

CLAY AND SHALE

By Robert L. Virta

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production tables were prepared by Ronald L. Hatch, Regina R. Coleman, and Glenn J. Wallace, international data coordinators.

The amount of clay sold or used by domestic producers in 1998 was 41.6 million metric tons (Mt) valued at \$1.66 billion, essentially unchanged from that of 1997. Production of ball clay and kaolin increased, and production of bentonite, common clay and shale, fire clay, and fuller's earth decreased. Of the clay and shale produced in 1998, common clay and shale accounted for 59% of the tonnage, and kaolin accounted for 64% of the value. Imports of clays increased to 86,000 metric tons (t) valued at \$27.7 million. Exports increased to 5.23 Mt valued at \$843 million (table 1).

Legislation and Government Programs

The U.S. Environmental Protection Agency (EPA) continued its work on the Maximum Achievable Control Technology (MACT) for the clay-products-manufacturing industries. The MACT is required under the National Emissions Standards for Hazardous Air Pollutants Program, which was established by the 1990 Amendments to the Clean Air Act. Clay processors and manufacturers of lightweight aggregate, brick, tile, and whiteware are covered under the MACT. The EPA has been gathering and analyzing emissions data from these industries so that a proposed MACT can be developed by September 2000 (American Ceramic Society Bulletin, 1998).

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.

Production

In 1998, 238 companies operated approximately 700 clay pits or quarries; of these, 20 companies, many with multiple operations, accounted for 50% of the tonnage and 76% 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; the District of Columbia; and Puerto Rico (table 2).

The 10 leading producer States, in decreasing order by tonnage, were Georgia, Wyoming, Alabama, North Carolina, Texas, Missouri, South Carolina, Ohio, California, and Tennessee. The 10 leading producing companies, in alphabetical order, were American Colloid Co. (bentonite and

fuller's earth), Dry Branch Kaolin Co. (kaolin), ECC International LTD (ECCI) (kaolin, purchased by IMETAL SA in 1998), Engelhard Corp. (fuller's earth and kaolin), General Shale Products Corp. (common clay and shale), Glen Gery Corp. (common clay and shale), Holnam Inc. (common clay and shale), J.M. Huber Corp. (kaolin), Solite Division, Big River Industries Inc. (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 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 552 survey forms issued, 366 were completed, representing approximately 70% of the total clay and shale production sold or used shown 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 1998, 5 companies mined ball clay from 30 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 1.13 Mt valued at \$51.1 million in 1998 from 1.06 Mt valued at \$49.8 million in 1997 (table 3). Tennessee supplied 63% of the Nation's output, followed by Texas, Kentucky, Mississippi, and Indiana. Production increased in Indiana, Mississippi, Tennessee, and Texas and decreased in Kentucky. Water-slurried ball clay was produced only in Tennessee. Airfloat 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.

Bentonite.—In 1998, 19 companies produced bentonite from approximately 60 quarries in 11 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 3.82 Mt valued at \$176 million in 1998 from 4.02 Mt valued at \$169 million in 1997 (table 5). Production of nonswelling bentonite increased to 410,000 t valued at \$15.5 million in 1998 from 397,000 t valued at \$13.5 million in 1997. Alabama led all States in the production of nonswelling bentonite, followed by Mississippi, Texas, Arizona, California, and Nevada.

Production of swelling bentonite decreased to 3.41 Mt valued at \$160 million in 1998 from 3.63 Mt valued at \$156 million in 1997. Wyoming led all States in the production of swelling bentonite, followed by Montana, Utah, California, Oregon, and Nevada.

Rheox Inc., a subsidiary of NL Industries, Inc., was purchased on January 30 by Elementis Specialties. Rheox produced organoclay rheological additives and bentonite for such uses as adhesives, greases, inks, lubricants, and oil drilling (Rheox Inc., February 2, 1998, Elementis completes Rheox acquisition, accessed February 22, 1999, at URL <http://www.rheox.com/wcompnews.html>).

Halliburton Co. and Dresser Industries Co. merged in 1998 (Halliburton Co., September 28, 1998, Halliburton Co., accessed September 1, 1999, at URL <http://www.halliburton.com/haldresser.asp>). Halliburton is a part owner of M-I L.L.C., and Dresser Industries owned Bentonite Performance Minerals through its Baroid Division (Industrial Minerals, 1998f).

American Colloid announced plans for the construction of a new foundry compounds blending plant in Indiana (North American Minerals News, 1998d). AMCOL International Corp., the parent company of American Colloid, dedicated a production facility of Nanocor, Inc., another AMCOL subsidiary, in Aberdeen, MS. The facility was the former acid-activation plant for American Colloid's bentonite operation in Mississippi. The plant will have an annual capacity of 10,000 t. Nanocor produced ultrafine bentonite products for use in the plastics industry (Nanocor, Inc., 1998).

Common Clay and Shale.—In 1998, 172 firms produced common clay and shale from approximately 380 pits in 41 States and Puerto Rico. 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 production was used by producers to manufacture structural clay products, aggregate, and cement or for civil engineering applications.

Domestic sales or use of common clay and shale decreased to 24.5 Mt valued at \$137 million in 1998 from 24.6 Mt valued at \$150 million in 1997 (table 7). The major producing States, in decreasing order by tonnage, were Alabama, North Carolina, Texas, Georgia, Ohio, South Carolina, Missouri, Arkansas, California, and Pennsylvania.

Fire Clay.—Fire clay producers were mostly refractories manufacturers that used the clays in firebrick and other refractories. In 1998, 49 quarries were operated by 16 firms in 7 States.

Fire clay sold or used by domestic producers decreased slightly to 410,000 t valued at \$7.52 million in 1998 from 415,000 t valued at \$8.01 million in 1997 (table 9). Missouri was the leading producing State, followed by Ohio, South Carolina, California, Kentucky, Alabama, and New Mexico.

Fuller's Earth.—In 1998, 17 companies produced fuller's earth (attapulgite and montmorillonite varieties) from 37 quarries in 11 States. Attapulgite was mined from approximately 10 mines in the Florida panhandle and southwestern Georgia; these two States accounted for all the domestic attapulgite production. Most of the fuller's earth producers were small, independent firms, but five were large,

diversified corporations with international mineral interests.

Production of fuller's earth decreased to 2.35 Mt valued at \$230 million in 1998 from 2.37 Mt valued at \$255 million in 1997 (table 11). Production of attapulgite was estimated to be 793,000 t valued at \$90 million in 1998, an increase from 707,000 t valued at \$90 million in 1997. Georgia was the major producing State, followed by Florida and Nevada. Sepiolite clay, which is included under fuller's earth, was produced in Nevada. Production of montmorillonite was estimated to be 1.56 Mt valued at \$166 million in 1998, a decrease from 1.66 Mt valued at \$165 million in 1997. Montmorillonite was produced, in decreasing order by tonnage, in Mississippi, Missouri, California, Illinois, Virginia, Florida, Georgia, Kansas, Tennessee, and Texas.

American Colloid sold its fuller's earth operations to Oil-Dri Corp. The sale included a 91,000-metric-ton-per-year (t/yr) plant near Mounds, Il. and mineral reserves in Illinois, Nevada, and Tennessee (Industrial Minerals, 1998c).

Clorox Co. acquired First Brands Corp. in a transaction valued at approximately \$2 billion. Clorox was the third largest domestic seller of kitty litter, which the company had manufactured on a contract basis. With its purchase of First Brands, Clorox became the largest domestic seller of kitty litter, surpassing Ralston Purina Co. The purchase included First Brands' mines in California and Georgia and a manufacturing plant in Kansas (Industrial Specialties News, 1998).

A reorganization was announced by ITC, Inc., to handle better sales of Floridin's Min-U-Gel and Florigel attapulgite gelling clay business, which it purchased in 1997. Its Americas Division will manage sales in North America, Central America, and South America, and the International Division will manage sales elsewhere in the world (Ceramic Industry, 1998a).

Kaolin.—In 1998, 25 firms mined kaolin from approximately 80 quarries in 11 States. Domestic production increased to 9.45 Mt valued at \$1.05 billion in 1998 from 9.28 Mt valued at \$1.03 billion in 1997 (table 13). Georgia was the largest kaolin producer, followed by South Carolina, Alabama, Arkansas, California, Nevada, North Carolina, Texas, Florida, Pennsylvania, and Tennessee.

Approximately 50% of the kaolin produced was water washed; 21%, calcined; 15%, delaminated; 10%, airfloat; and 4%, unprocessed (table 14). A total of 1.97 Mt valued at \$286 million of calcined kaolin was produced. Of this amount, 819,000 t valued at \$267 million was pigment-grade (low-temperature) and 1.15 Mt valued at \$18.7 million was refractory-grade (high-temperature) calcined kaolin (table 15).

Kaolin production in Georgia increased to 8.35 Mt valued at \$998 million in 1998 from 8.2 Mt valued at \$977 million in 1997. Approximately 56% of the production was sold as water washed; 17%, calcined; 17%, delaminated; 7%, airfloat; and 3%, unprocessed (table 16). Production in South Carolina decreased to 395,000 t valued at \$22 million in 1998 from 447,000 t valued at \$29 million in 1997. Approximately 80% of the production was airfloat kaolin with the remainder being calcined or unprocessed (table 18).

The purchase of ECCI by IMETAL was finalized in April 1999. IMETAL created a Pigments and Additives Group that

included Dry Branch Kaolin Co., which IMETAL purchased several years ago; the kaolin operations of ECC; Georgia Marble Co.; and Dry Branch Kaolin's share in the Rio Capim Caulim kaolin operation in Brazil. The purchase required the divestiture of some production capacity of hydrous and calcined kaolin in Georgia (English China Clay LTD, 1999; IMETAL SA, 1999).

Engelhard Corp. continued its expansion program. The company invested \$45 million to expand its calcining operations in 1997. Further capacity increases were planned in 1999 (North American Minerals News, 1998a).

Thiele Kaolin opened its slurry facility in Wisconsin Rapids, WI. The facility was constructed to service paper mills throughout the Midwest (North American Minerals News, 1998e).

Group Laperriere & Verreault, J.M. Huber, and Mintech Canada Inc. announced plans to construct a research facility near Trois-Rivieres in Quebec. The pilot scale facility will test and develop products for paper-coating applications. The facility was expected to be operational by the end of 1999 (North American Minerals News, 1998c).

Global Industrial Technologies Inc., the parent company of Harbison-Walker Refractories Co., completed its purchase of A.P. Green Industries Inc. in July. The combined operations will operate as Harbison-Walker although the A.P. Green product names will still be used (North American Minerals News, 1998b).

United Catalysts Inc., the parent company of Albion Kaolin Co., purchased Evans Clay Co. With the purchase, Albion Kaolin has become the largest airfloat kaolin operation in the world (Albion Kaolin Company, September 2, 1999, [untitled], press release, accessed September 2, 1999, at URL <http://www.albionkaolin.com/history/history.htm>).

Utah Clay Technology Inc. continued to develop its Utah kaolin deposit. The deposit is located in the Wah Wah Mountains south of Salt Lake City, UT. The company was considering the purchase of an existing bentonite-processing operation in southern Utah and adding a kaolin-processing line to the facility (Industrial Minerals, 1998n).

Consumption

Ball Clay.—The principal domestic ball clay markets, in decreasing order, were floor and wall tile, sanitaryware, and pottery (table 4). Consumption increased to 1.13 Mt in 1998 from 1.06 Mt in 1997. The largest increase was for sanitaryware. Most markets were relatively unchanged compared to those of 1997. Increased sales for absorbents and unspecified markets resulted in a large increase under the miscellaneous category in table 4. Sales and use of ball clay have increased in recent years because growth in commercial and residential building construction and home renovations has increased demand for sanitaryware, tile, and whiteware.

Bentonite.—Major markets for bentonite were drilling mud, foundry sand, iron ore pelletizing, and pet waste absorbents. Domestic consumption decreased by approximately 2% in 1998. A large increase in sales for pet waste absorbent and filtering and clarifying of oils and greases was offset by a

slightly larger decrease in sales for animal feed, drilling mud, foundry sand, and waterproofing and sealing applications. Domestic sales of bentonite for major markets were 869,000 t for foundry sand bond, 773,000 t for pet waste absorbent, 665,000 t for drilling mud, 529,000 t for iron ore pelletizing, and 236,000 t for sealant applications (table 6).

Total sales (domestic and exports) of swelling bentonite were approximately 725,000 t for drilling mud, 840,000 t for foundry sand bond, 588,000 t for pelletizing iron ore, 775,000 t for pet waste absorbent, and 143,000 t for waterproofing and sealing. These five markets accounted for 90% of swelling bentonite sales and 80% of total bentonite sales.

Much of the data on other sales of swelling and nonswelling bentonite were concealed to avoid disclosing company proprietary data. Sales of swelling bentonite were as follows: more than 90%, adhesive and animal feed applications; almost 90%, filler and extender applications; slightly more than 50%, miscellaneous refractory applications; and less than 50%, ceramics. Filtering, clarifying, and decolorizing applications accounted for most of the nonswelling bentonite sold.

The major domestic uses for swelling bentonite, in decreasing order, were pet waste absorbents, drilling mud, foundry sand, iron ore pelletizing, waterproofing and sealing, and animal feed. Major export markets were in drilling mud, foundry sand, and iron ore pelletizing applications. The major domestic uses for nonswelling bentonite, in decreasing order, were in foundry sand, filtering, clarifying, and decolorizing of oils and greases, absorbents, chemical manufacture, animal feed, and drilling mud. Exports were limited to filtering, clarifying, and decolorizing of oils and greases and foundry sand applications.

Common Clay and Shale.—Common clay was used most frequently in the manufacture of heavy clay products, such as building brick, drain tile, flue linings, lightweight aggregate, portland cement, sewer pipe, structural tile, and terra cotta (table 8). Consumption of common clay and shale decreased slightly to 24.5 Mt in 1998. Large increases in sales for brick, lightweight aggregate, and refractories were entirely offset by decreased sales for portland cement manufacture. The strong housing and commercial building market has helped maintain sales of common clay and shale for brick and lightweight aggregate manufacture.

Fire Clay.—Fire clays were used in refractory products, such as firebrick and block, grogs and calcines, high-alumina brick and specialties, saggers, 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 decreased slightly to 410,000 t in 1998 from 415,000 t in 1997 (table 10). Major markets for fire clay, in decreasing order, were firebrick, refractory mortar and cement, common brick, grogs and calcines, miscellaneous refractories, and pottery.

Fuller's Earth.—The major domestic uses for attapulgite and montmorillonite varieties of fuller's earth, in decreasing order, were pet waste absorbents, oil and grease absorbents, pesticide carriers, and flow control agents in animal feed (table 12). Consumption of fuller's earth decreased slightly in 1998.

Sales of montmorillonite decreased by 6% in tonnage in 1998

compared with those of 1997. Major markets for montmorillonite, in decreasing order, were pet waste absorbents, oil and grease absorbents, pesticide carriers, and fertilizer carrier applications. Sales increased for oil and grease absorbents and other unspecified end uses. Consumption of montmorillonite declined for pet waste absorbents, waterproofing and sealing, animal feed, fertilizers, paper coating, pesticides, filtering and decolorizing oils and greases, and exports. Most of the sales losses were in the export and pet waste absorbent markets.

Sales of attapulgite increased by 12% in tonnage in 1998 compared with those of 1997. Most of the sales data were concealed to avoid disclosing company proprietary data; major markets, in decreasing order, were pet waste absorbents, oil and grease absorbents, pesticide carriers, cement, fertilizer carriers, drilling mud, gypsum products, animal feed, and adhesive applications. Sales increased for oil and grease absorbents, fertilizer carriers, cement, and pesticides.

Sales of montmorillonite-variety of fuller's earth accounted for more than 80% of total sales for animal feed, more than 50% for oil and grease absorbents, 75% for pet waste absorbents, more than 50% for pesticide carriers, and most of the sales for filtering, clarifying, and decolorizing oils and greases. Attapulgite accounted for all of the sales for adhesive, asphalt tile, cement, drilling mud, gypsum products, paint, pharmaceutical, and miscellaneous refractory applications and more than 75% of fertilizer carrier sales.

Kaolin.—The major domestic markets for kaolin, in decreasing order, were paper coating and filler, refractories, fiberglass, paint, rubber, catalyst, and brick (table 20). Consumption increased slightly in 1998; the largest increases were in paper coating (100,000 t) and refractories (210,000 t). Major domestic markets for kaolin from Georgia, in decreasing order, were paper coating, paper filling, refractories, fiberglass, and paint (table 17). Large increases were in sales for paper coating and refractories. Sales for adhesives, fiberglass, paint, and rubber decreased. The major market for kaolin from South Carolina was rubber, followed by common and face brick, fiber glass, adhesives, paper coating and filler, sanitaryware, pesticide carriers, plastics, and firebrick (table 19). Gains made in the brick and rubber sales were offset by losses in sales in the catalyst, export, fertilizer, fiberglass, roofing granule, refractory markets.

Absorbent Uses.—Sales for absorbent uses were about 2.51 Mt, an increase of 3% compared with that of 1997. Fuller's earth accounted for 68% of the clay used for absorbents (table 12), followed by bentonite (table 6), and kaolin. Pet waste absorbents accounted for approximately 86% of absorbent consumption, followed by oil and grease absorbents (12%) and miscellaneous absorbent applications (2%).

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 1.69 Mt, a decrease of 7% compared with that of 1997. The largest ceramics market was ceramic floor and wall tile (42%), followed by sanitaryware (18%), roofing granules (10%), and pottery (10%). Ball clay accounted for 43% of the clay used in ceramics, followed by common clay and shale

(34%) and kaolin (21%). Small amounts of bentonite, fire clay, and fuller's earth also were used in the manufacture of ceramics. Ball clay dominated the electrical porcelain, glazing, pottery, and sanitaryware markets (table 4). Common clay and shale was the predominant clay used in roofing granules (table 8). Kaolin dominated the catalyst and crockery markets (table 20). Ball clay and common clay and shale were the predominant clays used in floor and wall tile manufacture, and ball clay and kaolin dominated fine china markets (tables 4, 8, and 20).

Sales of china and pottery have increased in recent years, following the growth in the U.S. economy. Fueling the growth is increased disposable income. Sales of high-value merchandise and moderately priced dinnerware have increased, as have sales of giftware. Sales of dinnerware were estimated to be \$1.7 billion in 1998. In 1997, 53% of the respondents to a survey by the Society of Glass and Ceramic Decorators (SGCD) reported that they met or exceeded their budget goals; 86% of the respondents predicted modest sales increase in 1998. For comparison, 42% of respondents to the SGCD survey reported sales below budget goals in 1996 (Ceramic Industry, 1998b).

The healthy economy and resulting growth in construction also resulted in a thriving domestic tile market. Sales of tiles increased to 154 million square meters (Mm²) in 1997 from 132 Mm² in 1996 and exports increased to 4.41 Mm² in 1997 from 3.28 Mm² in 1996. Imports, however, increased by 16.8% as a result of slow sales in Asian markets. The increase in imports has resulted in lost sales for several of the major tile producers. Tile imports are expected to continue to increase because the North American Free Trade Agreement will eventually give Mexico duty-free access to the U.S. markets. Additionally, tariff reductions with other countries will take effect as a result of the General Agreement on Trade and Tariffs negotiations (Ceramic Industry, 1998c).

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

Expanded Clay and Shale.—Approximately 4.17 Mt of clays were used in the production of lightweight aggregate (table 21). Nearly all 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 (table 8).

Hydraulic Cement.—Clays provide the alumina and silica required to manufacture hydraulic cements. In 1998, approximately 5.41 Mt of clays were consumed, a 9% decrease compared with that of 1997. In decreasing order, common clay and shale, kaolin, fuller's earth, and fire clay were used in the manufacture of portland cement clinker. More than 97% of the clay consumed by the cement industry was common clay and shale (tables 8 and 20).

Structural Clay Products.—Approximately 13.7 Mt of clays were 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 (tables 8, 20, and 22). Other markets, in decreasing order by tonnage, were flue

linings, flower pots, sewer pipe, structural tile, drain tile, terra cotta, and roofing tile (table 8). Approximately 98% of the clay used in these applications was common clay and shale (table 8).

Housing construction continued to increase in 1998, although the rate of growth was expected to slow in 1999. Construction of commercial buildings, educational buildings, electric utilities, and highways was expected to offer the greatest promise of growth. Overall construction was expected to grow by 2% per year through 2003 (McGraw-Hill Companies, 1999).

In 1998, 8.26 billion building and face bricks valued at \$1.48 billion were shipped within the United States; this was an increase from 7.71 billion bricks in 1997. Shipments of clay floor and wall tile were 58.9 Mm² valued at \$863 million compared with 59 Mm² in 1997. Shipments of vitrified clay and sewer pipe fittings were 108,000 t valued at \$49.5 million, a decrease from 134,000 t in 1997 (U.S. Department of Commerce, 1999a).

Drilling Mud.—Sales (domestic and exports) for drilling mud applications were 772,000 t, an 8% decrease from that of 1997. Swelling-type bentonite accounted for approximately 94% of the clay used in drilling mud (table 6). Ball clay, fuller's earth, and kaolin also were used in drilling mud applications.

Drilling activity declined in 1998 with an estimated 23,900 wells completed compared with 29,139 wells in 1997. Total footage dropped to an estimated 42.7 million meters in 1998 from 47.5 Mm in 1997. Predictions for 1999 are for even fewer wells completed and fewer exploratory wells drilled (Oil & Gas Journal, 1999).

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 5.46 Mt of clays were sold for use as fillers, extenders, and binders in 1998, a decrease of 3% compared with that of 1997. Paper coating and filling accounted for 72% of sales, followed by paint (6%), rubber (4%), animal feed (4%), pesticides (3%), and wallboard production (2%). Adhesive, asphalt emulsion, asphalt tile, fertilizer carrier, gypsum products, ink, medical (pharmaceutical and cosmetic), plastic, textile, and vinyl flooring each accounted for less than 1% of the fillers and extenders markets.

Kaolin accounted for approximately 87% of the clay used in filler and extender applications (table 20), followed by fuller's earth (7%) (table 12), common clay and shale (3%), ball clay (2%) (table 4), bentonite (1%) (table 6), and trace amounts of fire clay. Ball clay was the predominate clay used in asphalt emulsions; bentonite in ink applications; common clay and shale in wallboard production; fuller's earth in fertilizer and pesticide applications; and kaolin in adhesive, cosmetic, medical, paint, paper, pharmaceutical, plastics, rubber, textile, and vinyl flooring markets. Bentonite, fuller's earth, and kaolin were the predominant clays used in asphalt tile, and bentonite and fuller's earth were the predominant clays used in animal feeds.

Fiberglass.—The decrease in sales to the fiberglass industry was slight in 1998. Data were concealed to avoid revealing company proprietary data (table 20).

Iron Ore Pelletizing.—Sales (domestic and exports)

decreased slightly to 588,000 t in 1998 (table 6). Swelling bentonite was the only type of clay used for this application.

Paper Products.—Kaolin accounted for essentially all the clay used for paper coating (3.01 Mt sold domestically and 2.02 Mt exported), and all the clay used for paper filling (850,000 t sold domestically and 110,000 t exported). Sales for coating grades increased by 2%, and sales for filler grade decreased by 9% compared with that of 1997 (table 20).

Refractories.—Approximately 3.09 Mt of clays was used for the manufacture of refractories, a 5% increase compared with that of 1997. The largest domestic markets were grogs and calcines (37%), foundry sand (28%), refractory mortar and cement (15%), firebrick (7%), 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 the refractory mortar and cement categories because of the uncertainty in the data for specific market destinations.

Kaolin accounted for 39% of refractory sales (table 20), followed by bentonite (28%) (table 6), common clay and shale (20%) (table 8), fire clay (10%) (table 10), ball clay (2%), and fuller's earth (less than 1%). Fire clay was the predominate clay used in firebrick; bentonite, in foundry sand; common clay, in refractory mortar and cement; and kaolin, in calcine, grog, high alumina brick, kiln furniture, and plug, tap, and wad.

Production data for refractories manufactured in 1998 were not available from the U.S. Bureau of the Census. For 1997, shipments of clay refractories were valued at \$967 million, a slight increase compared with those of 1996. In 1997, 820,000 t (273 million bricks) valued at \$555 million of clay refractory brick and shapes were shipped by manufacturers. This can be subdivided into fire clay brick and shapes, 393,000 t (131 million bricks) valued at \$180 million; high alumina brick and shapes, 378,000 t (101 million bricks) valued at \$318 million; and insulating brick and shapes, 49,000 t (41.2 million bricks) valued at \$58.3 million. Shipments of unshaped clay refractories were 671,000 t valued at \$355 million. This can be broken out into refractory mortars, 59,000 t valued at \$30.5 million; plastic refractories, 139,000 t valued at \$76.7 million; castable refractories, 312,000 t valued at \$185 million; and fire clay gunning mixes, 161,000 t valued at \$63.1 million. Approximately 187,000 t of miscellaneous refractories valued at \$28.9 million also was sold in 1997 (U.S. Department of Commerce, 1999b).

Prices

Ball Clay.—The average value for ball clay reported by domestic producers was \$45.22 per metric ton. The average values for imported and exported ball clay were \$210.86 and \$70.43 per ton, respectively.

Bentonite.—The average value reported by domestic producers for nonswelling bentonite was \$37.80 per ton. The average value for swelling bentonite was \$46.92 per ton. The average value for all bentonite was \$46.07 per ton. The average value of imported bentonite was \$478.79 per ton. The average value of exported bentonite was \$100.73 per ton.

Common Clay and Shale.—The average value for all common clay and shale produced in the United States and Puerto Rico was \$5.92 per ton. The average value of clay and shale used in lightweight aggregate was \$15.20 per ton.

Fire Clay.—The average value for fire clay reported by domestic producers was \$18.34 per ton. The average of imported fire clay was \$85.58 per ton. The average value of exported fire clay was \$115.48 per ton.

Fuller's Earth.—The average value of attapulgite-fuller's earth was estimated to be \$113 per ton. The average value of montmorillonite-fuller's earth was \$106.75 per ton. The average value of all fuller's earth was estimated to be \$109.06 per ton. The average value of imported fuller's earth was \$131.94 per ton. The average value of exported fuller's earth was \$161.16 per ton.

Kaolin.—The average value of kaolin was \$111.11 per ton for all kaolin grades. The average value for airfloat was \$53.88 per ton; refractory grade (high-temperature calcined), \$16.24; pigment grade (low-temperature calcined), \$326.01; all types of calcined, \$145.18 per ton; delaminated, \$101.43 per ton; water washed, \$119.70 per ton; and unprocessed, \$7.15 per ton. The average value of the imported kaolin was \$238.19 per ton. The average value of exported kaolin was \$161.41 per ton.

Foreign Trade

Ball Clay.—Ball clay exports increased to 140,000 t valued at \$9.86 million, according to the U.S. Bureau of the Census (table 23). Domestic ball clay producers also reported that 142,000 t of ball clay was exported in 1998 (table 4). Shipments to Canada increased to 65,000 t in 1998 from no shipments in 1997. There was no evidence of major changes in the Canadian ceramic industry, however, to account for such a large increase in consumption. Thus, exports to Canada were likely incorrectly reported in previous years and probably should have been in the 40,000- to 65,000-t range for the past few years.

In 1998, imports were 2,670 t of ball clay valued at \$563,000 (table 24).

Bentonite.—Bentonite exports decreased to 818,000 t valued at \$82.4 million (table 23). Domestic bentonite producers reported exports of 427,000 t (table 6). The discrepancy between producers and the U.S. Bureau of Census may result from producers including most of the exports destined for Canadian and Mexican markets (approximately 250,000 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 6,600 t valued at \$3.16 million. Imports of chemically activated material were 18,900 t valued at \$9.63 million (table 24).

Fire Clay.—Approximately 168,000 t of fire clay valued at \$19.4 million was exported (table 23). In 1998, 2,150 t of fire clay valued at \$184,000 was imported (table 24).

Fuller's Earth.—Approximately 121,000 t of fuller's earth

valued at \$19.5 million was exported (table 23). Domestic producers reported 67,800 t of exports in 1998 (table 12). The discrepancy between producer and U.S. Bureau of the Census data is partially explained by the fact that producers may include some of the exports destined for Canada (approximately 44,000 t) 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 Bentonite concerning discrepancies between export data reported by producers and those reported by the U.S. Bureau of the Census.

Approximately 288 t of decolorizing and fuller's earth valued at \$38,000 was imported in 1998 (table 24).

Kaolin.—The U.S. Bureau of the Census reported that 3.55 Mt of kaolin valued at \$573 million was exported in 1998 (table 23). Producers reported exports of 2.40 million t (table 20). Most of the kaolin destined for Canadian paper markets (763,000 t) and for various Mexican markets (188,000 t) probably was reported under domestic consumption. Also, discrepancies between producer and Bureau of the Census data are similar to the situation with bentonite.

Kaolin imports increased to 52,900 t valued at \$12.6 million (table 24). Approximately 70% of the imports were from Brazil, which until 3 years ago was a minor source.

World Review

World production of bentonite was approximately 9.33 Mt (table 25), fuller's earth production was estimated to be 3.32 Mt (table 26), and kaolin production was about 39.8 Mt (table 27). The United States continued to be the leading producer of all three varieties of clays, followed by Greece and countries of the former Soviet Union for bentonite, Germany for fuller's earth, and Uzbekistan for kaolin. Spain led all countries in the production of sepiolite.

Argentina.—Azco Mining Inc. agreed to purchase a 50% stake in Oro Argentina Ltd., which had interests in a white bentonite deposit in San Juan Province. The bentonite deposit was believed to be one of the largest undeveloped deposits in the world. Potential uses for the bentonite will be in beer and wine clarification, detergents, oil bleaching, paint, paper, and pharmaceuticals. The \$1.5 million purchase agreement allows Azco to buy the remaining 50% share within 2 years if the project proves viable. Work on the infrastructure was underway at yearend (Azco Mining Inc., 1998).

Australia.—Rio Tinto LTD completed a feasibility study for mining kaolin near Wickopin but did not release details of the report. The company would like to develop a 750,000 t/yr operation at the site (Industrial Minerals, 1998).

Despite several attempts to begin mining, Australian Kaolin NL was placed in receivership as a result of debt accumulation. The company was working to resolve its financial and management issues. Australian Kaolin has a kaolin deposit in Queensland along the Skardon River north of Weipa. The company initially expected to produce 75,000 t/yr and 100,000 t/yr of calcined kaolin and hydrous kaolin, respectively, beginning in 1998 (Industrial Minerals, 1999). In 1998, Sons

of Gwalia Ltd, which had a kaolin mine in Western Australia, purchased a 15% share of Australian Kaolin (Industrial Minerals, 1998d).

Brazil.—Mineral Resources Exploration Company, the State geological survey, continued to accept bids for its kaolin deposit on the Capim River in Ipixuna do Para. The deposit contains approximately 560 Mt of high-whiteness kaolin reserves (Mining Journal, 1998).

China.—Inner Mongolia Sanbao Zunger Kaolin Co. Ltd. announced plans for mining kaolin from its Jungar deposit south of Hohhot, Inner Mongolia. The deposit contained more than 1 billion metric tons of reserves, and Sanbao Zunger Kaolin controlled approximately 8 Mt of the reserves. The ore is 98% kaolin and is suitable for paper applications. The company has begun construction at the site. The plant will initially produce 20,000 t/yr of calcined kaolin and eventually produce 50,000 t/yr. Production will be sold within China and exported (Industrial Minerals, 1998g).

Egypt.—Volclay International Corp., a subsidiary of AMCOL International Corp., acquired a minority share of Egypt Mining and Drilling Chemicals Co. and Egypt Bentonite Derivatives Co. This acquisition will give Volclay better access to Middle Eastern bentonite markets (AMCOL International Corp., 1998).

Georgia.—Silver & Baryte Ores Mining Co. SA (S&B) acquired a 97.7% share of Askana Ltd. in the Republic of Georgia. Askana had a deposit near Tbilisi that contains more than 5 Mt of sodium bentonite. In 1998, the company produced about 20,000 t/yr, but S&B planned to increase production to 60,000 t/yr. The bentonite will supplement S&B's calcium bentonite production from Greece (Industrial Minerals, 1998m).

Germany.—Fuchs'sche Tongruben GmbH and Co. KG, a subsidiary of Watts Blake Bearne and Co. PLC, acquired plastic clay and feldspar quarries, mineral reserves, and a plant in the Westerwald region from Villeroy & Boch AG. The reserves contain about 13 Mt of plastic clay that is particularly suited for producing ceramic tile. The acquisition of the plant will facilitate production from its Berggarten reserves (Watts Blake Bearne Group, 1998).

India.—The Rajasthan State Mineral Development Corp. privatized its bentonite mines in the Barmer district. The deposit contains 267 Mt of bentonite. The major market for the bentonite was in foundry sand bond (Industrial Minerals, 1998h).

Italy.—S&B acquired a 35% share of Laviosa Chimica Minerali SpA. Under the agreement, S&B will finance a capital increase in Laviosa. The companies have yet to disclose how the partnership will operate. S&B had extensive bentonite reserves in Greece and more mining experience. Laviosa had focused more on development, marketing, and international trade (Industrial Minerals, 1998j).

Korea, Republic of.—Volclay International, a subsidiary of AMCOL International, purchased the assets of Tae Kwang Bentonite Co. Tae Kwang Bentonite, located near Kyungju, produced bentonite for the domestic foundry industry. Volclay hoped to expand the markets served by Tae Kwang Bentonite (Industrial Minerals, 1998b).

Morocco.—The Bureau de Recherches de Participations Mineres opened bidding for three bentonite deposits in Morocco. The deposits are located southwest of Nador and contain 1.8 Mt of ore. Testing demonstrated the bentonite's suitability for drilling muds, foundry sand bond, granular absorbents, and fillers (Industrial Minerals, 1998e).

Saudi Arabia.—Tam Industries Co. Ltd. formed a joint venture with Ahmad Saeed and Co., a Pakistani firm. Ahmad Saeed, which was a producer of ball clay, bentonite, and ceramic clays, will provide the technical expertise to develop a large bentonite deposit in Saudi Arabia. The deposit contains approximately 10 Mt of calcium bentonite. The ore will be treated with soda ash to produce sodium bentonite for animal feed, cat litter, drilling muds, and foundry sand bond. Products will be sold domestically and exported (Industrial Minerals, 1998a).

Thailand.—Volclay Siam Ltd. Co., a subsidiary of Volclay, completed construction of its bentonite-processing plant in Amphur Pluak-Daeng. The plant had a capacity of 50,000 t/yr using two 50-inch roller mills. The plant will process bentonite imported from China, India, and the United States and sell to domestic and regional foundry and construction industries (Industrial Minerals, 1998o).

Turkey.—Sayberg Mining Ltd., a 50-50 joint venture between F.J.H. Ambergen of the Netherlands and V. Saygili of Turkey, was formed to mine sodium and calcium bentonite in Turkey. The calcium bentonite deposits are located near Ordu and contained an estimated 15 Mt of ore. As much as 5 Mt may be high-grade white bentonite. The sodium bentonite deposits are located near Tokat, where reserves were estimated to be 2.5 Mt. Mining was scheduled to begin in 1999. The company will ship crude bentonite to European markets. Sayberg Mining will investigate construction of a processing plant during the second year of production after markets are more firmly established. The bentonite reportedly is suitable for civil engineering, foundry, and oil well drilling applications; the white bentonite is suitable for specialty applications (Industrial Minerals, 1998i).

Uzbekistan.—A joint venture between Kulkoni Handel GmbH from Germany and Ugol, a Uzbekistan coal monopoly, was formed to mine kaolin in eastern Uzbekistan. The kaolin deposit is associated with coal deposits owned by Ugol. Reserves were estimated to be 78.5 Mt. Construction started on a 100,000-t/yr plant with expansion to 200,000 t/yr planned. The kaolin was reported to be suitable for ceramics and paper. Sales will focus on neighboring countries and the Middle East owing to transportation costs (Industrial Minerals, 1998k).

Research

Low-shear viscosity is an important property in determining if a kaolin is suitable for paper applications. Much of the unsuitable kaolin clay contains small amounts of montmorillonite, either as crystals or coatings on the edges of the kaolin crystals. Montmorillonite in the samples absorbs water required for particle suspension, which reduces the low-shear viscosity of the suspension. Kaolin worked mechanically using a pug mill prior to dispersion with hexametaphosphate

and treatment with soda ash reduced low-shear viscosity significantly. The mechanical action of pug milling liberated the smectite from the kaolin and dispersed it within the sample. This, in effect, aided in the suspension of the coarser kaolin particles. Removal of particles of less than 0.2 micrometer in diameter (desliming) by centrifugation also reduced low-shear viscosity because the montmorillonite accounted for a large percentage of the ultrafine particles. Through pug milling and desliming, the low-shear viscosity of kaolin slurries could be improved, thus making them suitable for paper-coating and ceramic applications (Lowe and others, 1998).

In a study at the University of Ankara in Turkey, the ability of a bentonite and clinoptilolite mixture to remove heavy metals from landfill effluent was tested. Usually, bentonite is used to seal landfills and to prevent contamination of ground water from landfill effluent. The objective of this study was to determine if bentonite-amended zeolite beds also could effectively remove heavy metals from landfill effluent and reduce leachate-based hazards. Clinoptilolite was ground to sand and blended with bentonite. The bentonite-to-zeolite ratio of 0.04 was used for ion-exchange testing. The zeolite and bentonite mixture was found to have removed more than 90% of the chromium, copper, lead, and zinc and more than 80% of the arsenic and nickel from the landfill effluent through ion exchange (Kayabali and Kezer, 1998).

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 during the past 6 or 7 years with an accompanying growth in housing, industrial manufacturing, and other industries that consume clays. The strength of the economy should ensure that clay markets remain strong for several years to come.

References Cited

- AMCOL International Corp., 1998, AMCOL International Corp. subsidiary acquires minority interest in Egyptian minerals operations: Arlington Heights, IL, AMCOL International Corp. press release, June 22, 1 p.
- American Ceramic Society Bulletin, 1998, Effect of MACT on the ceramic industries: American Ceramic Society Bulletin, v. 77, no. 10, October, p. 47-50.
- Azco Mining, Inc., 1998, Azco Mining, Inc. enters into industrial mineral venture: Fernwood, WA, Azco Mining, Inc. press release, November 18, 1 p.
- Ceramic Industry, 1998a, Business briefs from around the world: Ceramic Industry, v. 148, no. 6, June, p. 38.
- 1998b, China and pottery on the upswing: Ceramic Industry, v. 148, no. 9, p. 46-50.
- 1998c, Tile market at an high: Ceramic Industry, v. 148, no. 9, p. 70-72.
- English China Clay plc, 1999, IMETAL completes acquisition of ECC: Roswell, GA, English China Clay plc press release, April 28, 1999, 1 p.
- IMETAL SA, 1999, Success of the English China Clays take-over: Paris, IMETAL SA press release, April 27, 1999, 1 p.
- Industrial Minerals, 1998a, Ahmad Saeed/Tam Industries bentonite j-v: Industrial Minerals, no. 365, February, p. 17.
- 1998b, AMCOL acquires Korean minerals interest: Industrial Minerals, no. 372, September, p. 23.
- 1998c, AMCOL selling fuller's earth unit to Oil-Dri: Industrial Minerals, no. 367, April, p. 33.
- 1998d, ...and buys stake in Australian Kaolin: Industrial Minerals, no. 374, November, p. 9.
- 1998e, BRPM industrial mineral prospects up for investment: Industrial Minerals, no. 367, September, p. 30.
- 1998f, Halliburton/Dresser in \$7,000 m. stock merger: Industrial Minerals, no. 368, May, p. 19.
- 1998g, High grade kaolin plant to start-up: Industrial Minerals, no. 373, October, p. 11.
- 1998h, Indian bentonite privatised: Industrial Minerals, no. 372, September, p. 101.
- 1998i, J-v to develop bentonite, olivine & MnO₂ reserves: Industrial Minerals, no. 374, November, p. 15.
- 1998j, Laviosa/Silver & Baryte join forces in bentonite: Industrial Minerals, no. 367, April, p. 27.
- 1998k, New kaolin project: Industrial Minerals, no. 374, November, p. 19.
- 1998l, Rio Tinto assess kaolin deposit: Industrial Minerals, no. 366, March, p. 82.
- 1998m, S&B gains 97.7% stake in Askana bentonite: Industrial Minerals, no. 368, May, p. 11.
- 1998n, Utah Clay kaolin on stream in early '99: Industrial Minerals, no. 373, October, p. 17.
- 1998o, Volclay Siam's 50,000 tpa bentonite plant launch: Industrial Minerals, no. 369, June, p. 17.
- 1999, Administrators called in to Australian Kaolin: Industrial Minerals, no. 382, July, p. 9.
- Industrial Specialties News, 1998, Clorox signs agreement to buy First Brands: Industrial Specialties News, v. 12, no. 20, October 26, p. 1-2.
- Kayabali, Kamil, and Kezer, Hasan, 1998, Testing the ability of bentonite-amended natural zeolite (clinoptilolite) to remove heavy metals from liquid waste: Environmental Geology, v. 34, no. 2-3, May, p. 95-102.
- Lowe, R.A., and others, 1998, The reduction of kaolin slurry viscosity using pugging and desliming: Littleton, CO, Society of Mining, Metallurgy, and Exploration, Inc., Preprint 98-85, 4 p.
- McGraw-Hill Companies and U.S. Department of Commerce, 1999, Construction, chap. 6 of U.S. Industry & Trade Outlook '99: New York, McGraw-Hill, p. 6-1-6-17.
- Mining Journal, 1998, Brazil relaunches kaolin tender: Mining Journal, v. 330, no. 8467, February 13, p. 126.
- Nanocor, Inc., 1998, AMCOL International's Nanocor subsidiary to celebrate grand opening of production facility: Arlington Heights, IL, Nanocor, Inc. press release, April 24, 1 p.
- North American Minerals News, 1998a, Engelhard to spend \$12 million on more kaolin capacity: North American Minerals News, no. 33, February, p. 5.
- 1998b, Harbison-Walker Refractories Co.: North American Minerals News, no. 40, September, p. 9-12.
- 1998c, Huber & Mintech establishing paper coating test center joint venture in Quebec: North American Minerals News, no. 39, August, p. 5.
- 1998d, Tenth bentonite blending plant for American Colloid Co.: North American Minerals News, no. 32, January, p. 5.
- 1998e, Thiele Kaolin opens slurry facility: North American Minerals News, no. 43, December, p. 2.
- Oil & Gas Journal, 1999, Extended decline likely in U.S., Canada drilling: Oil & Gas Journal, v. 97, no. 4, January 25, p. 73-74.
- U.S. Department of Commerce, 1999a, Clay construction products—First quarter 1999: U.S. Department of Commerce, MQ32D(99-1), June 17, 6 p.
- 1999b, Refractories—1997: U.S. Department of Commerce, MA32C(97), October 5, 12 p.
- Watts Blake Bearne and Co. Plc, 1998, WBB Group acquires clay and feldspar quarries in Germany: Newton Abbot, United Kingdom, Watts Blake Bearne and Co. Plc press release, January 7, 5 p.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Clays. Ch. in Mineral Commodity Summaries, annual.¹
- Clays. Ch. in United States mineral resources, U.S. Geological Survey Professional Paper 820, 1973.

Other

- American Forest and Paper Association.

¹Prior to January 1996, published by the U.S. Bureau of Mines.

China Clay Producers Association.
Clays. Ch. in Mineral facts and problems, U.S. Bureau of
Mines Bulletin 675, 1985.
Cosmetic, Toiletry, and Fragrance Association.
Engineering and Mining Journal.
Industrial Minerals and Rocks, 6th ed., AIME, 1994.

Mining Engineering.
Mining Magazine.
National Paint and Coatings Association.
Society of the Plastics Industry.
World Mining.

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

(Thousand metric tons and thousand dollars)

	1994	1995	1996	1997	1998
<u>Domestic clays sold or used by producers:</u>					
Quantity	42,000	43,000 r/	43,100	41,800 r/	41,600
Value	\$1,590,000	\$1,730,000	\$1,710,000	\$1,670,000	\$1,660,000
<u>Exports:</u>					
Quantity	4,620	4,680	4,830	5,080	5,230
Value	\$739,000	\$812,000	\$825,000	\$860,000	\$843,000
<u>Imports for consumption:</u>					
Quantity	36	35	45	64	86
Value	\$14,900	\$16,000	\$21,000	\$23,200	\$27,700

r/ Revised.

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 1998, 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	2,400	W	--	W	2,400	23,100
Arizona	--	W	W	--	--	--	W	W
Arkansas	--	--	995	--	--	W	995	1,370
California	--	29	918	W	W	82	947	12,300
Colorado	--	--	257	--	--	--	257	1,840
Connecticut	--	--	55	--	--	--	55	W
Florida	--	--	W	--	W	W	W	W
Georgia	W	--	1,650	--	686	8,350	10,700	1,080,000
Illinois	--	--	123	--	W	--	123	560
Indiana	--	--	681	--	--	--	681	1,330
Iowa	--	--	301	--	--	--	301	1,040
Kansas	--	--	585	--	W	--	585	2,510
Kentucky	W	--	872	W	--	--	872	3,930
Louisiana	--	--	620	--	--	--	620	11,100
Maine	--	--	W	--	--	--	W	W
Maryland	--	--	339	--	--	--	339	1,380
Massachusetts	--	--	W	--	--	--	W	W
Michigan	--	--	644	--	--	--	644	4,520
Minnesota	--	--	W	--	--	--	W	W
Mississippi	W	W	502	--	372	--	874	33,800
Missouri	--	--	1,030	288	W	--	1,310	8,660
Montana	--	W	W	--	--	--	W	W
Nebraska	--	--	134	--	--	--	134	345
Nevada	--	W	--	--	W	W	W	W
New Jersey	--	--	W	--	--	--	W	W
New Mexico	--	--	33	1	--	--	35	190
New York	--	--	622	--	--	--	622	7,560
North Carolina	--	--	2,380	--	--	W	2,380	11,600
North Dakota	--	--	42	--	--	--	42	W
Ohio	--	--	1,530	62	--	--	1,590	10,100
Oklahoma	--	--	658	--	--	--	658	4,450
Oregon	--	W	177	--	--	--	177	W
Pennsylvania	--	--	886	--	--	W	886	2,270
South Carolina	--	--	1,220	36	--	395	1,650	26,000
South Dakota	--	--	188	--	--	--	188	W
Tennessee	712	--	W	--	W	W	712	30,100
Texas	W	W	2,120	--	W	W	2,120	10,100
Utah	--	W	298	--	--	--	298	4,760
Virginia	--	--	872	--	W	--	872	2,850
Washington	--	--	178	--	--	--	178	W
West Virginia	--	--	231	--	--	--	231	515
Wyoming	--	3,150	W	--	--	--	3,150	145,000
Total	1,130	3,820	24,500	410	2,350	9,450	41,600	1,660,000

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
1997:								
Tennessee	283 r/	15,100 r/	157	6,960	249	7,120	689 r/	29,200 r/
Other 2/	177 r/	13,000	--	--	195 r/	7,640 r/	372 r/	20,700
Total	461 r/	28,100 r/	157	6,960	444 r/	14,800	1,060 r/	49,800 r/
1998:								
Tennessee	299	15,900	162	7,140	250	7,060	712	30,100
Other 2/	173	12,800	--	--	244	8,150	417	21,000
Total	473	28,700	162	7,140	494	15,200	1,130	51,100

r/ Revised.

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

2/ Includes Indiana (1998), Kentucky, Mississippi, and Texas.

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

(Metric tons)

Use	1997	1998
Fillers, extenders, binders 2/	78,600	82,900
Floor and wall tile	315,000	325,000
Miscellaneous ceramics 3/	72,400 r/	76,000
Pottery	102,000	108,000
Refractories 4/	64,600 r/	50,600
Sanitaryware	219,000	239,000
Miscellaneous 5/	64,600 r/	107,000
Exports 6/	146,000	142,000
Total	1,060,000 r/	1,130,000

r/ Revised.

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

2/ Includes animal feed, asphalt emulsions, pesticides, rubber (1997), and other fillers, extenders and binders.

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

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

5/ Includes absorbents (1998), 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 (1997), 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
1997:						
California	W	W	W	W	29	3,420
Mississippi	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
1998:						
California	W	W	W	W	29	2,700
Mississippi	W	W	--	--	W	W
Nevada	W	W	W	W	W	W
Oregon	--	--	W	W	W	W
Wyoming	--	--	3,150	145,000	3,150	145,000
Other 2/	410	15,500	260	15,100	641	27,900
Total	410	15,500	3,410	160,000	3,820	176,000

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, Colorado (1998), Montana, Texas, and Utah.

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

(Metric tons)

Use	1997	1998
Domestic:		
Absorbents:		
Pet waste absorbents	604,309	773,284
Other absorbents	W	W
Adhesives	15,139	12,856
Animal feed	109,977	77,442
Ceramics (except refractories) 2/	W	W
Drilling mud	788,684	664,912
Filler and extender applications 3/	41,250	48,695
Filtering, clarifying, decolorizing, mineral oils and greases, vegetable oils, dessicants	82,444	103,540
Foundry sand	901,173	868,548
Pelletizing (iron ore) 4/	535,929	529,226
Miscellaneous refractories 5/	7,801	2,525
Miscellaneous 6/	126,125	79,820
Waterproofing and sealing	266,726	235,968
Total	3,479,557	3,396,816
Exports:		
Drilling mud	149,686	64,751
Foundry sand	292,619	239,060
Other 7/	101,200	123,268
Total	543,505	427,079
Grand total	4,023,062	3,823,895

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 (1997) and pottery.

3/ Includes medical, pharmaceutical, cosmetics, paint, pesticides and related products, plastics, asphalt emulsions (1997) and tiles, ink, and miscellaneous fillers and extenders applications.

4/ Excludes shipments to Canada. Total sales were 598,000 tons in 1997 and 588,000 tons in 1998.

5/ Includes kiln furniture (1998), 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, filtering and clarifying oils, 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	1997		1998	
	Quantity	Value	Quantity	Value
Alabama	2,590	25,400	2,400	23,100
Arkansas	979	1,400	995	1,370
California	937	10,300	918	9,610
Georgia	1,820	11,600	1,650	5,470
Indiana	947	2,040	681	1,330
Kansas	545	2,500	585	2,510
Kentucky	865	3,910	872	3,930
Michigan	712	3,750	644	4,520
Mississippi	502	3,460 r/	502	3,410
Missouri	1,050	4,140	1,030	4,440
New York	477	12,100	622	7,560
North Carolina	2,460	11,900	2,380	11,600
Ohio	1,450 r/	7,050 r/	1,530	7,290
Oklahoma	653	4,430	658	4,450
Pennsylvania	839	2,740	886	2,270
South Carolina	1,070	2,850	1,220	3,950
Texas	2,150	13,600	2,120	10,100
Virginia	830	3,160	872	2,850
Other 3/	3,740 r/	24,300 r/	3,940	27,700
Total	24,600 r/	150,000 r/	24,500	137,000

r/ Revised.

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, 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	1997	1998
Ceramics and glass 3/	179,000 r/	182,000
Civil engineering and sealing	W	W
Floor and wall tile:		
Ceramic	318,000	349,000
Other 4/	57,700	W
Heavy clay products:		
Brick, extruded	11,100,000 r/	11,100,000
Brick, other	1,940,000	2,130,000
Drain tile and sewer pipe	56,800	25,400
Flowerpots	W	35,300
Flue linings	59,900	55,600
Structural tile	W	16,300
Other 5/	122,000	85,900
Lightweight aggregate:		
Concrete block	2,550,000	2,540,000
Highway surfacing	278,000	311,000
Structural concrete	740,000	871,000
Miscellaneous 6/	429,000	441,000
Portland and other cements	5,890,000 r/	5,140,000
Refractories 7/	452,000 r/	632,000
Miscellaneous 8/	404,000 r/	520,000
Total	24,600,000 r/	24,500,000

r/ Revised. 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 (1997), terra cotta (1997), and miscellaneous clay products.

6/ Includes miscellaneous lightweight aggregates.

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

8/ Includes civil engineering and sealing, exports, miscellaneous fillers and extenders, wall board, 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	1997		1998	
	Quantity	Value	Quantity	Value
Missouri	298 r/	4,280 r/	288	4,220
Ohio	61 r/	2,860 r/	62	2,810
Other 3/	57	874	59	487
Total	415 r/	8,010 r/	410	7,520

r/ Revised.

1/ Refractory uses only.

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

3/ Includes Alabama, California, Kentucky, New Mexico, and South Carolina (1998).

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

(Metric tons)

Use	1997
Ceramics and glass 2/	W
Heavy clay products and lightweight aggregates 3/	W
Refractories:	
Firebrick, block and shapes	176,000
Other refractories 4/	175,000 r/
Miscellaneous	65,000 r/
Total	415,000 r/

r/ Revised. 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 common brick, portland cement, terra cotta, and other unknown uses.

4/ Includes foundry sand, grogs and calcines, high alumina brick and specialties, mortar and cement, plug, tap and wad, 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	Attapulgite		Montmorillonite		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1997:						
Florida	(2/)	(2/)	W	W	W	W
Georgia	576	70,500	(3/)	(3/)	576	70,500
Southern States 4/	--	--	840	101,000	840	101,000
Western States 5/	(6/)	(6/)	955	83,300	955	83,300
Total	576	70,500	1,800	184,000	2,370	255,000
1998:						
Florida	(2/)	(2/)	W	W	W	W
Georgia	686	74,800	(3/)	(3/)	686	74,800
Southern States 4/	--	--	845	71,800	845	71,800
Western States 5/	(6/)	(6/)	820	83,400	820	83,400
Total	686	74,800	1,670	155,000	2,350	230,000

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

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

2/ Included with "Montmorillonite: Southern States."

3/ Included with "Attapulgite: Georgia."

4/ Includes Mississippi, Tennessee, Virginia, and items indicated by symbol W.

5/ Includes California, Illinois, Kansas, Missouri, Nevada, Texas, and Utah (1997).

6/ Included with "Montmorillonite: Western States."

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

(Metric tons)

Use	1997	1998
Absorbents:		
Oil and grease absorbent	274,000	279,000
Pet waste absorbent	1,470,000	1,410,000
Miscellaneous absorbent	W	W
Animal feed	113,000	108,000
Drilling mud	W	W
Fertilizers	42,500	53,200
Fillers, extenders, binders 2/	73,000	77,600
Filtering, clarifying, decolorizing, animal, mineral, vegetable oils, and greases	5,930	W
Pesticides and related products	176,000	136,000
Miscellaneous 3/	173,000	222,000
Exports 4/	44,000	67,800
Total	2,370,000	2,350,000

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 emulsions and tiles, gypsum products, medical, pharmaceutical and cosmetics (1998), paint, paper coating (1997), textiles, and other unknown uses.

3/ Includes crock and earthenware (1998), portland cement, refractories, waterproofing and sealing (1997), and other unknown uses.

4/ Includes absorbents, fillers, extenders and binders, floor and wall tiles, refractories (1997), 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	1997		1998	
	Quantity	Value	Quantity	Value
Arkansas	W	W	W	W
Florida	W	W	W	W
Georgia	8,200 r/	977,000 r/	8,350	998,000
South Carolina	447	29,000	395	22,000
Other 2/	637 r/	27,900 r/	701	29,100
Total	9,280 r/	1,030,000 r/	9,450	1,050,000

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

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

2/ Includes Alabama, California, 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	1997		1998	
	Quantity	Value	Quantity	Value
Airfloat	1,290 r/	70,100 r/	980	52,800
Calcined 2/	1,690	269,000	1,970	286,000
Delaminated	1,440	146,000	1,400	142,000
Unprocessed	196 r/	2,130 r/	380	2,720
Water washed	4,670	546,000	4,720	565,000
Total	9,280 r/	1,030,000 r/	9,450	1,050,000

r/ Revised.

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

2/ Includes pigment 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	Refractory-grade		Pigment-grade	
	Quantity	Value	Quantity	Value
1997:				
Alabama and Georgia	W	W	742	244,000
Other 2/	W	W	41	8,550
Total	909	16,100	784	253,000
1998:				
Alabama and Georgia	W	W	790	261,000
Other 2/	W	W	29	6,790
Total	1,150	18,700	819	267,000

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

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

2/ Includes Arkansas, California, Colorado, South Carolina (1997), and Texas.

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

(Thousand metric tons and thousand dollars)

Kind	1997		1998	
	Quantity	Value	Quantity	Value
Airfloat	849	37,800	614	26,700
Calcined 2/	1,200	244,000 3/	1,430	261,000 3/
Delaminated	1,440	146,000	1,400	142,000
Unprocessed	90 r/	W	232	W
Water-washed	4,630	545,000	4,680	564,000
Total	8,200 r/	977,000 r/	8,350	998,000

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

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

2/ Includes pigment and refractory grade calcined kaolin.

3/ Excludes value for refractory-grade; included in "Total."

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

(Metric tons)

Use	1997	1998
Domestic:		
Ceramics and glass:		
Catalysts (oil-refining)	W	W
Electrical porcelain	W	W
Fiber glass	429,000	W
Roofing granules	W	W
Sanitaryware	W	W
Other 3/	319,000	621,000
Fillers, extenders, binders:		
Adhesives	71,100	45,100
Paint	296,000	268,000
Paper coating	2,980,000	3,080,000
Paper filling	905,000	840,000
Plastic	33,600	32,900
Rubber	84,500	59,400
Other 4/	98,400	99,000
Heavy clay products 5/	46,600	W
Refractories 6/	565,000	726,000
Undistributed 7/	37,200 r/	226,000
Total	5,870,000 r/	6,000,000
Exports:		
Paint	72,800	70,700
Paper coating 8/	2,010,000	2,020,000
Paper filling 8/	105,000	110,000
Rubber	7,020	4,730
Undistributed 9/	138,000	148,000
Total	2,330,000	2,350,000
Grand total	8,200,000 r/	8,350,000

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

1/ Includes high-temperature and 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 (1997), pottery, and miscellaneous ceramics.

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

5/ Includes brick (common and face), portland cement (1997), and miscellaneous clay products.

6/ Includes grogs and calcines, high-alumina specialties, and miscellaneous refractories.

7/ Includes chemical manufacturing (1998), civil engineering and sealings (1997), floor and wall tiles, and other unknown uses.

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

9/ Includes catalyst (oil-refining), 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	1997		1998	
	Quantity	Value	Quantity	Value
Airfloat	390	27,500	319	21,500
Unprocessed	57 2/	1,540 2/	76	491
Total	447	29,000	395	22,000

1/ Data are rounded to three significant digits.

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	1997	1997
Adhesives	14,800	12,300
Animal feed	W	W
Ceramics 2/	24,400	W
Fertilizers, pesticides, related products	W	W
Fiber glass	W	W
Paper coating and filling	W	W
Plastics	5,290	W
Rubber	133,000	146,000
Refractories 3/	10,300	W
Other uses 4/	201,000	199,000
Exports 5/	57,500	37,000
Total	447,000	395,000

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 fine china/dinnerware, glazes, glass, and enamels, pottery, roofing granules, sanitaryware and miscellaneous ceramics.

3/ Includes firebrick, blocks and shapes, and miscellaneous refractories (1997).

4/ Includes asphalt tile, catalysts (oil-refining), civil engineering and sealings, gypsum products (1997 miscellaneous fillers, extenders, and binders, and other unknown uses.

5/ Includes fillers, extenders, and binders.

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

(Metric tons)

Use	1997	1998
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	227,000	W
Electrical porcelain	13,300 r/	W
Fine china and dinnerware	18,200 r/	W
Floor and wall tile	33,400	34,100
Pottery	27,100	27,000
Roofing granules	22,900	2,490
Sanitaryware	53,700	59,400
Miscellaneous	66,700	236,000
Chemical manufacture	W	W
Civil engineering	6,930	W
Fiber glass, mineral wool	471,000 r/	W
Fillers, extenders, binders:		
Adhesive	85,900	57,500
Fertilizer	5,200	3,640
Medical, pharmaceutical, cosmetic	W	23,100
Paint	329,000	268,000
Paper coating	2,990,000	3,090,000
Paper filling	918,000	850,000
Pesticide	19,000	16,800
Plastic	38,900	36,600
Rubber	218,000	206,000
Miscellaneous	114,000	174,000
Heavy clay products:		
Brick, common and face	105,000	134,000
Portland cement	71,000	W
Refractories:		
Firebrick, block and shapes	10,500 r/	3,860
Groggs and calcines	867,000	1,120,000
High-alumina brick, specialties, kiln furniture	45,700	W
Foundry sand, mortar, cement, miscellaneous refractories	73,300	82,600
Miscellaneous applications	63,500 r/	630,000
Total	6,890,000 r/	7,050,000
Exports:		
Ceramics	129,000	141,000
Foundry sand, grogs and calcines; other refractories	W	W
Paint	72,800	78,100
Paper coating	2,010,000	2,020,000
Paper filling	105,000	110,000
Rubber	64,600	41,800
Miscellaneous	10,500	9,020
Total	2,390,000	2,400,000
Grand total	9,280,000 r/	9,450,000

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/
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
Ohio and Oklahoma	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
1998:						
Alabama and Arkansas	851	106	22	--	978	14,600
California e/	141	104	--	76	321	7,540
Florida and Indiana	202	44	--	--	246	1,500
Kansas, Kentucky, Louisiana	300	138	56	145	638	9,540
Missouri	--	--	--	133	133	1,770
New York	82	54	--	--	136	5,600
North Carolina e/	300	52	--	--	354	4,050
Ohio and Oklahoma	228	3	12	--	242	1,470
Texas e/	49	157	222	31	459	2,520
Utah and Virginia	191	48	--	54	293	5,120
Total	2,340	706	311	441	3,800	53,600

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	1997		1998	
	Quantity	Value	Quantity	Value
Alabama	917	2,030	930	1,970
Arkansas	449	464	446	357
California	254	1,160	190	629
Colorado	240	1,790 r/	222	1,700
Connecticut, New Jersey, 3/ New York 3/	244 r/	971	252	993
Georgia	1,410	9,410	1,340	3,690
Illinois	92	W	121	674
Indiana and Iowa	366 r/	1,120 r/	391	1,180
Kentucky 3/ and Tennessee 3/	816	2,760 r/	831	943
Maryland and West Virginia 4/	271	884	336	1,300
Mississippi and Missouri	507	2,230	509	2,560
North Carolina	1,980	6,630 r/	1,950	6,750
Ohio	813 r/	3,880 r/	843	4,030
Oklahoma	405	2,760 r/	410	2,790
Pennsylvania	646	2,010	790	1,730
South Carolina	922	2,180	962	3,070
Texas	1,020	5,600 r/	1,010	5,370
Virginia	689	2,180	731	1,870
Other 5/	1,040	4,490 r/	1,010	4,770
Total	13,100 r/	52,600 r/	13,300	46,300

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, Utah, Washington, and Wyoming.

TABLE 23
U.S. EXPORTS OF CLAYS IN 1998, 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	--	--	(2/)	395	(2/)	48	1	186
Australia	--	--	13	1,510	11	1,990	--	--
Belgium	--	--	13	865	(2/)	7	(2/)	202
Brazil	(2/)	16	11	2,330	--	--	(2/)	52
Canada	65	5,550	206	17,800	7	1,280	44	6,710
Finland	1	12	3	390	--	--	--	--
France	1	33	30	1,250	(2/)	21	1	77
Germany	--	--	15	1,600	3	281	(2/)	85
Indonesia	--	--	3	767	(2/)	23	(2/)	25
Italy	--	--	5	403	--	--	4	1,130
Japan	15	447	164	13,800	4	1,210	(2/)	152
Korea, Republic of	(2/)	5	10	2,090	3	618	(2/)	32
Malaysia	(2/)	4	16	1,330	--	--	4	344
Mexico	17	770	42	2,970	60	4,430	1	219
Netherlands	(2/)	31	51	4,330	64	8,010	28	2,890
Singapore	(2/)	8	36	3,930	--	--	1	141
South Africa	1	33	1	400	(2/)	60	(2/)	34
Taiwan	17	595	23	3,710	7	585	(2/)	29
Thailand	--	--	10	1,010	(2/)	48	1	118
United Kingdom	--	--	93	7,300	(2/)	28	10	1,770
Venezuela	8	829	16	2,530	1	173	2	454
Other	15	1,520	57	11,600	8	626	24	4,840
Total	140	9,860	818	82,400	168	19,400	121	19,500
Country	Kaolin		Clays, n.e.c. 3/		Total			
	Quantity	Value	Quantity	Value	Quantity	Value		
Argentina	11	2,020	7	2,410	19	5,050		
Australia	16	10,200	3	3,210	44	16,900		
Belgium	63	14,200	6	2,020	83	17,300		
Brazil	3	1,300	3	2,290	18	5,980		
Canada	763	82,100	208	32,600	1,290	146,000		
Finland	350	54,000	3	827	357	55,300		
France	6	1,350	4	2,190	42	4,920		
Germany	18	6,340	11	3,560	48	11,900		
Indonesia	68	15,400	5	1,500	77	17,700		
Italy	178	25,200	5	1,630	191	28,400		
Japan	1,040	170,000	14	11,500	1,240	198,000		
Korea, Republic of	116	19,400	4	3,900	134	26,000		
Malaysia	2	553	1	634	22	2,870		
Mexico	188	20,300	21	3,400	330	32,100		
Netherlands	221	35,900	13	12,600	378	63,800		
Singapore	1	317	3	3,240	41	7,630		
South Africa	12	2,910	4	2,420	18	5,850		
Taiwan	146	26,100	14	3,630	208	34,600		
Thailand	11	2,560	3	1,640	26	5,360		
United Kingdom	45	9,210	48	19,500	196	37,800		
Venezuela	11	4,410	6	1,890	43	10,300		
Other	283	68,900	46	22,500	433	110,000		
Total	3,550	573,000	432	139,000	5,230	843,000		

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 dina's earth, activated clays and earths, and artificially activated clays.

Source: Bureau of the Census.

TABLE 24
U.S. IMPORTS FOR CONSUMPTION OF CLAY IN 1998, BY KIND 1/

Kind	Quantity (metric tons)	Value (thousands)
China clay or kaolin:		
Brazil	36,500	\$7,480
China	99	90
New Zealand	198	128
United Kingdom	15,800	4,390
Other	405	471
Total	52,900	12,600
Fire clay:		
Belgium	16	21
Canada	2,100	140
United Kingdom	16	15
Other	18	8
Total	2,150	184
Decolorizing earths and fuller's earth:		
Canada	277	32
China	1	3
Korea, Republic of	10	3
Total	288	38
Bentonite:		
Canada	557	247
France	2	9
Germany	171	92
Japan	612	121
Mexico	254	105
Netherlands	285	304
Turkey	1,320	652
United Kingdom	3,400	1,630
Total	6,600	3,160
Common blue clay and other ball clay:		
Italy	21	7
United Kingdom	2,650	556
Total	2,670	563
Other clay:		
Canada	1,440	535
Germany	98	103
Italy	23	11
South Africa	40	58
United Kingdom	982	439
Other	316	468
Total	2,900	1,610
Chamotte or dina's earth:		
Germany	1	2
Artificially activated clay and activated earth:		
Austria	739	1,020
Canada	970	614
Denmark	162	570
Germany	1,010	1,450
Mexico	15,100	5,040
Other	854	947
Total	18,900	9,630
Grand total	86,400	27,700

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/	1994	1995	1996	1997	1998 e/
Algeria 4/	20,215	17,088	17,200	17,000 e/	17,000
Argentina	313,407	111,011	134,588	104,880 r/	105,000
Armenia	100 e/	110	2,750	2,750 e/	3,000
Australia e/ 4/	35,000	35,000	35,000	35,000	35,000
Bosnia and Herzegovina e/	800	800	800	800	800
Brazil (beneficiated)	144,950	150,000	186,000	224,055 r/	220,000
Bulgaria	76,300	125,800	202,000 r/	171,000 r/ e/	175,000
Burma	795	2,655	4,846 r/	610 r/	1,000
Chile	1,213	684	1,191	717 r/	721 5/
Croatia	10,391	7,327	9,728	7,331	7,500
Cyprus	46,530	49,487	70,927 r/	101,000 r/	140,000 5/
Czech Republic	65,000	54,000	59,000	110,000	100,000
Egypt	2,379	1,930	1,136 r/	1,200 r/ e/	1,000
France e/	7,000	--	--	--	--
Georgia	13,000 e/	13,000	13,000	12,000	11,000
Germany	499,000	529,000	491,000	510,000 r/ e/	500,000
Greece	697,773	1,115,119	973,517	950,000 e/	950,000
Guatemala e/	4,408 5/	4,500	4,500	4,500	3,800
Hungary	14,700	22,792	15,376	14,848	15,000
Indonesia	14,409	26,057	26,000 e/	25,000 e/	25,000
Iran 6/	71,759	54,798	85,000 e/	105,300 r/	105,000
Italy	386,000	591,000	475,000	513,000 r/	500,000
Japan	484,115	478,056	468,728	495,646 r/	444,507 5/
Macedonia e/	30,000	30,000	30,000	30,000	30,000
Mexico	92,476 r/	72,599	69,810	111,503	185,729 5/
Morocco	24,919	29,308	39,680	49,633	50,000
Mozambique	3,349	3,500 r/ e/	11,051 r/	13,799 r/	14,000
New Zealand (processed)	930	3,699	13,734	12,802 r/	14,000
Pakistan	11,180	5,759	15,290	12,000 e/	14,196 5/
Peru	27,682	26,961	18,592	22,285 r/	18,600 5/
Philippines	3,415	7,636	8,000 e/	8,000 e/	8,000
Poland	19,900	6,300	8,000	10,000 e/	10,000
Romania	41,056	42,277	43,543	27,133	30,000
Serbia and Montenegro	215	192	95	100 e/	100
South Africa 7/	71,773	70,927	48,076	33,326 r/	34,000
Spain	179,233	172,265	151,155	150,000 e/	150,000
Tanzania e/	70	70	75	75	75
Turkey	516,187	602,499	515,452 r/	500,000 r/ e/	500,000
Turkmenistan e/	50,000	50,000	50,000	50,000	50,000
U.S.S.R. e/ 8/	1,300,000	1,300,000	1,200,000	1,100,000	900,000
United States	3,290,000	3,820,000	3,740,000	4,020,000	3,820,000
Zimbabwe 7/	169,097	169,823	185,953	186,000 r/ e/	140,000
Total	8,740,000 r/	9,800,000	9,420,000	9,750,000 r/	9,330,000

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, 1999.

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/	1994	1995	1996	1997	1998 e/
Algeria e/	4,550 4/	4,500	4,500	4,500	4,500
Argentina e/	1,600	1,600	1,500	1,500	1,500
Australia (attapulgitite) e/	15,000	15,000	15,000	15,000	15,000
Germany (unprocessed)	498,000	529,000 r/	491,000 r/	511,000 r/ 4/	500,000
Italy	24,000	34,000	26,000	30,000	30,000
Mexico	21,377	15,755	41,800	51,430	48,016 4/
Morocco (smectite)	22,782	15,027	16,623	17,000	17,000
Pakistan	15,335	12,862	13,415	14,000 e/	14,144 4/
Senegal (attapulgitite) e/	119,000	120,000	120,000	100,000	100,000
South Africa (attapulgitite)	10,230	8,049	14,318	9,349 r/	9,500
Spain (attapulgitite)	91,124	94,266	94,000 e/	90,000 r/ e/	90,000
United Kingdom 5/	134,000	132,300	143,000	140,000	140,000
United States 6/	2,640,000	2,640,000	2,600,000	2,370,000	2,350,000
Total	3,600,000	3,620,000 r/	3,580,000 r/	3,350,000 r/	3,320,000

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, 1999.

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/	1994	1995	1996	1997	1998 e/
Algeria	16,984	24,068	24,000 e/	25,000 e/	25,000
Argentina	50,471	39,860	64,241	34,030 r/	35,000
Australia (includes ball clay) e/	200,000	210,000	210,000	220,000	220,000
Austria (marketable)	65,000	57,000	60,000 e/	60,000 e/	60,000
Bangladesh 4/	3,283	6,541	7,000 e/	7,200 e/	7,500
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)	1,037,570	1,067,109	1,057,671 r/	1,280,000 r/	1,300,000
Bulgaria e/	115,000 5/	115,000	115,000	115,000	110,000
Burundi e/	5,000	1,000	1,000	1,000	1,000
Chile	73,081	10,845	13,452	14,238 r/	11,530 5/
Colombia (includes common clay)	6,700,000	7,300,000	3,957,000 r/	8,040,000 r/	8,000,000
Czech Republic	2,706,000	2,800,000	2,798,000	2,982,000	2,900,000
Denmark (sales) e/	3,500	3,500	3,000	3,000	2,500
Ecuador	6,883	45,054 r/	86,541 r/	50,000 r/ e/	50,000
Egypt	180,000 e/	293,381	258,725 r/	260,000 r/ e/	260,000
Eritrea	5,231	3,200 e/	2,620	2,500 e/	1,000
Ethiopia e/	8	15	15	16 r/	16
France (marketable)	327,000	345,000	326,000	332,000 r/	330,000
Germany	1,631,000	1,925,000	1,794,000 r/	1,800,000 e/	1,800,000
Greece	117,254	68,682	60,453	60,000 r/	60,000
Guatemala e/	-- r/	76 r/	109 r/	110 r/	110
Hungary (processed)	5,000	4,847	5,000 e/	5,000 e/	5,000
India:					
Processed	134,002	160,689	183,268	190,000 e/	200,000
Salable crude	548,467	552,128	557,778	575,000 r/ e/	560,000
Indonesia	53,236	14,373	15,000 e/	16,000 e/	14,500
Iran	227,650	265,591	350,000 r/	510,000 r/	500,000
Israel e/	40,000	40,000	40,000	40,000	40,000
Italy: Kaolinitic earth e/	7,000	10,000	10,000	9,000	9,000
Japan	138,412	182,122	141,230	110,915	90,000
Korea, Republic of	2,675,485	2,792,139	2,501,600	2,688,489	2,259,809 5/
Madagascar e/	1,200	1,545 5/	1,500	1,500	1,500
Malaysia	252,628	211,182	209,562	187,411	181,000
Mexico	193,034	221,685	253,971	235,278 r/	339,013 5/
New Zealand	40,720	13,662	26,325	21,874 r/	26,000
Nigeria	105,000 e/	11,950 r/	102,078 r/	100,000 r/ e/	100,000
Pakistan	47,894	30,746	54,860	55,000 e/	69,077 5/
Paraguay e/	74,000	66,300 5/	16,500 r/	66,700 r/	66,700
Peru	7,908 r/	8,445	14,295	7,875 r/	7,900
Poland (washed)	52,600	53,000	71,700	70,000 e/	70,000
Portugal	181,933	180,000 e/	177,423 r/	180,000 e/	180,000
Romania	47,566	49,024	45,199	29,169	30,000
Serbia and Montenegro:					
Crude	69,927	56,926	55,000 e/	55,000 e/	60,000
Washed	7,110	4,900	5,000 e/	5,000 e/	6,000
Slovakia	24,100	13,300	23,240	24,000 e/	25,000
Slovenia: e/					
Crude	10,000	10,000	10,000	10,000	10,000
Washed	4,000	4,000	7,000	7,000	4,000
South Africa	131,863	146,587	146,496	120,148 r/	130,000
Spain (marketable): Crude and washed 6/	337,339	316,074	315,000 e/	315,000 e/	300,000
Sri Lanka	7,500 e/	16,000	7,700	19,900 r/	20,000
Sweden e/	100	460 r/	460 r/	450 r/	450
Taiwan e/	100,000	100,000	100,000	100,000	70,000
Thailand (beneficiated)	417,064	460,629	553,770	366,563 r/	350,000
Turkey	179,775	489,635	449,561 r/	500,000 e/	500,000
Ukraine	1,015,000	950,000	900,000 e/	850,000 e/	850,000
United Kingdom (sales) 7/	2,653,918	2,585,881	2,281,000	2,400,000 e/	2,300,000
United States 8/	8,770,000	9,480,000	9,120,000	9,410,000	9,450,000 5/
Uzbekistan e/	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000

See footnotes at end of table.

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

(Metric tons)

Country 3/	1994	1995	1996	1997	1998 e/
Venezuela	10,345	3,020	7,542	8,225	8,000
Vietnam e/	1,000	1,000	1,000	1,100 r/	1,100
Zimbabwe	462	57	--	-- e/	--
Total	37,600,000	39,600,000 r/	35,400,000 r/	40,400,000 r/	39,800,000

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, 1999.

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

7/ Dry weight.

8/ Kaolin sold or used by producers.