>	104,000	107,000
Rubber	116,000	112,000
Refractories <sup>3</sup>	7,030	5,890
Other uses <sup>4</sup>	88,900	67,900
Exports <sup>5</sup>	44,200	41,800
Total	374,000	355,000

Revised.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes unprocessed kaolin.

<sup>&</sup>lt;sup>3</sup>Includes calcined kaolin.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes catalysts (oil-refining), fine china/dinnerware, glazes, glass, and enamels, pottery, roofing granules, sanitaryware, and miscellaneous ceramics.

<sup>&</sup>lt;sup>3</sup>Includes firebrick, blocks and shapes, and miscellaneous refractories.

<sup>&</sup>lt;sup>4</sup>Includes asphalt tile; brick (common and face); catalysts (oil refining); chemical manufacturing; civil engineering and sealings; drilling mud; fillers, extenders, and binders; heavy clay products, lightweight aggregates; paints; and plastics.

<sup>&</sup>lt;sup>5</sup>Includes refactories and fillers, extenders, and binders.

 ${\rm TABLE~20}$  Kaolin sold or used by producers in the united states, by  ${\rm use}^{\rm l}$ 

#### (Metric tons)

Use	2002	2003
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	210,000	209,000
Electrical porcelain	8,300	7,850
Fine china and dinnerware	27,400	30,500
Floor and wall tile	63,100	61,900
Pottery	13,400	13,800
Roofing granules	36,500	36,100
Sanitaryware	85,200	85,300
Miscellaneous	W	W
Chemical manufacture	31,600	34,900
Civil engineering	W	W
Fiberglass, mineral wool	288,000	288,000
Fillers, extenders, binders:	,	,
Adhesive	67,400	71,700
Fertilizer	3,550	3,490
Medical, pharmaceutical, cosmetic	754	745
Paint	298,000	284,000
Paper coating	2,540,000	2,450,000
Paper filling	450,000	438,000
Pesticide	W	W
Plastic	49,700	47,200
Rubber	177,000	172,000
Miscellaneous	107,000	103,000
Heavy clay products:	,	,
Brick, common and face	70,900	95,000
Portland cement	W	58,400
Refractories <sup>2</sup>	904,000	761,000
Miscellaneous applications	91,600	68,600
Total	5,520,000	5,320,000
Exports:	2,520,000	2,520,000
Ceramics	203,000	152,000
Paint	85,000	82,600
Paper coating	2,040,000	1,970,000
Paper filling	93,900	91,300
Rubber	50,700	48,000
Miscellaneous	19,000	21,700
Total	2,490,000	2,360,000
Grand total	8,010,000	7,680,000
W. W. d. 1.1.	0,010,000	7,000,000

W Withheld to avoid disclosing company proprietary data; included with "Domestic, fillers, extenders, binders, miscellaneous" or "Domestic, miscellaneous applications."

Data are rounded to no more than three significant digits; may not add to totals shown.

Includes firebrick (blocks and shapes), grogs and calcines, high-alumina kaolin (brick and specialties), kiln furniture, and miscellaneous refractories.

# TABLE 21 COMMON CLAY AND SHALE USED IN LIGHTWEIGHT AGGREGATE PRODUCTION IN THE UNITED STATES BY STATE $^{\rm I}$

#### (Thousand metric tons and thousand dollars)

	Concrete	Structural		Total	
State	block	concrete	Other <sup>2</sup>	Quantity	Value
2002:					
Alabama	749	53	89	891	18,200
Arkansas	203	102		305	1,340
California	47	181		228	11,200
Florida	68	23		91	1,280
Indiana	137	8		145	295
Kansas			73	73	1,010
Kentucky	109	36		145	557
Louisiana	319	159	53	531	1,170
Missouri	<del></del>		125	125	1,860
New York	82	54		136	5,600
North Carolina <sup>e</sup>	301	52		353	4,050
Ohio <sup>e</sup>	149	8		157	764
Oklahoma	22	3		25	659
Texas <sup>e</sup>	49	157	253	459	2,520
Utah	<del></del>	71	133	204	3,450
Virginia	141			141	980
Total	2,380 <sup>r</sup>	907 <sup>r</sup>	726	4,010	54,900
2003:					
Alabama	575	41	68	685	18,200
Arkansas	201	50		251	346
California	48	179		227	11,100
Florida <sup>e</sup>	68	23		91	1,280
Indiana <sup>e</sup>	137	8		145	295
Kansas			80	80	1,110
Kentucky <sup>e</sup>	109	36		145	557
Louisiana <sup>e</sup>	319	159	53	531	1,170
Missouri			114	114	1,700
New York <sup>e</sup>	82	54		136	5,600
North Carolina <sup>e</sup>	301	52		353	4,050
Ohio <sup>e</sup>	149	8		157	764
Oklahoma <sup>e</sup>	22	3		25	659
Texas <sup>e</sup>	49	157	253	459	2,520
Utah	48	27	95	170	2,870
Virginia <sup>e</sup>	141			141	980
Total	2,250	799	664	3,710	53,200

<sup>&</sup>lt;sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Includes highway surfacing.

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)

	200	2002		)3
State	Quantity	Value <sup>e</sup>	Quantity	Value
Alabama	642	2,050	567	1,790
Arkansas	464	504	459	520
California	243	1,170	314	1,010
Colorado	176	1,130	209	1,400
Georgia	1,110	4,100	1,130	3,430
Illinois	172	763	169	914
Kentucky <sup>3</sup>	400	2,360	469	1,330
Maryland	200	243	201	244
Mississippi	420	2,080	448	1,920
North Carolina	1,960	6,540	1,730	5,540
Ohio	817	4,840	602	2,890
Oklahoma	731	1,170	797	1,240
Pennsylvania	674	2,160	709	2,060
South Carolina	814	2,150	880	1,610
Texas	1,010	16,200	902	3,970
Other <sup>4</sup>	2,950	11,600	3,280	15,300
Total	12,800	59,000	12,900	45,100

<sup>&</sup>lt;sup>e</sup>Estimated.

<sup>&</sup>lt;sup>1</sup>Includes extruded and other brick.

<sup>&</sup>lt;sup>2</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>3</sup>Extruded brick only.

<sup>&</sup>lt;sup>4</sup>Includes all other States except Alaska, Delaware, Hawaii, Idaho, Nevada, New Hampshire, Rhode Island, Vermont, and Wisconsin.

 $\label{eq:table 23} \text{U.S. EXPORTS OF CLAYS IN 2003, BY COUNTRY}^1$ 

(Thousand metric tons and thousand dollars)

-	Ball c	lay	Bento	nite	Fire o	clay	Fuller's	earth	Kao	olin	Clays,	n.e.c. <sup>3</sup>	То	tal
Country	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	(2)	15	(2)	94	(2)	77	1	194	10	2,120	1	1,210	12	3,710
Australia			10	1,170	12	1,680			24	10,200	6	6,250	52	19,300
Belgium	(2)	60	5	4,240			1	80	31	14,200	2	958	38	19,500
Brazil	(2)	15	(2)	205	(2)	24	(2)	105	6	2,350	3	1,650	9	4,350
Canada	54	2,730	216	17,400	8	1,110	7	1,245	790	80,800	187	43,000	1,260	146,000
Finland	46	2,110	3	121					292	56,300	1	775	342	59,300
France			(2)	293	(2)	126			3	1,150	1	1,360	5	2,940
Germany	(2)	4	17	1,150			(2)	63	29	11,100	4	2,050	50	14,400
Indonesia			6	966	(2)	69			73	15,700	2	1,250	81	17,900
Italy	(2)	3	6	1,060	(2)	3	1	347	133	20,300	6	2,730	146	24,400
Japan	3	356	190	15,800	23	2,380	(2)	52	859	135,000	14	8,780	1,090	162,000
Korea, Republic of	(2)	70	17	1,930	2	439			155	30,000	12	7,780	186	40,200
Malaysia			19	1,870			2	187	3	1,010	2	1,260	26	4,330
Mexico	2	93	39	3,350	113	10,500	1	284	224	21,800	48	7,680	427	43,700
Netherlands	(2)	75	37	12,400	15	1,280	13	1,761	221	35,900	20	17,200	306	68,700
Singapore			1	651			(2)	51	3	1,060	5	3,440	9	5,210
South Africa			1	303			(2)	11	4	1,720	4	1,330	8	3,370
Taiwan	1	281	24	3,440	7	466			26	6,620	7	3,400	228	33,800
Thailand			20	1,800			(2)	13	39	8,110	5	2,500	50	10,900
United Kingdom	1	52	27	3,660	(2)	3	1	191	29	9,140	9	7,140	67	20,200
Venezuela	14	1,160	4	1,420	(2)	40	1	284	22	11,300	2	580	43	14,800
Other	18	1,420	82	14,800	105	9,180	22	3,960	548	97,800	75	30,400	698	139,000
Total	139	8,430	721	88,100	285	27,400	48	8,828	3,520	574,000	416	153,000	5,130	859,000

<sup>--</sup> Zero

Source: U.S. Census Bureau.

 ${\rm TABLE~24}$  U.S. IMPORTS FOR CONSUMPTION OF CLAY IN 2003, BY  ${\rm KIND}^1$ 

	Quantity	Value <sup>2</sup>
Kind	(metric tons)	(thousands)
China clay or kaolin:		
Brazil	208,000	\$28,300
Canada	504	311
France	806	314
Germany	186	220
Japan	90	143
Mexico	368	190
Peru	442	137
United Kingdom	13,200	4,920
Other	447	124
Total	224,000	34,700
Fire clay:		
Canada	231	75
China	200	26
Germany	17	67
Other	34	77
Total	482	245

See footnotes at end of table.

<sup>&</sup>lt;sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Less than 1/2 unit.

<sup>&</sup>lt;sup>3</sup>Also includes chamotte or dina's earth, activated clays and earths, and artificially activated clays.

 $\label{eq:table 24--Continued}$  U.S. IMPORTS FOR CONSUMPTION OF CLAY IN 2003, BY  $\mathsf{KIND}^1$ 

17: 1	Quantity	Value <sup>2</sup>
Kind	(metric tons)	(thousands
Decolorizing earths and fuller's earth:	_ 2510	0.
India	_ 2,510	\$:
Venezuela		23
Total	2,590	2
Bentonite:	_	
Argentina		24
Canada	3,500	995
China		113
Germany	133	152
Greece	5,600	33
Japan	_ 39	74
Mexico	82	18
Netherlands	292	50
Spain	11	44
Turkey	2,120	955
United Kingdom	227	137
Other	315	113
Total	12,700	3,010
Common blue clay and other ball clay:		
China	_ 2	Ç
France	_ 2	4
Ukraine	12,900	1,070
United Kingdom	427	13:
Total	13,300	1,220
Other clay:		, .
Canada		276
China		20
Germany	233	364
Mexico		120
Netherlands		64
Peru	1,070	583
Spain	1,340	55′
United Kingdom	- 1,540 292	148
Other	- 252 253	254
Total	5,060	2,580
Chamotte or dina's earth, Bulgaria	_ 3,000	2,300
Artificially activated clay and activated earth:		
Canada		621
China		
		79
Denmark	_ 16	49
Germany	3,330	2,650
Mexico	_ 15,500	5,110
Netherlands	_ 423	212
Norway	100	3:
United Kingdom	_ 93	25:
Venezuela	257	70
Other	183	350
Total	21,000	9,430
Grand total	279,000	51,20

Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

<sup>&</sup>lt;sup>2</sup>U.S. customs declared value.

 ${\small TABLE~25} \\ {\small BENTONITE:~WORLD~PRODUCTION,~BY~COUNTRY}^{1,2}$ 

(Metric tons)

Country <sup>3</sup>	1999	2000	2001	2002	2003 <sup>e</sup>
Algeria <sup>4</sup>	15,491	22,708	21,286	27,178	25,346
Argentina	128,809	123,092	135,450 <sup>r</sup>	120,006 <sup>r</sup>	128,406
Armenia	3,493	2,807	1,000 r, e	258 <sup>r</sup>	642
Australia <sup>e, 4</sup>	180,000	180,000	180,000	200,000	200,000
Bosnia and Herzegovina <sup>e</sup>	800	800	800	800	800
Brazil, beneficiated	274,623	273,975	160,381	174,909 <sup>r</sup>	175,000
Bulgaria	242,725	296,000 r	320,000 r, e	211,000 r	250,000
Burma	998	978	900 e	900	900
Chile	1,104	1,314	1,695	1,632 <sup>r</sup>	1,650
Commonwealth of Indepedent States <sup>e, 6</sup>	700,000	750,000	750,000	750,000	750,000
Croatia	8,441	10,013	10,580	11,000	11,000
Cyprus	138,853	167,500	126,600	128,400 <sup>r</sup>	130,000
Czech Republic	160,000	280,000	224,000 r	174,000 <sup>r</sup>	175,000
Egypt <sup>e</sup>	50,000	50,000	50,000	50,000	50,000
Georgia <sup>e</sup>	9,891 5	7,084 5	7,000	7,000	7,000
Germany <sup>e</sup>	500,000 5	500,000	500,000	500,000	500,000
Greece <sup>e</sup>	950,000 5	950,000	950,000	950,000	950,000
Guatemala	4,301	3,317	3,000 e	3,100	3,200
Hungary	5,000 r	4,800 <sup>r</sup>	5,200 r	2,800 r	30,000
Indonesia <sup>e</sup>	5,213 5	5,000	5,000	5,000	5,000
Iran <sup>7</sup>	64,957	70,000	80,000	80,000	80,000
Italy	500,000	500,000 e	500,000 e	500,000	500,000
Kenya		64	50	50	50
Japan	428,247	415,115	405,738	400,000	400,000
Macedonia <sup>e</sup>	30,000	30,000	30,000	30,000	30,000
Mexico	208,611	269,730	415,133	432,941 r	425,000
Morocco	36,528	43,152	71,741	58,754 <sup>r</sup>	71,544
Mozambique	10,828	16,144	1,357 <sup>r</sup>	r	:
New Zealand, processed <sup>e</sup>	15,000 5	10,000	10,000	7,800	7,800
Pakistan	15,349	27,700	27,000 e	28,000	28,000
Peru	19,659	21,059	18,217	20,760 r	14,900
Philippines	1,844	2,800	5,128	5,500	5,000
Poland <sup>8</sup>	5,000	29,700	29,000	26,200 r	27,000
Romania	19,577	35,789	24,779	15,402	15,000
Serbia and Montenegro	77	75 <sup>e</sup>	75 <sup>e</sup>	75	75
Solovakia	60,000	71,000	80,000	84,000	80,000
South Africa <sup>9</sup>	50,363	85,187	116,384	218,512	145,060
Spain <sup>e</sup>	150,000 5	150,000	150,000	150,000	150,000
Turkey	899,614	636,273	674,175 <sup>r</sup>	559,224 r	600,000
Turkmenistan <sup>e</sup>	50,000	50,000	50,000	50,000	50,000
Ukraine <sup>e</sup>	300,000	300,000	300,000	300,000	300,000
United States	4,070,000	3,760,000	3,970,000	3,970,000	3,940,000
Zimbabwe <sup>9</sup>	140,000	140,000 e	· · ·	· · ·	
Total	10,500,000 r	10,300,000 r	10,400,000 r	10,300,000	10,200,000

<sup>&</sup>lt;sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>&</sup>lt;sup>1</sup>World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Table includes data available through August 21, 2004.

<sup>&</sup>lt;sup>3</sup>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.

<sup>&</sup>lt;sup>4</sup>Includes bentonitic clays.

<sup>&</sup>lt;sup>5</sup>Reported figure.

<sup>&</sup>lt;sup>6</sup>Information is inadequate to formulate reliable estimates for individual countries, except Armenia, Georgia, Turkmenistan, and Ukraine.

<sup>&</sup>lt;sup>7</sup>Year beginning March 21 of that stated.

<sup>&</sup>lt;sup>8</sup>Montmorillite type bleaching clay.

<sup>&</sup>lt;sup>9</sup>May include other clays.

 $\label{eq:table 26} TABLE~26$  FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY  $^{1,2}$ 

#### (Metric tons)

Country <sup>3</sup>	1999	2000	2001	2002	2003 <sup>e</sup>
Algeria	2,489	3,431	3,254	3,521	2,573 4
Argentinae	1,500	1,500	1,500	1,500	1,500
Australia, attapulgite	5,639	5,600	5,600	6,000	6,000
Germany, unprocessed <sup>e</sup>	500,000	500,000	500,000	500,000	500,000
Italy <sup>e</sup>	30,000	30,000	30,000	30,000	30,000
Mexico	47,522	51,685	148,194	147,064 <sup>r</sup>	152,917 4
Morocco, smectite	21,956	30,665	40,664	43,243 <sup>r</sup>	14,944 4
Pakistan	15,565	15,288	15,000 <sup>e</sup>	15,000	15,000
Senegal, attapulgite	136,000	131,000	130,000 <sup>e</sup>	176,454	177,000
South Africa, attapulgite	7,067	7,337	9,229	7,990	14,473 4
Spain, attapulgite <sup>e</sup>	90,000	90,000	90,000	90,000	90,000
United Kingdom <sup>e, 5</sup>	140,000	140,000	140,000	140,000	140,000
United States <sup>6</sup>	2,560,000	2,910,000	2,890,000	2,730,000	3,600,000 4
Total	3,560,000	3,920,000	4,000,000	3,890,000	4,750,000

eEstimated. Revised.

 $\label{eq:table 27} \text{KAOLIN: WORLD PRODUCTION, BY COUNTRY}^{1,\,2}$ 

#### (Metric tons)

Country <sup>3</sup>	1999	2000	2001	2002	2003 <sup>e</sup>
Algeria	16,833	11,616	13,356	9,505	16,591 4
Argentina	52,665	34,023	12,367 <sup>r</sup>	9,956 <sup>r</sup>	10,600
Australia, includes ball clay <sup>e</sup>	200,000	220,000	220,000	230,000	230,000
Austria, marketable <sup>e</sup>	50,000	50,000	50,000	50,000	50,000
Bangladesh <sup>e, 5</sup>	7,700	7,900	8,000	8,100	8,200
Belgium <sup>e</sup>	300,000	300,000	300,000	300,000	300,000
Bosnia and Herzegovina <sup>e</sup>	3,000	3,000	3,000	3,000	3,000
Brazil, beneficiated	1,516,700	1,639,673	1,817,419	1,708,457 <sup>r</sup>	1,700,000
Bulgaria	97,500	108,000	100,000 e	100,000	100,000
Burundi	1,597	1,500			
Chile	4,361	6,445	5,300	6,164	6,170
Colombia, includes common clay <sup>e</sup>	8,000,000 4	8,400,000	8,500,000	8,500,000	8,500,000
Czech Republic	5,183,000	5,573,000	5,543,000 r	3,650,000 <sup>r</sup>	4,000,000
Denmark, sales <sup>e</sup>	2,500	2,500	2,500	2,500	2,500
Ecuador	20,652	11,022	703 <sup>r</sup>	8,144 <sup>r</sup>	9,000
Egypt	290,000	290,000	300,000 <sup>e</sup>	300,000	300,000
Eritrea	1,138	943	588	250	250 4
Ethiopia	681	1,654	1,800 r, e	1,800	1,800
France, marketable	325,000	300,000	300,000 <sup>e</sup>	300,000	300,000
Germany	1,800,000	1,800,000	1,800,000 e	1,800,000	1,800,000
Greece	60,000	60,000	60,000 <sup>e</sup>	60,000	60,000
Guatemala <sup>e</sup>	61	77	100	100	100

See footnotes at end of table.

<sup>&</sup>lt;sup>1</sup>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 August 21, 2004.

<sup>&</sup>lt;sup>2</sup>World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>3</sup>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.

<sup>&</sup>lt;sup>4</sup>Reported figure.

<sup>&</sup>lt;sup>5</sup>Salable product.

<sup>&</sup>lt;sup>6</sup>Sold or used by producers.

### TABLE 27--Continued KAOLIN: WORLD PRODUCTION, BY COUNTRY<sup>1, 2</sup>

#### (Metric tons)

- 3	1999	2000	2001	2002	20026
Country <sup>3</sup>			2001		2003 <sup>e</sup>
Hungary, processed <sup>e</sup>	7,000	7,000	7,000	7,000	7,000
India:	150.000	1.00.000	150,000 6	170.000	100.000
Processed	150,000	160,000	170,000 e	170,000	180,000
Salable crude	520,000	530,000	540,000 e	540,000	540,000
Indonesia	21,389	15,000 e	15,000 e	15,000	15,000
Iran	837,277	850,000 <sup>r</sup>	806,000 <sup>r</sup>	810,000 <sup>r</sup>	800,000
<u>Israel</u> <sup>e</sup>	20,000	13,000			
Italy, kaolinitic earth <sup>e</sup>	9,000	10,000	10,000	10,000	10,000
Japan	53,092	25,739	19,976 <sup>r</sup>	19,000 e	19,000
Jordan	34,040	36,795	38,000 e	41,000	41,000
Kazakhstan <sup>e</sup>	70,000	70,000	70,000	70,000	70,000
Kenya	192	793	700	700	700
Korea, Republic of	1,858,359	2,097,450	2,383,833	2,831,027	2,500,000
Madagascar <sup>e</sup>	120	170	170	110 <sup>r</sup>	170
Malaysia	213,973	233,885	364,458	323,916 <sup>r</sup>	376,958 4
Mexico	489,993	532,268	681,709	745,498 <sup>r</sup>	800,000
New Zealand	16,700	16,300	15,000	16,000	16,000
Nigeria	110,000	165,765 <sup>r</sup>	209,478 <sup>r</sup>	200,000 r, e	200,000
Pakistan	64,692	49,574	50,000 e	50,000	50,000
Paraguay	6,600 r	6,500 r	6,500 r	6,700 r	6,600
Peru	1,332	6,165	5,532	1,934 <sup>r</sup>	2,653 4
Poland, washed	88,792	89,900 <sup>r</sup>	101,200 <sup>r</sup>	113,500 <sup>r</sup>	115,000
Portugal <sup>e</sup>	175,000	175,000	175,000	175,000	175,000
Romania	25,456	19,007	21,867	22,514	20.000 4
Russia, concentrate	40,600	45,000	45,000 e	45,000	45,000
Serbia and Montenegro:	40,000	45,000	43,000	45,000	43,000
Crude	40.221	20 475	60,900	60,000	60,000
	40,321	39,475	,	/	,
Washed	3,000	4,000	10,000	10,000	10,000
Slovakia	22,000	32,000	35,000 <sup>r</sup>	33,000 <sup>r</sup>	35,000
Slovenia:e		40.000	40.000	40.000	
Crude	10,000	10,000	10,000	10,000	10,000
Washed	4,000	4,000	4,000	4,000	4,000
South Africa	122,400	98,897	85,556	91,380	85,260
Spain, marketable, crude and washed <sup>e, 6</sup>	320,000	365,000 4	350,000	350,000	350,000
Sri Lanka	12,573	12,230	9,403	8,613	8,500
Sweden <sup>e</sup>	450				
Taiwan	r	<sup>r</sup>	r	r	
Thailand, beneficiated	113,005	201,226	168,063	127,132 <sup>r</sup>	130,000
Turkey	449,954	595,415 <sup>r</sup>	574,550 <sup>r</sup>	372,344 <sup>r</sup>	400,000
Uganda	198	14	90	178 <sup>r</sup>	180
Ukraine	221,526	225,000 e	225,000 e	225,000	225,000
United Kingdom, sales <sup>7</sup>	2,303,607	2,420,000	2,400,000 e	2,400,000	2,400,000
United States <sup>8</sup>	9,160,000	8,800,000	8,110,000	8,010,000	7,680,000 4
Uzbekistan <sup>e</sup>	5,500,000	5,300,000	5,500,000	5,500,000	5,500,000
Venezuela	12,000	10,000 <sup>r</sup>	10,000 <sup>r, e</sup>	10,000 <sup>r, e</sup>	10,000
Vietname	398,000	520,000	600,000	600,000	650,000
Total	41,400,000 <sup>r</sup>	42,800,000	42,900,000	41,100,000 <sup>r</sup>	41,000,000
Total	41,400,000	+2,000,000	72,700,000	71,100,000	71,000,000

<sup>&</sup>lt;sup>e</sup>Estimated. <sup>r</sup>Revised. -- Zero.

<sup>&</sup>lt;sup>1</sup>World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>&</sup>lt;sup>2</sup>Table includes data available through August 21, 2004.

<sup>&</sup>lt;sup>3</sup>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.

<sup>&</sup>lt;sup>4</sup>Reported figure.

<sup>&</sup>lt;sup>5</sup>Data for year ending June 30 of that stated.

<sup>&</sup>lt;sup>6</sup>Includes crude and washed kaolin and refractory clays not further described.

<sup>&</sup>lt;sup>7</sup>Dry weight.

<sup>&</sup>lt;sup>8</sup>Kaolin sold or used by producers.