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*COVER PHOTO:*

*Common clay is used for making brick, one of the most common building materials and the largest end use for all varieties of clay. Photograph of the new U.S. Bureau of Mines headquarters in Washington, DC.*

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## CLAYS

By Robert L. Virta

Mr. Virta, a physical scientist with 16 years of U.S. Bureau of Mines experience, has been the acting commodity specialist for clays since 1991. Domestic survey data were prepared by Maria Arguelles, statistical assistant. The international tables were prepared by Ron Hatch, Douglas Rhoten, and Ted Spittal, international data coordinators.

The amount of clay sold or used by domestic producers increased 3% in tonnage to 44 million metric tons and decreased 7% in value to \$1.5 billion. Production of ball clay, bentonite, fire clay, and kaolin decreased in 1991. Common clay and shale, and fuller's earth production increased. Common clays accounted for 62% of the tonnage, and kaolin accounted for 61% of the value of clays produced in 1991. Imports increased 17% in tonnage to 35,000 tons and 11% in value to 13 million. Exports decreased 3% in tonnage to 4 million tons and increased 1% in value to \$590 million. (See table 1.) Clays were produced in 44 States and Puerto Rico. The seven leading producer States, in descending order, were Georgia, Wyoming, Texas, Ohio, Alabama, California, and North Carolina. (See table 2.)

### DOMESTIC DATA COVERAGE

Domestic production data for clays are developed by the U.S. Bureau of Mines from one voluntary survey of U.S. operations. Of the 1799 operations covered

by the survey, 1240 responded, representing 75% of the total clay and shale production sold or used shown in table 1. (See table 3.)

## BACKGROUND

### Definitions, Grades, and Specifications

Clays are categorized into six groups by the U.S. Bureau of Mines. The categories are kaolin, ball clay, fire clay, bentonite, fuller's earth, and common clay and shale. The definitions listed in this work for the high-alumina clays, kaolin, ball clay, and fire clay are similar to those in U.S. Bureau of Mines Information Circular 8335.<sup>1</sup>

Kaolin, or china clay, is defined as a white, claylike material composed mainly of kaolinite and other kaolin-group minerals, such as halloysite and dickite. Kaolin has a specific gravity of 2.6 and a fusion point of 1,785° C. Kaolin is classified according to the method of preparation (crude, air-separated, water-washed, delaminated, air-dried, calcined, slip, pulp, slurry, or water suspension) and on specific physical and chemical properties.

Ball clay is a plastic, white-firing clay used mainly for bonding in ceramicware. The clays are of sedimentary origin and consist mainly of the kaolinite, sericite mica, and organic matter. Ball clays usually are much finer grained than kaolins and are renowned for their plasticity. They are classified according to the method of preparation (crude, shredded, air-floated, water-washed, or slurry) and specific physical and chemical properties.

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Fire clay is defined as detrital material, either plastic or rocklike, that commonly occurs as underclay below coal seams. Low concentrations of iron oxide, lime, magnesia, and alkalies in fire clay enable the material to withstand temperatures of 1,500° C or higher. It is composed mainly of kaolinite. Fire clays also contain other clays such as diaspore, burley, burley-flint, ball clay, and bauxitic clay and shale. Fire clays generally are used for refractories or to raise vitrification temperatures in heavy clay products. The fired colors of fire clays range from buffs to grays. Fire clays are classified according to their physical and chemical properties and the characteristics of the products made from them.

Bentonite is a clay composed primarily of smectite minerals. The primary smectite mineral is usually montmorillonite. Swelling-type bentonite has a high-sodium ion concentration. Its volume increases 15 to 20 times its dry volume when wetted with water. Nonswelling bentonites usually are high in calcium. Bentonite is classified according to its physical and chemical properties, with particular emphasis on particle size and swelling index.

The term "fuller's earth" is derived from the first major use of the material, which was for cleaning textiles by fullers. Fuller's earth does not refer to a clay with a specific composition or mineralogy. It is defined as a nonplastic clay or claylike material, usually high in magnesia, that is suitable for decolorizing and purifying mineral and vegetable oils. They are composed mainly of the needle- and/or lath-shaped clay mineral attapulgite or varieties of montmorillonite. Fuller's earths containing opal or other forms of colloidal silica also are produced. Fuller's earths are classified

according to their physical and chemical properties. Sepiolite-type clays are grouped with fuller's earths under the Bureau classification system.

Common clay is defined as a clay or claylike material that is plastic enough to mold easily. Its vitrification point is usually below 1,100° C. Shale is a laminated sedimentary rock that is formed by the consolidation of clay, mud, or silt. The common clays and shales are composed mainly of illite or chlorite. They also may contain kaolin and montmorillonite. Common clays and shales usually contain more alkali, alkaline earth, and ferruginous minerals and less aluminum than high-quality kaolins, fire clays, and ball clays. Iron present in the clay usually imparts a reddish color to the final product after firing. There is no formal classification of common clays and shales, although a clay may sometimes be referred to as common, brick, sewer pipe, or tile clay. Clay and shale are used in the manufacture of structural clay products such as brick, drain tile, portland cement clinker, and expanded lightweight aggregates.

The American Society for Testing and Materials, American Foundrymen's Association, American Oil Chemist's Society, American Petroleum Institute, Technical Association of the Pulp and Paper Industry, and other national organizations have developed tests and set standards for some applications. Many producers and consumers, however, use nonstandardized tests that are applicable to their specific needs. Individual companies often set the acceptable limits of mineralogical composition, particle size, and other physical and chemical properties. Detailed data on specifications have been published by the U.S. Bureau of Mines.<sup>2</sup>

## Products for Trade and Industry

Because of the many types of clay and different qualities within each type, the consumption pattern and the products for trade and industry are constantly changing. Consumption of kaolin in refractories has been growing since 1970 because of the increasing popularity of castable, ramming, gunning, and plastic mixes that use calcined kaolin aggregates (grog) in their formulations.<sup>3</sup> The consumption of calcined kaolin grogs also has increased in refractory brick manufacturing, replacing imported calcined refractory-grade bauxite grogs. Consumption of bentonite has decreased for iron ore pelletizing and for more expensive drilling mud and foundry uses. Bentonite products for waterproofing and sealing in construction and reservoir uses also have gained in popularity. Attapulgite-type fuller's earth production, like bentonite, is finding increasing applications in the premium drilling mud industry.

## Industry Structure

An estimated 319 companies operating more than 1,000 clays pits or mines reported production in 1991; of these, 103 companies, most with multiple operations, accounted for approximately 66% of the tonnage and 75% of the value for all types of clay produced and sold or used. Clay production was reported in all States and Puerto Rico except Alaska, Delaware, Hawaii, Rhode Island, Vermont, Wisconsin, and the District of Columbia.

The leading clay-producing States were Georgia, 9.5 million tons; Wyoming, 2.5 million tons; Texas, 2.3 million tons; Ohio, 2.2 million tons; Alabama,

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2.1 million tons; North Carolina, 2.1 million tons; and California, 2.1 million tons. (See table 2.) Most of the clay is mined by open pit methods. Less than 2% of U.S. clay output is from underground mines in 1991. Most of the underground production is in Pennsylvania, Ohio, and West Virginia, where the clays are mainly underclays associated with coal and suitable for refractory uses.

Forty-two firms operated 141 kaolin mines in 14 States. In 1991, three large, diversified firms accounted for about 60% of total domestic kaolin output. Most large kaolin producers have operations in Georgia, which accounted for 79% of the kaolin production.

The ball clay industry is small, with 6 producers operating 36 mines in 5 States in 1991. Three of the producers were large, diversified firms with widespread foreign and domestic mineral interests. Tennessee ball clay production represented about 66% of the total output.

Fireclay producers were mostly refractories manufacturers that used the clay in firebrick and other refractories. Seventy-eight mines were operated in 1991 by 19 firms in 7 States.

Firms producing bentonite operated 144 mines in 11 States. Four producers were large diversified firms with international mineral operations; three of the firms had interests in other types of clay in the United States. Wyoming was the leading State, accounting for 73% of the total output. Swelling-type bentonite is produced mainly in Wyoming and Montana and nonswelling-type

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bentonite is produced in Mississippi and Texas. The United States is the world's largest producer and exporter of bentonitic clays.

Nineteen companies produced fuller's earth from 37 mines in 10 States. Eleven of the mines were in the attapulgite-fuller's earth areas of Florida and Georgia. These two States accounted for 35% of domestic production. Most producers were small independent firms, but three were large diversified corporations with international mineral interests. The world's fuller's earth needs are supplied from relatively few areas. The United States is the world's largest producer and user of fuller's earth.

Firms producing common clay and shale in 1991 were manufacturers of structural clay products, clay pipe, lightweight aggregates, and cement. Most companies mined the clays used in making their products. Private mining contractors and haulers were employed in many of the operations. Some producers were diversified firms having interests in metals and other nonclay products. Some companies owned and operated several clay pits and plants in order to cover a large market area. The economic radius for shipment of common clay or shale products is usually 200 miles or less. The high cost of transport promotes the development of local ownership companies, or in the case of a large firm, the ownership and operation of several strategically located pits and associated fabricating plants.

#### Geology-Resources

Clay is formed by the mechanical and chemical breakdown (weathering) of rocks. The weathering products consist of mineral grains and rock fragments

of different size and different physical and chemical properties. The nonplastic portion consists of altered and unaltered rock fragments (grit), which are usually quartz, micas, feldspar, and iron oxides. The plastic portion usually is composed of clays and is low in grit.

Clays may be classified as residual or sedimentary. Residual clays are deposited in the same location in which they were formed. Sedimentary clays are those that have been transported, usually by water, and deposited elsewhere.<sup>4</sup> Sedimentary clays often undergo further alteration and classification during transport. Kaolin deposits in Georgia and South Carolina are sedimentary. Kaolin deposits in North Carolina and English china or kaolin clay deposits are residual.<sup>5</sup> The Kentucky and Tennessee ball clays and the Missouri fire clays are sedimentary deposits. Most bentonites, montmorillonites, and fuller's earth were formed in place through the weathering of volcanic ash or tuff. The attapulgite-type fuller's earth deposits of Florida and Georgia were probably not formed from volcanic ash or tuff. Geologists have never found any evidence of volcanic materials associated with these deposits.<sup>6</sup>

The definitions of reserves and reserve base are published in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification for Minerals." Reserves are the part of an ore body that can be economically extracted at the time of evaluation. Reserve base is the part of an ore body that meets specified minimum physical and chemical criteria related to current mining and production practices. Reserve base includes reserves, marginal reserves, and subeconomic resources.

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Common clays and shale deposits are found throughout the United States. Clays and shale were mined commercially in 43 States and Puerto Rico. Domestic resources are almost unlimited. Not all deposits, however, are near potential markets, and most deposits are not suitable for all applications. For example, most common clay or shale deposits can be used to manufacture common brick, but the color or strength of the final product may not meet the requirements of the local market. Relatively few deposits are suitable for manufacture of lightweight aggregate. Even with these limitations of location and use, resources of common clay and shale are "virtually unlimited."

U.S. reserves of other types of clays that are owned or controlled by domestic producers are estimated to be about 700 million tons. U.S. reserves of kaolin are estimated to be 400 million tons; ball clay, 30 million tons; fire clay, 100 million tons; bentonite, 120 million tons; and fuller's earth, 60 million tons.

Large quantities of high-quality kaolin suitable for paper-coating and paper-filler are found in Georgia. A small area in Georgia and Florida contains sizable reserves of attapulgite-type fuller's earth. Most bentonite for iron ore pelletizing and oil-well-drilling muds is mined in Wyoming. Fire clay deposits, such as those found in Missouri, are widespread. Deposits of high-quality fire clay are nearing depletion. Kentucky and Tennessee are two of only a few States that have sizable deposits of ball clay.

Technology

**Exploration.**--Exploration begins with an understanding of the geological occurrence of the clays of interest. With this knowledge, potential economic deposits can be located. Auger or core drills are then made to delineate the size and shape of the deposit and to obtain material for testing.

Kaolins usually are evaluated for filler and ceramic applications. The grit, particle size, brightness, and leachability are determined. Air-floated clays normally require only grit and brightness determinations. Kaolin, ball clay, and fire clay for ceramic and/or refractory applications are analyzed for grit, brightness, green and dry strengths, fired color, and iron and alumina contents. The common clays and shales usually are tested according to the intended end use, such as brick, structural-drain tile, or lightweight aggregate. Usually, prepared specimens are tested for plasticity, green strength, shrinkage, vitrification temperature range, etc. For lightweight aggregates, the bloating range is determined. Bentonites and fuller's earth clays are difficult to evaluate because there is no standard testing procedures or specifications. Generally, they are processed to meet the purchaser's specifications.

**Mining.**--Most clays are mined from open pits using modern surface mining equipment such as draglines, power shovels, front-end loaders, backhoes, scraper-loaders, and shale planers. Some kaolin is extracted by hydraulic mining and dredging. A few clay pits are operated using crude hand-mining methods. A small number of clay mines, principally in underclays in coal mining areas, are mined underground using room-and-pillar methods. Clays usually are transported by truck from the pit or blending areas to the

processing plants. Rail, conveyor belt, and in the case of kaolin, pipelines also are used.

About 100% of the clay is recovered from the minable beds in most open pit operations. Approximately 75% is recovered in underground operations. The waste-to-clay ratio is highest for kaolin, about 7:1, and lowest for common clay and shale, about 0.25:1.

*Processing.*--Clays are used in a large number of products so they must be treated in many different ways. Processing can consist of very simple and inexpensive crushing and screening for some common clays. It also can consist of very elaborate and expensive grinding, sizing, bleaching, delamination, etc. for paper-coating clays and high-quality filler clays for use in rubber, paint, plastic, and other products. In general, processing does not appreciably alter the chemical or mineralogical characteristics of the clays. The two exceptions are calcining and cation exchange.

Significant processing losses occur with kaolin and fuller's earth. About 40% of the kaolin and 30% of the fuller's earth delivered to the processing plants is discarded. Waste material from processing consists mostly of off-grade clays and small quantities of quartz, mica, feldspar, and iron-bearing minerals.

*Kaolin.*--Processing involves one or more of the following: crushing, blunging with dispersant, rough sedimentation, water fractionation, magnetic separation, ultraflotation, acid treatment, calcination, air floating, and attrition grinding, slurring, and delaminating. Kaolins used for paper coating applications may be bleached and further delaminated by grinding,

deflocculation, and elutriation to special sizes. Ultraflotation or wet magnetic separation treatment may be used to remove iron- or titanium-bearing minerals to obtain a whiter product.

**Ball Clay.**--Processing involves drying, shredding, pulverizing, air floating, and slurring.

**Fire Clay.**--Processing involves crushing, calcining, and blending.

**Bentonite.**--Processing involves weathering, drying, grinding, sizing, granulation, and the use of additives for cation exchange.

**Fuller's Earth.**--Processing involves blunging, extruding, drying, crushing, grinding, sizing, and dispersing.

**Common Clay and Shale.**--Processing involves crushing, blunging, extruding, and drying. Common bricks, tile, lightweight aggregate, etc., require firing in a kiln. The kiln firing or drying operation produces a finished manufactured product.

Processing costs for clays range from a few cents per ton for some common clays to more than \$400 per ton for some special paper-coating clays and high-quality clays that require very elaborate and expensive treatments.

Price schedules, although not complete, are available and are published regularly in trade journals such as the American Paint and Coatings Journal, Chemical Marketing Reporter, and Industrial Minerals (London).

Federal tax laws allow clay producers a depletion allowance on both domestic and foreign gross income not to exceed 50% of net income with depletion deduction. Depletion allowances are as follows: ball clay, bentonite, kaolin or china clay, sagger clay, and clay used or sold for purposes dependent on its refractory properties, 14% domestic and 14% foreign; fuller's earth, 14% domestic and 14% foreign; clay used for extraction of alumina or aluminum compounds, 22% domestic; clay used or sold for use in manufacturing drainage and roofing tile, flower pots, and kindred products, 5% domestic and 5% foreign; clay and shale used for making brick, tile, and lightweight aggregate, 7.5% domestic and 7.5% foreign. Severance taxes are levied by some producing States.

#### Byproducts and Coproducts

Firms in California, Florida, and Texas produce silica glass sand as a coproduct of its kaolin production. Flake mica is a byproduct in one kaolin operation in North Carolina. Bauxite is a coproduct in kaolin operations in Alabama and Georgia. Clay and limestone for cement manufacture are often produced from the same property and reported as coproducts or byproducts even though they are usually mined separately from different formations or beds. Sand, gravel, and stone aggregates are occasionally produced together with common clays.

#### Economic Factors

Economic factors affecting clays vary in importance with type, quality, and intended end use. The cost of transportation is an important factor for the

common clay and fire clay industries; mines must be close to consumers to be cost competitive. Other types of clays are less abundant and have higher unit values. They can be shipped greater distances from the mines and still be cost competitive. For example, paper-coating clay from Georgia and attapulgite-type fuller's earth from Florida and Georgia can be shipped nationwide. Bentonite for iron ore pelletizing from Montana and Wyoming can be shipped a considerable distance to the iron ore centers. In some of these cases, the shipping costs exceed the value of the clays at the mine or processing plant.

Because most clays are relatively low-cost materials in the crude state, mining costs must be kept as low as possible. Cost of the crude clays ranges from less than \$3 per ton for some common clays to above \$20 per ton for some of the higher quality materials.

Very little clay is imported because transportation costs would make the clays noncompetitive in price. Consequently, import duties have little impact on the amount of clays imported.

#### Operating Factors

To manufacture finished clay products, producers require equipment to mine and process the crude clay and a kiln for firing or drying their products. Mining, processing, and manufacturing are all energy-intensive operations. Many clay producers converted to coal from oil firing and gas firing. However, the conversion to coal and/or wood as a kiln fuel is gaining in

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popularity where feasible in heavy clay and refractory products manufacturing and in bentonite processing.

Losses in mining are extremely small, except in underground mining where recovery will average about 75%. Processing losses for material receiving, crushing, grinding, mixing, shredding, blending, and drying also are insignificant. Losses from washing, sizing, etc., reach 30% or 40%.

Clay mining lacks many of the hazards associated with other types of mining because only a few deposits require the use of explosives and most mines are open pit earth-moving operations. Domestic mine employment in 1991 was estimated to be 2,000 workers. Domestic mill employment was estimated to be 9,100 workers.

## ANNUAL REVIEW

### Issues

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 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 with those laws governing reclamation of the mined area.

Many local governments are enacting stricter regulations. In some cases they change the land use zoning. New regulations and land use changes

sometimes force a mine to close or relocate to a more distant deposit increases costs to the community because of increased transportation charges.

An issue that continues to interest a segment of the clay industry is the classification of crystalline silica as a probable human carcinogen. Mineral products containing 0.1% or more crystalline silica must be labeled in accordance to the Occupational Safety and Health Administration's Hazard Communication Standard (HCS), and employers must comply with the terms of HCS with regard to worker training. Some States are enacting stricter regulations with regard to crystalline silica based on the health findings.

Although domestic clay resources are more than adequate and clay is a mature industry, the average price for clays is expected to rise steadily. The increased prices reflect the demand for higher quality specialty clay by consumers and increased costs associated with land acquisition, severance taxes, land rehabilitation, energy requirements, and environmental factors. These rising prices, if unchecked, will have an adverse affect on the clay industry by making competing materials more cost competitive.

#### Production, Prices, and Foreign Trade

ECC Group PLC, United Kingdom, announced the sale of Southern Clay Products Inc. to Laporte PLC. Southern Clay Products mines ball clay from a mine near Gonzales, Texas and bentonite from a mine in Kaycee, Wyoming.<sup>7</sup>

Approval was granted for the expansion or creation of several mines, including a kaolin mine near Belview, Minnesota and common clay operations near Lewiston, Maine and Quinton, New Jersey.<sup>8</sup>

**Kaolin.**--Domestic production of kaolin increased 5% to 9.5 million tons. The value of production decreased 3% to \$9.2 billion. The unit value of kaolin decreased 8% to \$96 per ton. Filler- and refractory-grade kaolin had the highest reported values. Kaolin was produced in 14 States. Georgia accounted for 79%, and South Carolina accounted for 6% of total production. Georgia accounted for more than 94% of the total production value. (See table 4.) Filler, refractory, chemical- and water-washed, air-floated, and unprocessed grades were produced in Georgia. South Carolina produced only air-floated and unprocessed grades of kaolin. (See tables 5, 6, 7, 8, 9, 10.) Arkansas and California produced refractory- and chemical-grade kaolins. Kaolin producers reported major domestic end uses as paper-coating, 34%; paper-filling, 14%; refractories, 21%; fiberglass and insulation, 5%; face brick and rubber, 3% each; and paint and chemicals, 3%. (See table 11 and figure 1.)

Asea Brown Boveri Inc. sold Dry Branch Kaolin Co. to Imetal. The Dry Branch operation produces kaolin for the ceramics, ink, paint, paper, and rubber industries.<sup>9</sup>

Despite the overall slow economy, kaolin production increased. Domestic sales of paper-grade kaolin decreased 5% from that of 1990. However, the trend toward the use of high quality coated papers resulted in a growth of 4% for coating clay. Exports increased 35% because of a continued weak U.S.

dollar. U.S. sales of unprocessed kaolin declined 35% because of the completion of a major project that required large tonnages of low-value unprocessed kaolin. Calcined and water-washed kaolin production increased 76%, and 9%, respectively. This contrasts with an 18% decrease in sales of delaminated and 21% decrease in sales of air-float kaolin. (See tables 5, 6, 7, 8, 9, 10, 11.)

Exports of kaolin reported by the U.S. Department of Commerce increased 1% to 2.86 million tons valued at \$430 million. The unit value of the exported kaolin decreased slightly to \$150.71 per ton. Kaolin, including calcined material, was exported to 65 countries. The major importers, in descending order, were Japan, Canada, Finland, the Netherlands, Italy, and Mexico. Kaolin producers reported end use markets for their exports as follows: paper-coating, 68%; paper-filling, 20%; rubber, 2%; and other, including ceramics, paint, and refractories, 9%. (See tables 11 and 26.)

Kaolin imports for consumption increased about 1% to 3,373 tons valued at \$1.6 million. The unit value increased about 7% to \$476.43 per ton, reflecting the continuing strong worldwide demand for premium-quality kaolin. (See table 27.)

Kaolin prices quoted in the trade journals generally were unchanged from those of the previous year. (See table 12.)

The Food and Drug Administration amended the food additive regulations to allow the use of modified kaolin in paper and paperboard intended for use in contact with food.<sup>10</sup>

## *Ball Clay*

Production of domestic ball clay decreased 1% to 784,000 tons valued at about \$33 million. Tennessee supplied 66% of the Nation's output, followed by, in descending order of production, Kentucky, Mississippi, Texas, and Indiana. Production decreased in all the major producing States. The principal ball clay markets were dinnerware, floor and wall tile, and sanitaryware. (See table 13 and 14.)

The average unit value for ball clay reported by domestic producers increased slightly to \$42.63 per ton. Listed prices in the Chemical Marketing Reporter, January 6, 1992, per short ton, were unchanged from those of 1991. (See table 12.)

Ball clay exports decreased 16% to 58,000 tons valued at \$2.9 million. Unit value increased to \$50.15. Shipments were made to 24 countries. The major importer was Mexico, with 79% of the exports. (See tables 14 and 26.)

Ball clay imports for consumption, almost entirely from the United Kingdom, also decreased 53% to 750 tons valued at \$262,000. The unit value of these clays increased more than 21% to \$347.94 per ton. (See table 27.)

*Fire Clay.*--Fire clay sold or used by domestic producers decreased 24% in tonnage to 474,000 tons and 18% in value to \$13.1 million. Missouri was the leading producing State followed by Ohio, Alabama, New Jersey, Pennsylvania, and New Mexico. (See table 15).

The clay refractory industry had been in a period of low production because of decreased demand brought about by technological changes and lower consumption levels by its major users--steel, nonferrous metals, ceramics, glass, and minerals processing industries. The technological changes in steelmaking, away from integrated pig iron systems and toward electric furnaces and/or minimills, further compounded the problem by employing shapes and specialty refractories requiring less fire clay.

Fire clay was produced from mines in six States. Missouri, Ohio, and Alabama, in descending order of volume, accounted for more than 89% of the total domestic production.

North American Refractories Co. merged with Didier Taylor Refractories Corp. The combined companies will operate under the North American Refractories name.<sup>11</sup>

Exports of fire clay decreased 7% to 199,000 tons. The unit value of exported clay increased 9% to \$95.48 per ton. Fire clay was exported to 33 countries. The major recipients, in descending order, were the Netherlands, Mexico, Japan, Australia, and Taiwan. Fire clay imported from two countries amounted to 425 tons valued at \$80,000. (See tables 26 and 27.)

The unit value for fire clay, reported by producers, ranged from about \$5 to \$43 per ton.

**Bentonite.**--Bentonite production decreased more than 3% to 3.4 million tons, while the value increased 2% to \$125.4 million. Wyoming was the largest

bentonite producer, accounting for 73% of production. Wyoming also was the leading producer of swelling bentonite. (See table 16.) The three major end uses were drilling mud, foundry sand, and iron ore pelletizing with 20%, 17%, and 21%, respectively, of total sales. Sales of bentonite to the foundry sand and iron ore pelletizing industries increased 5% in 1991. (See figure 17.)

For the past two years, bentonite producers have reported that about 700,000 tons of bentonite were sold to the iron ore pelletizing industry, more than in previous years. Domestic bentonite consumption, based on data provided by the domestic iron ore pelletizing industry, was estimated to be between 510,000 and 520,000 tons. Bentonite exports to Canadian iron ore pelletizers were estimated to be between 110,000 to 130,000 tons, making sales to U.S. and Canadian pelletizers between 620,000 to 650,000 tons. Bentonite also was exported to other countries for pelletizing iron ore.

Bentonite was produced in 11 States. Most of the high-swelling or sodium bentonite was produced in Wyoming. Mines in Alabama and Mississippi produced more than one-half of the low-swelling or calcium bentonite. Calcium bentonite produced in Alabama and Mississippi was suitable for the production of absorbent, acid-activated, and foundry products. (See table 16.)

American Colloid Co. built a new blending facility in Alabama. The facility processes bentonite for use by the foundry industry.

The quoted price in the Chemical Marketing Reporter, January 6, 1992, for domestic bentonite, carload lots, f.o.b. mines, was \$28.60 per ton. The

average unit value reported by domestic producers increased 3% to \$36.54 per ton.

Bentonite exports decreased 6% to 660,000 tons valued at \$63.6 million. The unit value of exported bentonite increased about 18% to \$96.32 per ton. Bentonite was exported to 61 countries, 37 more than in 1990. The five major recipients, in descending order, were Japan, Canada, Taiwan, United Kingdom, Venezuela, and Australia. Domestic bentonite producers reported their exports were foundry sand, 62%; drilling mud, 24%; and others, 14%. (See tables 17 and 26.)

Bentonite imports for consumption consisted mostly of untreated bentonite clay and chemically or artificially activated materials. Bentonite imports increased 9% to 2,224 tons. Canada was the largest supplier of bentonite. The chemically activated category decreased 3% to 1,084 tons valued at \$1.8 million. Mexico accounted for 62% of the chemically activated bentonite imported into the United States. This was an increase of 9% over that of 1990. (See table 27.)

**Fuller's Earth.**--Production of fuller's earth increased 19% to 2.74 million tons valued at \$270 million. Reported production of fuller's earth is greater than that of 1990 because two producers were included under the fuller's earth category for the first time. They were reported under other clay categories in the past. The average unit value increased 2% to \$98.70 per ton. Production was reported in 10 States. Florida and Georgia accounted for nearly one-half of domestic production. Pet waste absorbents accounted for 65% of consumption. (See table 18 and figure 3.)

Production from the region that includes Attapulgius, Decatur County, GA, and Quincy, Gadsden County, FL, is composed predominantly of the lathshaped amphibole-like clay mineral attapulgite. Most of the fuller's earth produced in other areas of the United States contains varieties of montmorillonite and/or other clays.

Attapulgite, a fuller's earth-type clay, finds wide application in both absorbent and gelling and/or thickening areas. The thixotropic properties of attapulgite clays provide the important thickening and viscosity controls necessary for suspending solids. Mineral thickeners are used in such diverse markets as paint, joint compound cement, and saltwater drilling mud.

Fuller's earth was exported to 29 countries, 1 less than in 1990. The quantity decreased 59% to 27,000 tons. The unit value of exported fuller's earth increased 27% to \$164.44. The increase was attributed to a larger percentage of high-cost gelling and drilling mud grades shipped. Most of the fuller's earth was shipped to Canada (22%) and the Netherlands (33%). Small amounts of decolorizing fuller's earth were imported from Canada and the Federal Republic of Germany. (See tables 19, 26, 27.)

*Common Clay and Shale.*--Domestic sales or use of common clay and shale increased 5% in tonnage to 27.2 million tons and increased 4% in value to \$141 million. Of the nine major producing States, production increased in Alabama, California, Michigan, Missouri, South Carolina, and Texas and decreased in Georgia, North Carolina, and Ohio. Common clay and shale represented about 62% of the quantity but only 9% of the value of total domestic clay production. (See table 20.)

Domestic clay and shale are generally mined and used captively to fabricate or manufacture products. Less than 10% of the total output is usually sold. The average unit value for all common clay and shale produced in the United States and Puerto Rico decreased 11% to \$5.18 ton. The reported unit value ranged from \$2 per ton to \$36 per ton.

### Consumption and Uses

The manufacture of heavy clay products, including (1) building brick; sewer pipe; and drain, roofing, structural, terra cotta, and other tile; (2) portland cement clinker; and (3) lightweight aggregate, accounted for 29%, 23%, and 8%, respectively, of total domestic consumption. (See table 21.)

Kaolin has many industrial applications, and many grades are specifically designed for use as a filler in paper, paint, rubber, plastics,<sup>12</sup> and ceramics.<sup>13</sup> New uses are constantly being developed. Kaolin is a unique industrial mineral because it is chemically inert over a relatively wide pH range, is white in color, and has good covering or hiding power when used as a pigment or extender in coated films and filling applications. It also is soft and nonabrasive, has low conductivity of heat and electricity, and costs less than most materials with which it competes. Fillers and extenders must meet very rigid specifications, such as particle size, color, brightness, and viscosity.<sup>14</sup>

Ball clays are extremely refractory and their use, largely in whitewares, imparts a high green strength as well as plasticity to the bodies. Although white-firing ball clays are preferable, fired products that range to cream or buff colors do not generally impair the quality of the whiteware products.

Fire clays are used mostly in commercial refractory products such as firebrick and block of many shapes, insulating brick, saggars, refractory mortars and mixes, ramming and gunning mixes, grog and crude aggregates, and many other products. Fire clays are also added to common clays to increase the vitrification range of sewer pipes and bricks.

The swelling sodium bentonites are used largely in drilling muds, in foundry sands, and in pelletizing taconite iron ores. The nonswelling or calcium bentonites are used mostly in conjunction with the swelling bentonites in foundry sand mixes in which the sodium bentonites provide dry strength and the calcium bentonites provide high green strength. Fuller's earth and calcium bentonites find application in decolorizing and purifying mineral, vegetable, and animal oils. Clays used to process animal or vegetable oils usually are activated by acid treatment. Acid treatment produces a highly absorbent sievelike structure. Attapulgite is used in drilling muds instead of sodium bentonites for drilling saltwater formations. Sodium bentonite "breaks the emulsion" or flocculates in brine, thereby destroying the gellike colloidal suspension required for drilling. The major uses for attapulgite and montmorillonite types of the fuller's earths are in pet waste and oil and grease absorbents because of their absorbent properties.

Bentonite also is used for foundry casting by the steel, iron, and nonferrous casting. The bentonite provides good green strength and desirable dry strength characteristics. Sodium bentonites are used in steel casting. Ion-exchanged bentonites are used for iron and nonferrous casting. There is increased use of mixtures of ion exchanged and sodium bentonites to meet the more stringent demands of the casting industry.<sup>15</sup>

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

*Structural Clay Products.*--Structural clay products such as building brick, drain tile, and vitrified sewer pipe are used in building construction, for sewer systems, to drain farmers' fields, and for many other uses. Other clays, such as kaolin, fire clay, or ball clay, could in many cases be used to produce equally suitable "heavy clay" products, but they are generally more refractory and valuable for other uses. Of the total clay produced, about one-third is consumed in the manufacture of these structural products.

*Hydraulic Cement.*--The portland cement industry requires alumina and silica as constituents in the manufacture of portland cement. Common clays provide a low-cost source of these materials.

*Expanded Clay and Shale.*--For this purpose, certain bloating qualities and strength are required. Lightweight concrete blocks, floors, walls, and other shapes made from expanded clay and shale have a lower overall weight, which results in savings in the design of the supporting framework. Also, products made from expanded clay and shale have better insulating qualities than equivalent products made with sand and gravel and crushed stone aggregates.

*Refractories.*--Refractories require strength at high temperatures, resistance to corrosion, low coefficient of expansion, and many other physical and chemical properties, depending on application. Clays with physical properties most suitable for general refractory use have been classed as fire

clays. The current trend is for refractories designed for a specific use and castable mixes containing refractory aggregates and calcium aluminate cements.<sup>16</sup>

*Paper Products.*--Demand for clays for use as filler and coater in paper has followed the rapid increase in demand for paper. Kaolin is the principal clay used.

*Other Uses.*--Pottery and related products require good ceramic qualities, including plastic formation, desirable firing temperatures, color, etc. The principal clays meeting these and other specifications are ball clay and kaolin. Kaolin also is used as a raw material feed in formulating bottle and plate glass batches. Drilling mud is a scientifically designed mixture of several items. It contains, in addition to bentonite or attapulgite, ground barite for its high specific gravity.<sup>17</sup> Demand for bentonite in iron and steel production is based on its ability to form strong iron ore pellets from fine-grained taconite concentrates. Easily handled hard pellets are essential for efficient blast furnace operation.

*Heavy Clay Products.*--The value reported for shipments by the Bureau of the Census for heavy clay products decreased 20% to \$1.4 billion. The million standard brick count for building or common face brick decreased 20%. Shipments of clay floor and wall tile decreased 16% while vitrified clay and sewer pipe fittings decreased 15%. (See tables 22 and 23.)

*Lightweight Aggregates.*--Consumption of clay and shale in the production of lightweight aggregate decreased 5% to 3.6 million tons. Concrete block, the

largest category, (67% of total production), decreased 3% while the second biggest consuming area, structural concrete (20% of total production), decreased 10%. The third largest segment, highway surfacing (8% of production), increased slightly. The other category, the smallest segment consisting essentially of market areas such as recreational and horticultural uses, decreased 20%. (See table 24.)

*Refractories.*--All types of clay, except for fuller's earth, were used in manufacturing refractories. Kaolin, bentonite, and fire clay accounted for 57%, 26%, and 13%, respectively, of total clay used for this purpose. (See table 21.) The remainder, ball clay and common clay and shale, was used chiefly as bonding agents. Bentonite, both swelling and nonswelling, was used as a bonding agent in proprietary foundry formulations imparting both hot- and green-strength to the sand.

The tonnage of clays used for refractories increased 6% and constituted 7% of total clay produced. The continued use of high-alumina clay-base refractories, mostly calcined kaolin grogs in monoliths, and the upturn in demand for the more conventional refractory bricks and shapes were largely responsible. (See table 25.) The major refractory consuming industries--cement, foundry, glass, and ferrous and nonferrous metals--continued to undergo major changes in technology and production levels for their products.

*Filler.*--Bentonite, fuller's earth, and kaolin are the principal filler clays. Kaolin, either air-floated, water washed, low-temperature calcined, and/or delaminated, was used in the manufacture of adhesives, paint, paper, plastics, and rubber. Fuller's earth was used primarily in pesticides and

fertilizers. Clays were used in pesticides and fertilizers as either thickeners, carriers, diluents, or prilling agents. Bentonites were used mainly in animal feeds.

Of the total clay produced, 12% was used in filler applications; of this, kaolin accounted for 86%; fuller's earth, 7%; bentonite, 3%; and ball clay, common clay and shale, and fire clay, 4%. Kaolin consumed as fillers decreased 14% to 4.4 million tons. Use of paper-coating-grade kaolin increased 4%, and the use of paper-filler-grade kaolin decreased 22%. These two categories accounted for 71% of the total filler and extender category. (See table 21.)

**Absorbent Uses.**--Absorbent uses for clays accounted for about 2.4 million tons or 5% of total clay consumption. Demand for absorbents increased 14%. Fuller's earth was the principal clay used for absorbent purposes. This application accounted for 88% of its entire output. Demand for clays in pet waste absorbents increased significantly. The use of fuller's earth in floor or oil and grease absorbents, chiefly to absorb hazardous oily substances, accounted for 16% of the absorbent demand. (See table 21.)

**Drilling Mud.**--Demand for clays in rotary-drilling muds decreased to about 724,000 tons and accounted for 2% of total clay production. Swelling-type bentonite remained the principal clay used in drilling mud mixes, although fuller's earth, used mostly in saltwater drilling techniques, and nonswelling sodium-activated bentonites were also used to a limited extent. Bentonite and fuller's earth accounted for 100% of the total amount of clay used in this category. (See table 21.)

*Floor and Wall Tile.*--Common clay and shale, ball clay, and kaolin, in order of volume, were used in manufacturing floor, wall, and quarry tile. This end-use category accounted for 19% of the total clay production. (See table 21.)

*Pelletizing Iron Ore.*--Bentonite continued to be used as a binder in forming indurated iron ore pellets. Demand decreased 2% to 717,000 tons. (See table 21.)

*Ceramics and Glass.*--Total demand for clay in the manufacture of pottery, sanitaryware, china and dinnerware, and related products (excluding clay flower pots) accounted for 3% of the total clay output. This demand, principally ball and kaolin clays, decreased 28% to 1.01 million tons. The downturn in new residential housing construction, large consumers of whiteware and sanitaryware, was partially offset by the strong demand for these products in the remodeling areas. (See table 21.)

## World Review

*Capacity.*--The data in tables 28, 29, and 30 are rated capacity for mines as of December 31, 1991. Rated capacity is defined as the maximum quantity of product that can be produced on a normally sustainable long-term operating rate based on physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

Mine capacity for domestic clay production was aggregated from data voluntarily supplied by producers. The rated capacity data for the foreign mines were estimated from previous years' production in cooperation with the Division of International Minerals. (See table 31, 32, 33)

*Czechoslovakia.*--Czechoslovakia produces bentonite and kaolin. Bentonite is produced primarily from North and West Bohemia. Bentonite is used in metallurgical, oil drilling, and paint applications. Czechoslovakia is the sixth largest producer of kaolin. Five grades of kaolin are produced: chinaware or porcelain grade, ceramics grade, paper grade, titaniferous grade, and feldspathic grade.<sup>18</sup>

*Egypt.*--A kaolin deposit with estimated reserves of 30 million tons has been discovered in the Kalbafha district by the Geological Survey and Minerals Projects Authority.<sup>19</sup>

*Finland.*--Engelhard Corp. announced plans to construct a plant for blending imported kaolin near Kotka. The plant will be able to provide papermakers with 40,000 tons of hydrated calcined kaolin per year.<sup>20</sup>

*France.*--Coframines acquired a majority shareholding in Kaolins d'Arvor. Kaolins d'Arvor operates a mine and processing plant near Lorient. The company produces kaolin for paper and ceramics applications. Production capacity is 32,000 tons per year.<sup>21</sup>

Societe Kaoliniere Armoricaire (SOKA) mines kaolin from a deposit near Quessoy. The deposit consists of two kaolin layers, a white layer and a grey

layer containing 0.2% organics. A mixture of 20% white kaolin and 80% grey kaolin is used for ceramic applications. The kaolin is washed and sized using hydrocyclones. The slurry is thickened and dried to about 30% moisture content. Driers reduce the final water content to about 12%. Besides ceramics applications, the company also produces kaolin for adhesive, animal feed, fertilizer, insecticide, and rubber applications.<sup>22</sup>

*Germany.*--The Fuchs-Ton Division of Watts, Blake, Bearne & Co. PLC acquired a major share in the clay operations of Didier-Werke AG. The acquisition is expected to increase the company's clay sales by one third. The clays are sold to the wall tile, floor tile, refractory, pipe, brick, and tableware industries.<sup>23</sup>

Redland PLC, through its German subsidiary Braas, began negotiations for the purchase of brickworks and clay reserves in eastern Germany. The company will build a clay tile plant to supply the growing roof tile market.<sup>24</sup>

*Spain.*--Spain currently produces attapulgite, ball clay, bentonite, kaolin, and sepiolite. Attapulgite and sepiolite are mined by nine companies. Attapulgite is sold primarily for animal feed and salt water drilling applications. Some of the major applications for sepiolite are pet litter, animal feed products, catalysts, absorbents, fertilizers, and fillers. There is only one major producer of bentonite, Minas de Gador SA. The company mines calcium bentonite in Almeria and Madrid. Untreated, ion-exchanged, and acid activated bentonites are produced for foundry applications, vegetable oil bleaching, animal feed, ceramic, and wine clarification. Ball clay is produced by SA Minera Catalono-Aragonesa for applications such as stoneware,

bricks, and roof tiles. Kaolin is produced by six companies, primarily for paper, glass, and ceramic applications.<sup>25</sup>

*United Kingdom.*--Laporte PLC announced plans to construct a clay processing facility in Cheshire. The plant capacity will be 200,000 tons per year of activated earth-based material and absorbent granules.<sup>26</sup>

#### Current Research

The Bureau of Mines completed a study of the bonding mechanism between montmorillonite and high molecular weight polymers using infra-red spectrophotometry. High molecular weight polymers such as polyacrylamide (PAM) and polyethylene oxide (PEO) are used as flocculating agents. The results suggested that PAM was adsorbed to the clay by nitrogen atom of the polymer. PEO was bonded to the clay through a water bridge. PEO was thought to be adsorbed directly onto the surface of the bentonite.<sup>27</sup>

#### OUTLOOK

U.S. clay demand between 1982 and 1992 has rebounded slowly from 32 million to 44 million tons. This is well below the levels of the early 1970's. In general, there has been a decrease in construction activity in the public, private, and commercial sectors. Higher mortgage rates in the late 1970's and early 1980's and the limited availability of affordable housing and funds for public and business ventures contributed to the problem. The slow economy of recent years continued to depress construction activities despite declining interest rates. Demand for common clay and shale, which are strongly tied to

the construction industry, has declined over the past 10 years. Kaolin, ball clay, and fuller's earth have fared better than their common clay and shale counterparts because they are used in more diversified applications and industries. Domestic demand for specialty clays should remain strong in the near future.

The weak U.S. dollar in the latter part of the decade encouraged specialty clays producers to expand their share of export markets. Exports of domestic clays, mostly kaolin, bentonite, ball clay, and fuller's earth, are restricted to the higher valued specially treated varieties for use in drilling muds, paper-coating, and iron ore pelletizing and by the foundry industry. Export markets should continue to remain strong in the near future. Imports of clays, except for English china and ball clays and acid-activated bentonites, are minor. The English clays enjoy a small prestige-dictated market, while the activated clays are confined to use in the Southern and Northern States.

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Table 1.--Salient U.S. clays and clay products statistics<sup>1/</sup>  
(Thousand metric tons and thousand dollars)

|                                                | 1987        | 1988        | 1989        | 1990        | 1991        |
|------------------------------------------------|-------------|-------------|-------------|-------------|-------------|
| Domestic clays sold or used by producers:      |             |             |             |             |             |
| Quantity.....                                  | 43,234      | 44,515      | 42,254      | 42,904      | 44,092      |
| Value.....                                     | \$1,202,284 | \$1,390,908 | \$1,515,300 | \$1,619,824 | \$1,505,423 |
| Exports:                                       |             |             |             |             |             |
| Quantity.....                                  | 3,023       | 3,535       | 3,755       | 4,123       | 3,997       |
| Value.....                                     | \$512,964   | \$516,566   | \$550,343   | \$584,404   | \$590,174   |
| Imports for consumption:                       |             |             |             |             |             |
| Quantity.....                                  | 34          | 33          | 28          | 30          | 35          |
| Value.....                                     | \$9,392     | \$8,835     | \$10,928    | \$11,988    | \$13,249    |
| Clay refractories shipments: Value.....        | r/\$739,770 | r/\$813,739 | r/\$823,266 | \$802,530   | NA          |
| Clay construction products shipments: Value--- | \$1,782,023 | \$1,927,000 | \$1,786,000 | \$1,775,000 | \$1,418,000 |

r/Revised. NA Not available.

1/Excludes Puerto Rico.

Table 2.-Clays sold or used by producers in the United States1/ in 1991, by State  
(Thousand metric tons and thousand dollars)

| State          | Ball<br>clay | Ben-<br>tonite | Common<br>clay<br>and shale | Fire<br>clay | Fuller's<br>earth | Kaolin | Total2/<br>Total1  | Total<br>value    |
|----------------|--------------|----------------|-----------------------------|--------------|-------------------|--------|--------------------|-------------------|
| Alabama        | --           | W              | 2,044                       | 81           | --                | W      | 3/ 4/2,124 ✓       | 3/ 4/22,104       |
| Arizona        | --           | 35             | 193                         | --           | --                | --     | 228                | 3,830             |
| Arkansas       | --           | --             | 645                         | W            | --                | 212    | 5/857              | 5/8,048           |
| California     | --           | 147            | 1,815                       | --           | W                 | 113    | 6/2,075 ✓          | 6/27,463          |
| Colorado       | --           | W              | 261                         | 3            | --                | --     | 3/264              | 3/1,964           |
| Connecticut    | --           | --             | W                           | --           | --                | --     | W                  | W                 |
| Florida        | --           | --             | W                           | --           | 332               | 31     | 7/363              | 7/39,150          |
| Georgia        | --           | --             | 1,382                       | --           | 617               | 7,519  | 9,518 ✓            | 949,737           |
| Idaho          | --           | --             | W                           | --           | --                | 1      | 7/1                | W                 |
| Illinois       | --           | --             | 514                         | --           | 421               | --     | 935                | 38,877            |
| Indiana        | W            | --             | 930                         | --           | --                | --     | 8/930              | 8/3,516           |
| Iowa           | --           | --             | 530                         | --           | --                | --     | 530                | 2,226             |
| Kansas         | --           | --             | 607                         | --           | --                | --     | 607                | 2,828             |
| Kentucky       | W            | --             | 708                         | --           | --                | --     | 8/708              | 8/2,942           |
| Louisiana      | --           | --             | 360                         | --           | --                | --     | 360                | 3,646             |
| Maine          | --           | --             | W                           | --           | --                | --     | W                  | W                 |
| Maryland       | --           | --             | 259                         | --           | --                | --     | 259                | 1,141             |
| Massachusetts  | --           | --             | W                           | --           | --                | --     | W                  | W                 |
| Michigan       | --           | --             | 2,062                       | --           | --                | --     | 2,062              | 8,770             |
| Minnesota      | --           | --             | W                           | --           | --                | W      | W                  | W                 |
| Mississippi    | W            | 211            | 648                         | --           | 313               | W      | 4/ 8/1,172 ✓       | 4/ 8/34,382       |
| Missouri       | --           | --             | 1,751                       | 251          | W                 | --     | 6/2,002            | 6/11,059          |
| Montana        | --           | 320            | 42                          | --           | --                | --     | 363                | 11,332            |
| Nebraska       | --           | --             | 198                         | --           | --                | --     | 198                | 909               |
| Nevada         | --           | 16             | --                          | --           | W                 | W      | 4/ 6/16            | 4/ 6/3,204        |
| New Hampshire  | --           | --             | W                           | --           | --                | --     | W                  | W                 |
| New Jersey     | --           | --             | W                           | W            | --                | --     | W                  | W                 |
| New Mexico     | --           | --             | 28                          | W            | --                | --     | 5/28               | 5/74              |
| New York       | --           | --             | 421                         | --           | --                | --     | 421                | 2,417             |
| North Carolina | --           | --             | 2,064                       | --           | --                | W      | 4/2,064 ✓          | 4/9,015           |
| North Dakota   | --           | --             | 28                          | --           | --                | --     | 28                 | W                 |
| Ohio           | --           | --             | 2,116                       | 89           | --                | --     | 2,205 ✓            | 11,016            |
| Oklahoma       | --           | --             | 824                         | --           | --                | --     | 824                | 4,178             |
| Oregon         | --           | 19             | 194                         | --           | --                | --     | 213                | 1,086             |
| Pennsylvania   | --           | --             | 701                         | W            | --                | W      | 4/ 5/701           | 4/ 5/2,890        |
| Puerto Rico    | --           | --             | 145                         | --           | --                | --     | 145                | 335               |
| South Carolina | --           | --             | 1,154                       | --           | --                | 555    | 1,709              | 25,663            |
| South Dakota   | --           | --             | W                           | --           | --                | --     | W                  | W                 |
| Tennessee      | 514          | --             | W                           | --           | 314               | W      | 4/ 7/829           | 4/ 7/44,573       |
| Texas          | W            | W              | 2,266                       | --           | W                 | W      | 3/ 4/ 6/ 8/2,266 ✓ | 3/ 4/ 6/ 8/13,247 |
| Utah           | --           | W              | 210                         | --           | --                | --     | 3/210              | 3/1,028           |
| Virginia       | --           | --             | 723                         | --           | W                 | --     | 6/723              | 6/3,248           |
| Washington     | --           | --             | 263                         | --           | --                | --     | 263                | 2,633             |
| West Virginia  | --           | --             | 134                         | --           | --                | --     | 134                | 322               |
| Wyoming        | --           | 2,496          | W                           | --           | --                | --     | 7/2,496 ✓          | 7/81,573          |
| Undistributed  | 270          | 187            | 1,010                       | 51           | 743               | 1,144  | 3,404              | 124,996           |
| Total2/.....   | 784          | 3,432          | 27,233                      | 474          | 2,740             | 9,575  | 44,237             | 1,505,423         |

Withheld to avoid disclosing company proprietary data; included with "Total" and/or "Undistributed."

- 1/Includes Puerto Rico.
- 2/Data may not add to totals shown because of independent rounding.
- 3/Excludes bentonite.
- 4/Excludes kaolin.
- 5/Excludes fire clay.
- 6/Excludes fuller's earth.
- 7/Excludes common clay.
- 8/Excludes ball clay.

Table 3...Number of mines from which producers sold or used clays in the United States<sup>1/</sup> 2/ in 1991, by State

| State               | Ball<br>clay | Ben-<br>tonite | Common<br>clay<br>and shale | Fire<br>clay | Fuller's<br>earth | Kaolin | Total |
|---------------------|--------------|----------------|-----------------------------|--------------|-------------------|--------|-------|
| Alabama.....        | ..           | 1              | 28                          | 5            | ..                | 19     | 53    |
| Arizona.....        | ..           | 3              | 6                           | ..           | ..                | ..     | 9     |
| Arkansas.....       | ..           | ..             | 18                          | 2            | ..                | 3      | 23    |
| California.....     | 1            | 7              | 39                          | ..           | 2                 | 4      | 53    |
| Colorado.....       | ..           | 1              | 27                          | 3            | ..                | ..     | 31    |
| Connecticut.....    | ..           | ..             | 2                           | ..           | ..                | ..     | 2     |
| Florida.....        | ..           | ..             | 3                           | ..           | 5                 | 1      | 9     |
| Georgia.....        | ..           | ..             | 14                          | ..           | 9                 | 73     | 96    |
| Idaho.....          | ..           | 1              | 1                           | ..           | ..                | 2      | 4     |
| Illinois.....       | ..           | ..             | 9                           | ..           | 4                 | ..     | 13    |
| Indiana.....        | 1            | ..             | 13                          | ..           | ..                | 1      | 15    |
| Iowa.....           | ..           | ..             | 12                          | ..           | ..                | ..     | 12    |
| Kansas.....         | ..           | 1              | 23                          | ..           | ..                | ..     | 24    |
| Kentucky.....       | 7            | ..             | 14                          | 1            | ..                | ..     | 22    |
| Louisiana.....      | ..           | ..             | 8                           | ..           | ..                | ..     | 8     |
| Maine.....          | ..           | ..             | 3                           | ..           | ..                | ..     | 3     |
| Maryland.....       | ..           | ..             | 7                           | ..           | ..                | ..     | 7     |
| Massachusetts.....  | ..           | ..             | 2                           | ..           | ..                | ..     | 2     |
| Michigan.....       | ..           | ..             | 8                           | ..           | ..                | ..     | 8     |
| Minnesota.....      | ..           | ..             | 1                           | ..           | ..                | 2      | 3     |
| Mississippi.....    | 1            | 3              | 16                          | ..           | 3                 | ..     | 23    |
| Missouri.....       | ..           | 1              | 11                          | 44           | 4                 | ..     | 60    |
| Montana.....        | ..           | 5              | 6                           | 1            | ..                | ..     | 12    |
| Nebraska.....       | ..           | ..             | 5                           | ..           | ..                | ..     | 5     |
| Nevada.....         | ..           | 8              | ..                          | ..           | 2                 | 2      | 12    |
| New Hampshire.....  | ..           | ..             | 1                           | ..           | ..                | ..     | 1     |
| New Jersey.....     | ..           | ..             | 1                           | 1            | ..                | ..     | 2     |
| New Mexico.....     | ..           | ..             | 4                           | 2            | ..                | ..     | 6     |
| New York.....       | ..           | ..             | 9                           | ..           | ..                | ..     | 9     |
| North Carolina..... | ..           | ..             | 46                          | ..           | ..                | 2      | 48    |
| North Dakota.....   | ..           | ..             | 3                           | ..           | ..                | ..     | 3     |
| Ohio.....           | ..           | ..             | 49                          | 6            | ..                | ..     | 55    |
| Oklahoma.....       | ..           | ..             | 21                          | ..           | ..                | ..     | 21    |
| Oregon.....         | ..           | 11             | 7                           | ..           | ..                | ..     | 18    |
| Pennsylvania.....   | ..           | ..             | 29                          | 4            | ..                | 1      | 34    |
| Puerto Rico.....    | ..           | ..             | 2                           | ..           | ..                | ..     | 2     |
| South Carolina..... | ..           | ..             | 30                          | ..           | 1                 | 17     | 48    |
| South Dakota.....   | ..           | ..             | 1                           | ..           | ..                | ..     | 1     |
| Tennessee.....      | 23           | 10             | 67                          | 3            | 5                 | 1      | 34    |
| Texas.....          | 3            | 3              | 13                          | ..           | 1                 | ..     | 85    |
| Utah.....           | ..           | ..             | 14                          | ..           | ..                | ..     | 16    |
| Virginia.....       | ..           | ..             | 10                          | 6            | 1                 | ..     | 15    |
| Washington.....     | ..           | ..             | 3                           | ..           | ..                | ..     | 16    |
| West Virginia.....  | ..           | 89             | 3                           | ..           | ..                | ..     | 3     |
| Wyoming.....        | ..           | ..             | 3                           | ..           | ..                | ..     | 92    |
| Total.....          | 36           | 144            | 595                         | 78           | 37                | 128    | 1,018 |

<sup>1/</sup>Includes both active and idle operations.

<sup>2/</sup>Includes Puerto Rico.

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Table 4.--Kaolin sold or used by producers in the United States, by State

| State               | 1990                       |                      | 1991                       |                      |
|---------------------|----------------------------|----------------------|----------------------------|----------------------|
|                     | Metric tons<br>(Thousands) | Value<br>(Thousands) | Metric tons<br>(Thousands) | Value<br>(Thousands) |
| Arkansas.....       | 284                        | \$18,779             | 212                        | \$5,416              |
| California.....     | 122                        | 4,995                | 113                        | 4,865                |
| Florida.....        | 38                         | W                    | 31                         | 3,552                |
| Georgia.....        | r/7,043                    | r/862,295            | 7,519                      | 862,866              |
| South Carolina..... | 1,231                      | 42,409               | 555                        | 23,437               |
| Other1/.....        | 425                        | 25,388               | 1,145                      | 21,758               |
| Total.....          | r/9,143                    | r/953,866            | 9,575                      | 921,894              |

r Revision. W Withheld to avoid disclosing company proprietary data; included in "Other."  
 1/Includes Alabama, Idaho, Minnesota, Mississippi, Nevada, North Carolina, Pennsylvania, Tennessee, and Texas.

Table 5.--Kaolin sold or used by producers in the United States, by kind

| Kind              | 1990                       |                      | 1991                       |                      |
|-------------------|----------------------------|----------------------|----------------------------|----------------------|
|                   | Metric tons<br>(Thousands) | Value<br>(Thousands) | Metric tons<br>(Thousands) | Value<br>(Thousands) |
| Air-float.....    | 1,451                      | \$84,576             | 1,142                      | \$63,654             |
| Calcined1/.....   | r/1,385                    | r/287,792            | 2,444                      | 290,990              |
| Delaminated.....  | r/1,221                    | r/148,420            | 996                        | 110,997              |
| Unprocessed.....  | 1,246                      | 17,337               | 807                        | 12,483               |
| Water-washed..... | r/3,840                    | r/415,740            | 4,186                      | 443,769              |
| Total2/.....      | 9,143                      | 953,866              | 9,575                      | 921,894              |

r Revision.

1/Includes both low-temperature filler and high-temperature refractory grades.

2/Data may not add to totals shown because of independent rounding.

Table 6.--Calcined kaolin sold or used by producers in the United States, by State

| State                    | High-temperature           |                      | Low-temperature            |                      |
|--------------------------|----------------------------|----------------------|----------------------------|----------------------|
|                          | Metric tons<br>(Thousands) | Value<br>(Thousands) | Metric tons<br>(Thousands) | Value<br>(Thousands) |
| 1990                     |                            |                      |                            |                      |
| Alabama and Georgia..... | 553                        | \$70,362             | 1/473                      | r/ 1/\$188,109       |
| Other.....               | r/ 2/208                   | r/ 2/17,400          | 3/152                      | 3/11,921             |
| Total.....               | r/761                      | r/87,762             | r/625                      | r/200,030            |
| 1991                     |                            |                      |                            |                      |
| Alabama and Georgia..... | 1,509                      | 32,417               | 1/718                      | 1/245,240            |
| Other.....               | 2/110                      | 2/4,292              | 3/107                      | 3/9,041              |
| Total.....               | 1,619                      | 36,709               | 825                        | 254,281              |

r Revision.

1/Excludes Alabama.

2/Includes Arkansas, California, Colorado, Idaho, and South Carolina.

3/Includes Arkansas, Pennsylvania, and South Carolina.

Table 7.--Georgia kaolin sold or used by producers, by kind

| Kind              | 1990                       |                      | 1991                       |                      |
|-------------------|----------------------------|----------------------|----------------------------|----------------------|
|                   | Metric tons<br>(Thousands) | Value<br>(Thousands) | Metric tons<br>(Thousands) | Value<br>(Thousands) |
| Air-float.....    | 863                        | \$40,346             | 702                        | \$34,790             |
| Calcined1/.....   | r/975                      | r/252,959            | 1,500                      | 269,457              |
| Delaminated.....  | r/1,221                    | r/148,420            | 996                        | 110,997              |
| Unprocessed.....  | 231                        | 9,140                | 178                        | 5,589                |
| Water-washed..... | r/3,752                    | r/411,431            | 4,144                      | 442,032              |
| Total2/.....      | r/7,043                    | r/862,295            | 7,519                      | 862,866              |

r Revision.

1/Includes both low-temperature filler and high-temperature refractory grades.

2/Data may not add to totals shown because of independent rounding.

Table 8.--Georgia kaolin sold or used by producers, by use  
(Thousand metric tons)

| Use                                                                                                                                     | 1990          |                    |                    |         | 1991          |                    |                    |         |
|-----------------------------------------------------------------------------------------------------------------------------------------|---------------|--------------------|--------------------|---------|---------------|--------------------|--------------------|---------|
|                                                                                                                                         | Air-<br>float | Unpro-<br>cessed1/ | Water-<br>washed2/ | Total3/ | Air-<br>float | Unpro-<br>cessed1/ | Water-<br>washed2/ | Total3/ |
| <b>Domestic:</b>                                                                                                                        |               |                    |                    |         |               |                    |                    |         |
| Adhesives.....                                                                                                                          | 21            | --                 | 21                 | 42      | W             | --                 | 26                 | 26      |
| Aluminum sulfate and other chemicals.....                                                                                               | --            | W                  | --                 | W       | --            | W                  | --                 | W       |
| Asphalt tile and linoleum.....                                                                                                          | W             | r/W                | --                 | W       | W             | W                  | --                 | W       |
| Catalysts (oil-refining).....                                                                                                           | r/W           | --                 | 38                 | r/38    | W             | --                 | 35                 | 35      |
| Face brick.....                                                                                                                         | --            | 9                  | --                 | 9       | --            | 4                  | --                 | 4       |
| Fiberglass and mineral wool.....                                                                                                        | 199           | --                 | r/W                | r/199   | 223           | --                 | W                  | 223     |
| Fine china and dinnerware; crockery and earthenware.....                                                                                | r/10          | --                 | --                 | r/10    | W             | --                 | W                  | W       |
| Firebrick, blocks and shapes.....                                                                                                       | W             | 7                  | --                 | 7       | W             | 9                  | --                 | 9       |
| Grogs and calcines, refractory.....                                                                                                     | W             | W                  | W                  | W       | W             | W                  | W                  | W       |
| Medical, pharmaceutical, cosmetic.....                                                                                                  | W             | --                 | --                 | W       | W             | --                 | W                  | W       |
| Paint.....                                                                                                                              | 19            | --                 | 207                | 226     | W             | --                 | 200                | 200     |
| Paper coating.....                                                                                                                      | r/W           | --                 | r/2,442            | r/2,442 | --            | --                 | 2,604              | 2,604   |
| Paper filling.....                                                                                                                      | 147           | --                 | r/1,192            | r/1,339 | 147           | --                 | 905                | 1,052   |
| Plastics.....                                                                                                                           | 14            | --                 | r/32               | r/47    | W             | --                 | 50                 | 50      |
| Pottery.....                                                                                                                            | 25            | --                 | --                 | 25      | W             | --                 | --                 | W       |
| Refractories.....                                                                                                                       | 15            | r/W                | r/7                | r/22    | 7             | 23                 | 8                  | 38      |
| Roofing granules.....                                                                                                                   | W             | W                  | --                 | W       | W             | W                  | --                 | W       |
| Rubber.....                                                                                                                             | 13            | --                 | 46                 | 59      | 14            | --                 | 40                 | 55      |
| Sanitaryware.....                                                                                                                       | 39            | --                 | --                 | 39      | 33            | --                 | --                 | 33      |
| Miscellaneous, air-float:                                                                                                               |               |                    |                    |         |               |                    |                    |         |
| Common brick, fertilizers, gypsum products, pesticides and related products, roofing and structural tile, other uses not specified..... | r/271         | --                 | --                 | r/271   | 247           | --                 | --                 | 247     |
| Miscellaneous, unprocessed:                                                                                                             |               |                    |                    |         |               |                    |                    |         |
| Fertilizers, pesticides and related products, other uses not specified.....                                                             | --            | 718                | --                 | 718     | --            | 879                | --                 | 879     |
| Miscellaneous, water-washed:                                                                                                            |               |                    |                    |         |               |                    |                    |         |
| Gypsum products, ink, pesticides and related products, waterproofing and sealing, fertilizers, other uses not specified.....            | --            | --                 | r/199              | r/199   | --            | --                 | 185                | 185     |
| <b>Total3/-</b> .....                                                                                                                   | 774           | 733                | r/4,184            | r/5,692 | 671           | 915                | 4,053              | 5,639   |
| <b>Exports:</b>                                                                                                                         |               |                    |                    |         |               |                    |                    |         |
| Paint.....                                                                                                                              | --            | --                 | 26                 | 26      | --            | --                 | W                  | W       |
| Paper coating.....                                                                                                                      | r/W           | --                 | r/971              | r/971   | --            | W                  | 1,321              | 1,321   |
| Paper filling.....                                                                                                                      | 38            | --                 | r/191              | r/229   | --            | --                 | 386                | 386     |
| Rubber.....                                                                                                                             | --            | --                 | r/W                | r/W     | --            | --                 | 16                 | 16      |
| Undistributed.....                                                                                                                      | r/51          | (5/)               | 73                 | r/124   | 30            | 44                 | 83                 | 157     |
| <b>Total3/-</b> .....                                                                                                                   | 89            | (5/)               | r/1,262            | r/1,351 | 30            | 44                 | 1,805              | 1,880   |
| <b>Grand total3/-</b> .....                                                                                                             | 863           | 734                | r/5,446            | r/7,043 | 702           | 959                | 5,858              | 7,519   |

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r Revision. W Withheld to avoid disclosing company proprietary data; included in "Undistributed".

1/Includes high-temperature calcined.

2/Includes low-temperature calcined and delaminated.

3/Data may not add to totals shown because of independent rounding.

4/Includes electrical porcelain; floor and wall tile, ceramic; flue linings; glazes, glass, and enamels; high-alumina brick and specialties; kiln furniture; refractory mortar and cement.

5/Less than 1/2 unit.

Table 9.--South Carolina kaolin sold or used by producers, by kind

| Kind             | 1990                      |                     | 1991                      |                     |
|------------------|---------------------------|---------------------|---------------------------|---------------------|
|                  | Metric tons<br>(thousand) | Value<br>(thousand) | Metric tons<br>(thousand) | Value<br>(thousand) |
| Air-float.....   | 497                       | \$37,372            | 353                       | \$21,765            |
| Unprocessed..... | 734                       | 5,036               | 203                       | 1,672               |
| Total.....       | 1,231                     | 1/42,000            | 1/555                     | 23,437              |

r Revision.

1/Data do not add to total shown because of independent rounding.

Table 10.--South Carolina kaolin sold or used by producers, by kind and use  
(Thousand metric tons)

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| Kind and use                                      | 1990  | 1991  |
|---------------------------------------------------|-------|-------|
| Air-float:                                        |       |       |
| Adhesives-----                                    | 12    | W     |
| Animal feed and pet waste absorbent-----          | r/W   | W     |
| Ceramics1/-----                                   | 6     | 3     |
| Fertilizers, pesticides and related products----- | 19    | 8     |
| Fiberglass-----                                   | 135   | W     |
| Paint-----                                        | W     | W     |
| Paper coating and filling-----                    | 17    | 4     |
| Plastics-----                                     | W     | W     |
| Rubber-----                                       | 148   | 167   |
| Refractories2/-----                               | 7     | W     |
| Other uses3/-----                                 | r/92  | 144   |
| Exports4/-----                                    | 60    | 29    |
| Total-----                                        | 497   | 5/353 |
| Unprocessed: Face brick and other uses-----       | 734   | 203   |
| Grand total-----                                  | 1,231 | 5/555 |

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

1/Includes crockery and earthenware; electrical porcelain; fine china and dinnerware; floor and wall tile; pottery; and roofing granules.

2/Includes refractory calcines and grogs; firebrick, blocks and shapes; refractory mortar and cement; and high-alumina refractories.

3/Includes animal oil; catalysts (oil refining); chemical manufacturing; ink; medical; sewer pipe; and unknown uses.

4/Includes ceramics; adhesives; paper filling; pesticides and related products; and rubber.

5/ Data may not add to totals shown because of independent rounding.

Table 11.-- Kaolin sold or used by producers in the United State, by use  
(Thousand metric tons)

|                                                          | 1990 |               |                    |                    |         | 1991          |                    |                    |         |  |
|----------------------------------------------------------|------|---------------|--------------------|--------------------|---------|---------------|--------------------|--------------------|---------|--|
|                                                          | Use  | Air-<br>float | Unpro-<br>cessed1/ | Water-<br>washed2/ | Total3/ | Air-<br>float | Unpro-<br>cessed1/ | Water-<br>washed2/ | Total3/ |  |
| Domestic:                                                |      |               |                    |                    |         |               |                    |                    |         |  |
| Adhesives.....                                           |      | 33            | --                 | 22                 | 55      | 27            | --                 | 26                 | 52      |  |
| Aluminum sulfate and other chemicals.....                |      | --            | 136                | 72                 | 208     | --            | W                  | W                  | 170     |  |
| Animal feed.....                                         |      | W             | --                 | W                  | W       | W             | --                 | --                 | W       |  |
| Brick, extruded and other.....                           |      | W             | 220                | W                  | 291     | --            | 231                | W                  | 231     |  |
| Catalysts (oil and gas refining).....                    |      | 51            | --                 | 40                 | 91      | W             | --                 | 38                 | 38      |  |
| Cement, portland.....                                    |      | --            | 176                | --                 | 176     | --            | 180                | --                 | 180     |  |
| China and dinnerware.....                                |      | 18            | --                 | --                 | 18      | 15            | --                 | W                  | 15      |  |
| Crockery and other earthenware.....                      |      | 3             | --                 | --                 | 3       | 1             | --                 | W                  | 1       |  |
| Electrical porcelain.....                                |      | 14            | --                 | 2                  | 16      | 6             | --                 | 3                  | 9       |  |
| Fertilizers.....                                         |      | W             | --                 | W                  | 3       | W             | --                 | W                  | 5       |  |
| Fiberglass, mineral wool and other insulation.....       |      | 369           | --                 | 85                 | 454     | 328           | W                  | W                  | 400     |  |
| Firebrick, blocks and shapes.....                        |      | 63            | 67                 | W/5                | W/135   | 67            | 59                 | --                 | 126     |  |
| Floor and wall tile, ceramic; glazes, glass, enamels.... |      | W             | W                  | W                  | W       | W             | W                  | W                  | W       |  |
| Flue linings, high-alumina brick and specialties.....    |      | W             | W                  | W                  | W       | --            | --                 | W                  | W       |  |
| Foundry sand.....                                        |      | W             | W                  | W                  | 1       | --            | --                 | W                  | W       |  |
| Grog and calcines, refractory.....                       |      | W             | 756                | W                  | 759     | W             | 1,633              | W                  | 1,633   |  |
| Gypsum products and wallboard.....                       |      | W             | W                  | W                  | W       | W             | W                  | W                  | 3       |  |
| Ink.....                                                 |      | --            | --                 | W                  | W       | --            | --                 | 7                  | 7       |  |
| Kiln furniture; refractory mortar and cement.....        |      | W             | --                 | W                  | W       | W             | --                 | --                 | W       |  |
| Linoleum and asphalt tile.....                           |      | W             | --                 | W                  | W       | W             | --                 | W                  | W       |  |
| Medical, pharmaceutical, cosmetic.....                   |      | 3             | --                 | (5/)               | 3       | W             | --                 | --                 | 1       |  |
| Paint.....                                               |      | 20            | 3                  | 238                | 261     | 3             | W                  | 225                | 228     |  |
| Paper coating.....                                       |      | 54            | --                 | W/2,442            | W/2,496 | W             | --                 | 2,604              | 2,604   |  |
| Paper filling.....                                       |      | 164           | --                 | W/1,193            | W/1,358 | 152           | --                 | 905                | 1,057   |  |
| Pesticides and related products.....                     |      | 19            | --                 | 31                 | 50      | 7             | --                 | 16                 | 23      |  |
| Plastics.....                                            |      | 21            | --                 | W/32               | W/54    | 5             | --                 | 50                 | 55      |  |
| Pottery.....                                             |      | 28            | --                 | --                 | 28      | 22            | --                 | --                 | 22      |  |
| Roofing granules.....                                    |      | W             | W                  | --                 | 10      | W             | W                  | --                 | 11      |  |
| Rubber.....                                              |      | 161           | 1                  | 46                 | 208     | 181           | W                  | 40                 | 221     |  |
| Sanitaryware.....                                        |      | 41            | --                 | --                 | 41      | 35            | --                 | --                 | 35      |  |
| Waterproofing and sealing.....                           |      | --            | --                 | W                  | W       | W             | --                 | W                  | W       |  |
| Miscellaneous.....                                       |      | 222           | 647                | W/214              | W/997   | 219           | 272                | 288                | 516     |  |
| Total3/.....                                             |      | 1,284         | 2,006              | W/4,423            | W/7,713 | 1,068         | 2,374              | 4,201              | 7,643   |  |
| Exports:                                                 |      |               |                    |                    |         |               |                    |                    |         |  |
| Ceramics.....                                            |      | W/42          | --                 | W/4                | W/42    | 44            | --                 | 47                 | 91      |  |
| Foundry sand, grogs and calcines; other refractories.... |      | --            | --                 | --                 | --      | --            | 6                  | --                 | 6       |  |
| Paint.....                                               |      | --            | --                 | W/26               | 26      | --            | --                 | W                  | W       |  |
| Paper coating.....                                       |      | W/4           | --                 | W/971              | W/971   | --            | --                 | 1,321              | 1,321   |  |
| Paper filling.....                                       |      | 39            | --                 | W/191              | W/230   | --            | --                 | 386                | 386     |  |
| Rubber.....                                              |      | 60            | --                 | W/4                | W/60    | 29            | --                 | 16                 | 45      |  |
| Miscellaneous.....                                       |      | 26            | (5/)               | W/75               | W/102   | 1             | 44                 | 37                 | 83      |  |
| Total3/.....                                             |      | 167           | (5/)               | W/1,263            | W/1,430 | 74            | 51                 | 1,807              | 1,931   |  |
| Grand total3/.....                                       |      | 1,451         | 2,007              | W/5,686            | W/9,143 | 1,142         | 2,425              | 6,008              | 9,575   |  |

✓ r Revision. W Withheld to avoid disclosing proprietary data; included with "Total" and/or "miscellaneous".

✓ 1/Includes high-temperature calcined.

2/Includes low-temperature calcined and delaminated.

3/Data may not add to totals shown because of independent rounding.

4/Includes soil conditioners and mulches.

5/Less than 1/2 unit.

Table 12.-- Price quotations for kaolin and ball clay, 1991

|                                                                                                      | Per metric ton |
|------------------------------------------------------------------------------------------------------|----------------|
| <b>Kaolin</b>                                                                                        |                |
| Water-washed, fully calcined bags, carload lots, f.o.b. Georgia per ton                              | 323.00         |
| Calcined, paper-grade, same basis, per ton                                                           | 470.00         |
| Paper-grade, uncalcined, bulk, carload lots, f.o.b. Georgia, per ton:                                |                |
| No. 1 coating                                                                                        | 110.00         |
| No. 2 coating                                                                                        | 87.00          |
| No. 3 coating                                                                                        | 85.00          |
| No. 4 coating                                                                                        | 82.00          |
| Filler, general purpose, same basis per ton                                                          | 64.00          |
| Delaminated, water-washed, uncalcined, painted-grade, 1-micrometer average, same basis, per ton      | 284.00         |
| Dry-ground, air-floated, soft, same basis per ton                                                    | 52.00          |
| National Formulary, powder, colloidal, bacteria controlled, 50-pound bags, 5,000-pound lots, per ton | 273.00         |
| <b>Ball clay</b>                                                                                     |                |
| Domestic, air-floated, bags, carload lots Tennessee, per ton                                         | 49.00          |
| Domestic, crushed, moisture-repellent, bulk carload lots, Tennessee, per ton                         | 24.00          |

Source: Chemical Marketing Reporter, V. 240, No. 26, Jan. 6, 1992, pp. 26-36.

Table 13.--Ball clay sold or used by producers in the United States, by State

| State          | Air-float                 |                     | Water-slurried            |                     | Unprocessed               |                     | Total                     |                     |
|----------------|---------------------------|---------------------|---------------------------|---------------------|---------------------------|---------------------|---------------------------|---------------------|
|                | Metric tons<br>(thousand) | Value<br>(thousand) | Metric tons<br>(thousand) | Value<br>(thousand) | Metric tons<br>(thousand) | Value<br>(thousand) | Metric tons<br>(thousand) | Value<br>(thousand) |
| 1990           |                           |                     |                           |                     |                           |                     |                           |                     |
| Tennessee..... | 261                       | \$12,904            | 130                       | \$5,476             | 153                       | \$4,291             | 544                       | \$22,671            |
| Other 1/.....  | 160                       | 8,106               | --                        | --                  | 84                        | 2,679               | 244                       | 10,786              |
| Total 2/.....  | 421                       | 21,010              | 130                       | 5,476               | 236                       | 6,970               | 788                       | 33,456              |
| 1991           |                           |                     |                           |                     |                           |                     |                           |                     |
| Tennessee..... | 231                       | 11,597              | 129                       | 5,610               | 154                       | 4,418               | 514                       | 21,625              |
| Other 1/.....  | 128                       | 6,887               | --                        | --                  | 141                       | 4,909               | 270                       | 11,796              |
| Total 2/.....  | 360                       | 18,483              | 129                       | 5,610               | 295                       | 9,327               | 784                       | 33,421              |

1/Includes Indiana, Kentucky, Mississippi, and Texas.

2/Data may not add to totals shown because of independent rounding.

Table 14.--Ball clay sold or used by producers in the United States, by use  
(Thousand metric tons)

| Use                                    | 1990          |                    |                  |       | 1991          |                    |                  |       |
|----------------------------------------|---------------|--------------------|------------------|-------|---------------|--------------------|------------------|-------|
|                                        | Air-<br>float | Water-<br>slurried | Un-<br>processed | Total | Air-<br>float | Water-<br>slurried | Un-<br>processed | Total |
| Ceramics1/.....                        | W             | ..                 | W                | 12    | W             | ..                 | W                | 9     |
| Dinnerware2/.....                      | 100           | ..                 | W                | 100   | 89            | ..                 | 28               | 117   |
| Fillers, extenders, and binders3/..... | 101           | ..                 | 1                | 103   | 102           | ..                 | 18               | 120   |
| Floor and wall tile.....               | 35            | 12                 | 112              | 158   | 16            | W                  | 132              | 148   |
| Refractories4/.....                    | 39            | W                  | 1                | 40    | 32            | W                  | 6                | 38    |
| Sanitaryware.....                      | W             | 107                | 52               | 158   | W             | 110                | 45               | 155   |
| Miscellaneous.....                     | 72            | W                  | 54               | 127   | 54            | 19                 | 43               | 107   |
| Exports.....                           | 74            | ..                 | 17               | 91    | 67            | ..                 | 23               | 90    |
| Total5/.....                           | 421           | 130                | 236              | 788   | 360           | 129                | 295              | 784   |

W Withheld to avoid disclosing company proprietary data; included in "Total" and/or "Miscellaneous."

1/Includes catalyst (oil refining); fiberglass; glazes, glass, and enamels.

2/Includes crockery and other earthenware; fine china and dinnerware.

3/Includes animal feed; asphalt emulsions, asphalt tile; pesticides and related products; rubber; wallboard, other uses not specified.

4/Includes electrical porcelain; firebrick, block and shapes; high-alumina brick and specialties.

5/Data may not add to totals shown because of independent rounding.

Table 15.--Fire clay<sup>1/</sup> sold or used by producers in the United States, by State

| State                     | 1990                      |                     | 1991                      |                     |
|---------------------------|---------------------------|---------------------|---------------------------|---------------------|
|                           | Metric tons<br>(Thousand) | Value<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) |
| Alabama.....              | 96                        | \$3,981             | 81                        | \$3,494             |
| Colorado.....             | ..                        | ..                  | 3                         | 26                  |
| Missouri.....             | 283                       | 7,652               | 251                       | 5,476               |
| New Jersey.....           | W                         | W                   | W                         | W                   |
| New Mexico.....           | W                         | W                   | W                         | W                   |
| Ohio.....                 | 226                       | 4,038               | 89                        | 2,844               |
| Pennsylvania.....         | W                         | W                   | ..                        | ..                  |
| Other.....                | 21                        | 458                 | 51                        | 1,338               |
| Total <sup>2/</sup> ..... | 626                       | 16,128              | 474                       | 13,178              |

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

<sup>1/</sup>Refractory uses only.

Table 16.--Bentonite sold or used by producers in the United States, by State

| State                   | 1990                      |                           |                     | 1991                      |                           |                     | 1992                      |                           |                     |
|-------------------------|---------------------------|---------------------------|---------------------|---------------------------|---------------------------|---------------------|---------------------------|---------------------------|---------------------|
|                         | Nonswelling               | Swelling                  | Total               | Nonswelling               | Swelling                  | Total               | Nonswelling               | Swelling                  | Total               |
|                         | Metric tons<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) | Metric tons<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) | Metric tons<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) |
| Alabama and Mississippi | 411                       | --                        | \$17,217            | 281                       | U                         | 9,337               | 17                        | U                         | 1,378               |
| Arizona                 | 38                        | (1/)                      | 11,403              | 129                       | U                         | 11,176              | 7                         | U                         | --                  |
| California              | 136                       | (1/)                      | 17                  | U                         | U                         | 17                  | U                         | U                         | 11,176              |
| Colorado                | --                        | (1/)                      | U                   | U                         | U                         | U                   | U                         | U                         | U                   |
| Nevada                  | U                         | U                         | U                   | U                         | U                         | U                   | U                         | U                         | U                   |
| Oregon                  | --                        | U                         | U                   | U                         | U                         | U                   | U                         | U                         | U                   |
| Utah                    | U                         | U                         | U                   | U                         | U                         | U                   | U                         | U                         | U                   |
| Wyoming                 | --                        | U                         | U                   | U                         | U                         | U                   | U                         | U                         | U                   |
| Other/                  | 47                        | 2,954                     | 2,524               | 47                        | 2,496                     | 2,496               | 47                        | 1,031                     | 1,031               |
| Total/                  | 632                       | 31,575                    | 2,842               | 475                       | 22,969                    | 2,957               | 102,420                   | 3,432                     | 125,389             |

U Withheld to avoid disclosing company proprietary data; included in "Other."

1/Less than 1/2 unit.

2/Includes Montana and Texas.

3/Data may not add to totals shown because of independent rounding.

Table 17.--Bentonite sold or used by producers in the United States, by use  
(Thousand metric tons)

| Use                                    | 1990             |              |              | 1991             |              |              |
|----------------------------------------|------------------|--------------|--------------|------------------|--------------|--------------|
|                                        | Non-<br>swelling | Swelling     | Total1/      | Non-<br>swelling | Swelling     | Total1/      |
| <b>Domestic:</b>                       |                  |              |              |                  |              |              |
| Absorbents-----                        | W                | W            | W            | 129              | 175          | 305          |
| Adhesives-----                         | --               | 4            | 4            | --               | 11           | 11           |
| Animal feed-----                       | 15               | 91           | 106          | 9                | 91           | 100          |
| Catalysts (oil-refining)-----          | W                | --           | W            | W                | --           | W            |
| Drilling mud-----                      | 2                | 711          | 713          | 1                | 691          | 693          |
| Filtering, clarifying, decolorizing:   |                  |              |              |                  |              |              |
| Animal oils, mineral oils and          |                  |              |              |                  |              |              |
| greases, and vegetable oils-----       | 30               | 35           | 65           | W                | W            | 5            |
| Desiccants-----                        | W                | --           | W            | W                | --           | W            |
| Foundry sand-----                      | 226              | 638          | 865          | W                | 585          | 585          |
| Medical, pharmaceutical, cosmetic----- | W                | 16           | 16           | W                | W            | W            |
| Paint-----                             | --               | 6            | 6            | --               | 15           | 15           |
| Pelletizing (iron ore)-----            | --               | 683          | 683          | --               | 717          | 717          |
| Pesticides and related products-----   | W                | W            | W            | W                | W            | W            |
| Water treatment and filtering-----     | W                | W            | W            | W                | W            | W            |
| Waterproofing and sealing-----         | 15               | 141          | 156          | 83               | 133          | 216          |
| Miscellaneous2/-----                   | 304              | 94           | 398          | 244              | 107          | 351          |
| <b>Total1/-----</b>                    | <b>591</b>       | <b>2,420</b> | <b>3,011</b> | <b>468</b>       | <b>2,526</b> | <b>2,993</b> |
| <b>Exports:</b>                        |                  |              |              |                  |              |              |
| Drilling mud-----                      | --               | 113          | 113          | --               | 107          | 107          |
| Foundry sand-----                      | 2                | 252          | 254          | W                | 272          | 272          |
| Other3/-----                           | 38               | 57           | 95           | W                | 53           | 60           |
| <b>Total1/-----</b>                    | <b>41</b>        | <b>422</b>   | <b>462</b>   | <b>7</b>         | <b>431</b>   | <b>438</b>   |
| <b>Grand total1/-----</b>              | <b>632</b>       | <b>2,842</b> | <b>3,474</b> | <b>475</b>       | <b>2,957</b> | <b>3,432</b> |

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

1/Data may not add to totals shown because of independent rounding.

2/Includes data for asphalt emulsions; asphalt tile; cement, portland; ceramic floor and wall tile; face brick; fertilizers; firebrick, blocks and shapes; gypsum products; ink; kiln furniture; mineral wool and insulation; oil well sealing; paper coating and filling;

plastics; pottery; roofing tile; rubber; uses not specified; and data indicated by symbol W.

3/Includes absorbents; animal feed; asphalt emulsions; cement; filtering, clarifying, decolorizing; paint; plastics; waterproofing and sealing; and uses not specified.

Table 18.--Fuller's earth sold or used by producers in the United States, by State

| State           | Attapulgit                |                     | Montmorillonite           |                     | Total                     |                     |
|-----------------|---------------------------|---------------------|---------------------------|---------------------|---------------------------|---------------------|
|                 | Metric tons<br>(Thousand) | Value<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) |
| 1990            |                           |                     |                           |                     |                           |                     |
| Florida.....    | 353                       | \$35,928            | (3/)                      | (3/)                | 353                       | \$35,928            |
| Georgia.....    | 461                       | 59,243              | 187                       | 13,487              | 648                       | 72,729              |
| Southern1/..... | --                        | --                  | 509                       | 33,970              | 509                       | 33,970              |
| Western2/.....  | (4/)                      | (4/)                | 798                       | 81,018              | 798                       | 81,018              |
| Total5/.....    | 745                       | 95,171              | 1,563                     | 128,475             | 2,307                     | 223,645             |
| 1991            |                           |                     |                           |                     |                           |                     |
| Florida.....    | 332                       | 35,598              | (3/)                      | (3/)                | 332                       | 35,598              |
| Georgia.....    | 509                       | 63,273              | 108                       | 13,134              | 617                       | 76,407              |
| Southern1/..... | --                        | --                  | 677                       | 49,648              | 677                       | 49,648              |
| Western2/.....  | (4/)                      | (4/)                | 1,114                     | 108,782             | 1,114                     | 108,782             |
| Total5/.....    | 758                       | 98,871              | 1,982                     | 171,564             | 2,740                     | 270,435             |

1/Includes Mississippi, Tennessee, and Virginia.

2/Includes California, Illinois, Missouri, Nevada, and Texas.

3/Included under attapulgit.

4/Included under montmorillonite.

5/Data may not add to totals shown because of concealments for proprietary coverage of individual kinds.

Table 19--Fuller's earth sold or used by producers in the United States, by use  
(Thousand metric tons)

| Use                                                                  | 1990             |                      |                   | 1991             |                      |                   |
|----------------------------------------------------------------------|------------------|----------------------|-------------------|------------------|----------------------|-------------------|
|                                                                      | Atta-<br>pulgite | Montmoril-<br>lonite | Total1/<br>Total2 | Atta-<br>pulgite | Montmoril-<br>lonite | Total1/<br>Total2 |
| Domestic:                                                            |                  |                      |                   |                  |                      |                   |
| Adhesives.....                                                       | W                | --                   | W                 | W                | --                   | W                 |
| Drilling mud.....                                                    | 34               | --                   | 34                | 32               | --                   | 32                |
| Fertilizers.....                                                     | 44               | W                    | 44                | 39               | W                    | 39                |
| Filtering, clarifying, decolorizing<br>mineral oils and greases..... | 13               | --                   | 13                | 20               | W                    | 20                |
| Medical, pharmaceutical, cosmetic.....                               | W                | --                   | W                 | W                | --                   | W                 |
| Oil and grease absorbents.....                                       | 151              | 219                  | 370               | 167              | 180                  | 348               |
| Paint.....                                                           | W                | --                   | W                 | W                | --                   | W                 |
| Pesticides and related products.....                                 | 85               | 83                   | 168               | 57               | 142                  | 199               |
| Pet waste absorbents.....                                            | 220              | 1,128                | 1,347             | 224              | 1,549                | 1,773             |
| Portland and other cement.....                                       | --               | W                    | W                 | 26               | --                   | 26                |
| Other2/.....                                                         | W                | --                   | W                 | W                | --                   | W                 |
| Miscellaneous3/.....                                                 | 105              | 86                   | 192               | 113              | 60                   | 174               |
| Exports:                                                             | 94               | 46                   | 140               | 79               | 49                   | 129               |
| Grand total1/.....                                                   | 745              | 1,563                | 2,307             | 758              | 1,982                | 2,740             |

W Withheld to avoid disclosing company proprietary data; included with "other" and/or "Miscellaneous".

1/Data may not add to totals shown because of independent rounding.

2/Includes roofing tile and vegetable oils.

3/Includes animal feed; animal oils; gypsum products; miscellaneous absorbents; miscellaneous fillers, extenders, and binders; miscellaneous filtering, clarifying, gypsum products; miscellaneous fillers, extenders, and binders; miscellaneous filtering, clarifying; mortar and cement refractories; plastics; roofing tiles; wallboard; water treatment and filtering; waterproofing and sealing; and other uses not specified.

Table 20.--Common clay and shale sold or used by producers in the United States, 1/  
by State

| State                           | 1990                      |                     | 1991                      |                     |
|---------------------------------|---------------------------|---------------------|---------------------------|---------------------|
|                                 | Metric tons<br>(Thousand) | Value<br>(Thousand) | Metric tons<br>(Thousand) | Value<br>(Thousand) |
| Alabama-----                    | 1,954                     | r/\$16,266          | 2,044                     | \$18,609            |
| Arizona-----                    | 103                       | 470                 | 193                       | 937                 |
| Arkansas-----                   | 705                       | 2,799               | 645                       | 2,632               |
| California-----                 | r/1,699                   | r/14,206            | 1,815                     | 9,714               |
| Colorado-----                   | 262                       | 1,864               | 261                       | 1,938               |
| Connecticut and New Jersey----- | 165                       | 2,294               | 147                       | 1,899               |
| Georgia-----                    | 1,546                     | 7,015               | 1,382                     | 10,464              |
| Illinois-----                   | 598                       | 2,516               | 514                       | 2,442               |
| Indiana-----                    | 1,052                     | 3,273               | 930                       | 3,516               |
| Iowa-----                       | 423                       | 1,376               | 530                       | 2,226               |
| Kansas-----                     | 626                       | 4,056               | 607                       | 2,828               |
| Kentucky-----                   | 826                       | 8,282               | 708                       | 2,942               |
| Louisiana-----                  | 368                       | 1,066               | 360                       | 3,646               |
| Maine and Massachusetts-----    | 52                        | 237                 | 59                        | 264                 |
| Maryland-----                   | 339                       | 1,712               | 259                       | 1,141               |
| Michigan-----                   | 1,202                     | 4,094               | 2,062                     | 8,770               |
| Mississippi-----                | 528                       | 2,568               | 648                       | 6,608               |
| Missouri-----                   | 1,065                     | 5,212               | 1,751                     | 5,584               |
| Montana-----                    | 30                        | 193                 | 42                        | 167                 |
| Nebraska-----                   | 227                       | 1,685               | 198                       | 909                 |
| New Mexico-----                 | 28                        | 74                  | 28                        | 74                  |
| New York-----                   | 491                       | 2,906               | 421                       | 2,417               |
| North Carolina-----             | 2,179                     | 9,356               | 2,064                     | 9,015               |
| Ohio-----                       | 2,320                     | 9,296               | 2,116                     | 8,171               |
| Oklahoma-----                   | 631                       | 3,156               | 824                       | 4,178               |
| Oregon-----                     | 199                       | 327                 | 194                       | 300                 |
| Pennsylvania-----               | 841                       | 2,900               | 701                       | 2,890               |
| Puerto Rico-----                | 148                       | W                   | 145                       | 335                 |
| South Carolina-----             | 832                       | 2,077               | 1,154                     | 2,225               |
| South Dakota and Wyoming-----   | 163                       | 776                 | 224                       | 939                 |
| Tennessee-----                  | 482                       | W                   | W                         | W                   |
| Texas-----                      | 2,106                     | 13,058              | 2,266                     | 13,247              |
| Utah-----                       | 278                       | 1,774               | 210                       | 1,028               |
| Virginia-----                   | 882                       | 3,741               | 723                       | 3,248               |
| Washington-----                 | 158                       | 1,357               | 263                       | 2,633               |
| West Virginia-----              | 164                       | 384                 | 134                       | 322                 |
| Other2/-----                    | 233                       | 3,969               | 608                       | 2,846               |
| Total3/-----                    | r/25,906                  | r/136,333           | 27,233                    | 141,106             |

r Revision. W Withheld to avoid disclosing company proprietary data; Included with "Other."

1/Includes Puerto Rico.

2/Includes Florida, Idaho, Minnesota, New Hampshire, and North Dakota.

3/Data may not add to totals shown because of independent rounding.

Table 21.--Clays sold or used by producers in the United States/ in 1991, by use  
(Thousand metric tons)

66

| Use                                                               | Ball<br>clay | Bentonite | Common clay (refractory<br>and shale | Fire clay<br>(refractory<br>only) | Fuller's<br>earth | Kaolin | Total  |
|-------------------------------------------------------------------|--------------|-----------|--------------------------------------|-----------------------------------|-------------------|--------|--------|
| <b>Absorbents:</b>                                                |              |           |                                      |                                   |                   |        |        |
| Oil and grease-----                                               | --           | 81        | --                                   | --                                | 315               | --     | 395    |
| Pet waste absorbents-----                                         | --           | 217       | --                                   | --                                | 1,773             | --     | 1,991  |
| Other2/-----                                                      | W            | W         | --                                   | --                                | 33                | --     | 33     |
| <b>Ceramics and glass:</b>                                        |              |           |                                      |                                   |                   |        |        |
| Catalysts (oil-refining)-----                                     | --           | W         | --                                   | --                                | W                 | 38     | 38     |
| Crockery and other earthenware-----                               | --           | --        | W                                    | --                                | --                | 1      | 1      |
| Electrical porcelain-----                                         | 19           | --        | --                                   | --                                | W                 | 9      | 28     |
| Fine china and dinnerware-----                                    | 2            | --        | --                                   | --                                | --                | 15     | 18     |
| Glazes, glass and enamels-----                                    | --           | W         | --                                   | W                                 | --                | W      | W      |
| Mineral wool and insulation, fiberglass-----                      | --           | W         | --                                   | --                                | --                | 400    | 400    |
| Pottery-----                                                      | 115          | W         | 35                                   | W                                 | --                | 22     | 171    |
| Roofing granules-----                                             | --           | --        | W                                    | --                                | W                 | 11     | 11     |
| Sanitaryware-----                                                 | 155          | --        | --                                   | --                                | --                | 35     | 190    |
| Other2/-----                                                      | 11           | 32        | 217                                  | 21                                | 15                | 174    | 471    |
| <b>Chemical manufacturing-----</b>                                |              |           |                                      |                                   |                   |        |        |
| Civil engineering and sealing-----                                | 12           | 177       | 84                                   | --                                | --                | 44     | 317    |
| Drilling mud-----                                                 | --           | 693       | --                                   | --                                | 32                | --     | 724    |
| <b>Fillers, extenders and binders:</b>                            |              |           |                                      |                                   |                   |        |        |
| Adhesives-----                                                    | W            | 11        | --                                   | --                                | W                 | 52     | 64     |
| Animal feed-----                                                  | W            | 100       | --                                   | --                                | 37                | W      | 137    |
| Fertilizers-----                                                  | --           | W         | --                                   | --                                | 39                | 5      | 45     |
| Gypsum products and wallboard-----                                | W            | --        | --                                   | --                                | W                 | 3      | 3      |
| Ink-----                                                          | --           | W         | --                                   | --                                | --                | 7      | 7      |
| Medical, pharmaceutical, cosmetic-----                            | --           | W         | --                                   | --                                | W                 | 1      | 1      |
| Paint-----                                                        | W            | 15        | W                                    | --                                | W                 | 228    | 243    |
| Paper coating-----                                                | --           | W         | --                                   | --                                | --                | 2,604  | 2,604  |
| Paper filling-----                                                | W            | --        | --                                   | --                                | W                 | 1,057  | 1,057  |
| Pesticides and related products-----                              | W            | W         | --                                   | --                                | 199               | 23     | 222    |
| Plastics-----                                                     | W            | W         | --                                   | --                                | W                 | 55     | 55     |
| Rubber-----                                                       | W            | W         | --                                   | --                                | W                 | 221    | 221    |
| Other2/-----                                                      | 135          | 135       | 15                                   | 141                               | 80                | 94     | 369    |
| <b>Filtering,clarifying, decolorizing:</b>                        |              |           |                                      |                                   |                   |        |        |
| Animal oils, mineral oils and greases, and<br>vegetable oils----- | --           | 5         | --                                   | --                                | 20                | --     | 26     |
| Desiccants-----                                                   | --           | W         | --                                   | --                                | --                | --     | W      |
| <b>Floor and wall tile:</b>                                       |              |           |                                      |                                   |                   |        |        |
| Ceramic-----                                                      | 158          | (3/)      | 279                                  | --                                | --                | W      | 437    |
| Quarry tile-----                                                  | 10           | --        | 50                                   | --                                | --                | --     | 60     |
| Other2/-----                                                      | --           | --        | W                                    | --                                | --                | W      | W      |
| <b>Heavy clay products:</b>                                       |              |           |                                      |                                   |                   |        |        |
| Brick, extruded-----                                              | W            | W         | 9,120                                | --                                | --                | 245    | 9,365  |
| Brick, other-----                                                 | --           | --        | 2,645                                | W                                 | --                | 12     | 2,657  |
| Drain tile-----                                                   | --           | --        | 13                                   | --                                | --                | --     | 13     |
| Flower pots-----                                                  | --           | --        | 25                                   | --                                | --                | --     | 25     |
| Flue linings-----                                                 | --           | --        | 47                                   | --                                | --                | W      | 47     |
| Portland and other cements-----                                   | --           | W         | 10,013                               | W                                 | 26                | 180    | 10,219 |
| Roofing tile-----                                                 | --           | W         | W                                    | --                                | --                | --     | W      |
| Sewer pipe, vitrified-----                                        | --           | --        | W                                    | --                                | --                | --     | W      |
| Structural tile-----                                              | --           | --        | 36                                   | --                                | --                | --     | 36     |
| Other2/-----                                                      | W            | 5         | 688                                  | 21                                | --                | 18     | 732    |
| <b>Lightweight aggregate:</b>                                     |              |           |                                      |                                   |                   |        |        |
| Concrete-----                                                     | --           | --        | 2,438                                | --                                | --                | --     | 2,438  |
| Highway surfacing-----                                            | --           | --        | 274                                  | --                                | --                | --     | 274    |
| Structural concrete-----                                          | --           | --        | 707                                  | --                                | --                | --     | 707    |
| Other2/-----                                                      | --           | W         | 180                                  | --                                | W                 | --     | 180    |
| Pelletizing iron ore-----                                         | --           | 717       | W                                    | --                                | --                | --     | 717    |
| <b>Refractories:</b>                                              |              |           |                                      |                                   |                   |        |        |
| Firebrick, blocks, and shapes-----                                | 1            | W         | 92                                   | 319                               | --                | 126    | 539    |
| Foundry sand-----                                                 | --           | 585       | --                                   | W                                 | --                | W      | 585    |
| Grogs and calcines-----                                           | --           | --        | --                                   | W                                 | --                | 1,633  | 1,633  |
| High alumina brick and specialties-----                           | 15           | --        | --                                   | 27                                | --                | W      | 42     |
| Kiln furniture-----                                               | 1            | W         | --                                   | --                                | --                | W      | 1      |
| Mortar and cement, refractory-----                                | --           | --        | W                                    | --                                | --                | --     | W      |
| Other2/-----                                                      | W            | 243       | 6                                    | 66                                | W                 | 31     | 346    |
| Other4/-----                                                      | 51           | 96        | 197                                  | 14                                | 27                | 65     | 450    |
| Exports-----                                                      | 90           | 438       | 7                                    | 4                                 | 129               | 1,931  | 2,599  |
| Total5/-----                                                      | 784          | 3,432     | 27,233                               | 474                               | 2,740             | 9,575  | 44,237 |

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

1/Includes Puerto Rico.

2/Includes uses indicated by symbol W.

3/Less than 1/2 unit.

4/Uses not specified.

5/Data may not add to totals shown because of independent rounding.

Table 22.--Shipments of principal structural clay products in the United States

| Product                                                                              | 1987    | 1988    | 1989    | 1990    | 1991    |
|--------------------------------------------------------------------------------------|---------|---------|---------|---------|---------|
| Unglazed common and face brick:                                                      |         |         |         |         |         |
| Quantity.....million standard brick--                                                | 7,313   | 7,811   | 6,698   | 6,783   | 5,405   |
| Value.....million--                                                                  | \$1,060 | \$1,188 | \$1,000 | \$1,014 | \$796   |
| Unglazed structural tile:1/                                                          |         |         |         |         |         |
| Quantity.....thousand metric tons---                                                 | 84      | 53      | W       | W       | W       |
| Value.....million--                                                                  | \$50    | \$6     | W       | W       | W       |
| Vitrified clay and sewer pipe fittings:                                              |         |         |         |         |         |
| Quantity.....thousand metric tons---                                                 | 295     | 286     | 232     | 220     | 187     |
| Value.....million--                                                                  | \$74    | \$74    | \$64    | \$60    | \$51    |
| Unglazed, salt-glazed, ceramic-glazed structural facing tile including glazed brick: |         |         |         |         |         |
| Quantity.....million standard brick--                                                | 32      | 26      | 35      | 31      | W       |
| Value.....million--                                                                  | \$11    | \$18    | \$15    | \$14    | W       |
| Clay floor and wall tile including quarry tile:                                      |         |         |         |         |         |
| Quantity.....million square feet----                                                 | 462     | 488     | 545     | 509     | 430     |
| Value.....million--                                                                  | \$587   | \$641   | \$707   | \$687   | \$571   |
| Total value.....do.....                                                              | \$1,782 | \$1,927 | \$1,786 | \$1,775 | \$1,418 |

W Withheld to avoid disclosing individual company proprietary data.

1/Includes first 9 months only, 1987.

Source: Bureau of the Census Report Form H32-D(92)-1, Current Industrial Reports--Clay Construction Products.

Table 23.--Common clay and shale used in building brick production in the United States, by State/

| State                                         |       | 1990       |            | 1991        |            |
|-----------------------------------------------|-------|------------|------------|-------------|------------|
|                                               |       | Metric ton | r/Value    | Metric tons | Value      |
|                                               |       | (Thousand) | (Thousand) | (Thousand)  | (Thousand) |
| Alabama                                       | 953   | \$4,799    | 794        | \$3,552     | 201        |
| Arizona/ and New Mexico/                      | 60    | 169        | 65         | 707         | 1,965      |
| Arkansas                                      | 322   | 835        | 279        | 707         | 1,965      |
| California                                    | 400   | 7,640      | 396        | 1,965       | 707        |
| Colorado                                      | 229   | 1,724      | 233        | 1,814       | 2,612      |
| Connecticut, New Jersey/2/, and New York/2/   | 352   | 3,097      | 297        | 2,612       | 3,402      |
| Georgia                                       | 97    | 5,316      | 938        | 3,402       | 613        |
| Idaho, Washington, Wyoming/2/ and Montana/3/  | 97    | 789        | 97         | 2,074       | 1,610      |
| Illinois                                      | 109   | 487        | 464        | 2,074       | 1,610      |
| Indiana and Iowa                              | 405   | 1,371      | 322        | 547         | 2,933      |
| Kansas                                        | 158   | 586        | 151        | 2,852       | 2,852      |
| Kentucky/2/ and Tennessee/2/                  | r/743 | 8,188      | 635        | 2,852       | 2,852      |
| Louisiana                                     | 83    | 280        | 75         | 283         | 1,012      |
| Maine, Massachusetts/2/, and New Hampshire/2/ | 63    | 309        | 62         | 283         | 1,012      |
| Maryland and West Virginia/4/                 | 355   | 1,697      | 244        | 1,012       | 422        |
| Michigan/2/ and Minnesota/2/                  | 163   | 456        | 121        | 422         | 2,124      |
| Mississippi                                   | 374   | 2,407      | 390        | 2,124       | 849        |
| Missouri                                      | 173   | 583        | 205        | 849         | 435        |
| Nebraska and North Dakota/2/                  | 176   | 507        | 146        | 435         | 5,269      |
| North Carolina                                | 1,844 | 5,659      | 1,722      | 5,269       | 3,975      |
| Ohio                                          | 1,055 | 5,202      | 949        | 3,975       | 1,545      |
| Oklahoma                                      | 287   | 1,070      | 324        | 1,545       | 68         |
| Oregon                                        | 20    | 68         | 20         | 68          | 2,156      |
| Pennsylvania                                  | 749   | 2,385      | 576        | 2,156       | 1,499      |
| South Carolina                                | 577   | 1,715      | 594        | 1,499       | 6,578      |
| Texas                                         | 896   | 6,414      | 1,061      | 6,578       | 432        |
| Utah/2/                                       | 127   | 1,086      | 94         | 432         | 2,067      |
| Virginia                                      | 628   | 2,310      | 511        | 2,067       | 53,594     |
| Total/5/ 6/                                   |       | 12,378     | 67,149     | 11,765      | 53,594     |

r Revision.  
1/Include extruded and other brick.  
2/Extruded brick only.  
3/Includes Montana only for 1991.

4/ other brick only.  
5/Includes 1.5 million tons used in other brick production.

6/Data may not add to totals shown because of independent rounding.

Table 24.--Common clay and shale used in lightweight aggregate production in the United States, by State

| State                                 | Thousand metric tons |                        |                      |       | Total value<br>(thousand) |
|---------------------------------------|----------------------|------------------------|----------------------|-------|---------------------------|
|                                       | Concrete<br>block    | Structural<br>concrete | Highway<br>surfacing | Other |                           |
| 1990                                  |                      |                        |                      |       |                           |
| Alabama and Arkansas.....             | 708                  | 85                     | 11                   | --    | 804<br>r/\$10,729         |
| California.....                       | 78                   | 99                     | --                   | --    | 177<br>r/723              |
| Florida and Indiana.....              | 254                  | 29                     | --                   | --    | 284<br>r/1,932            |
| Kansas, Kentucky, and Louisiana.....  | 246                  | 229                    | 15                   | 67    | 557<br>r/1,741            |
| Mississippi and Missouri.....         | 128                  | 11                     | 15                   | 119   | 273<br>r/1,730            |
| New York and Montana.....             | 259                  | 41                     | --                   | --    | 300<br>r/2,069            |
| North Carolina.....                   | 245                  | 82                     | --                   | --    | 327<br>r/3,659            |
| Ohio, Oklahoma, and Pennsylvania..... | 246                  | 37                     | 1                    | --    | 284<br>r/2,014            |
| Texas.....                            | 66                   | 157                    | 222                  | 31    | 473<br>r/2,518            |
| Utah and Virginia.....                | 297                  | 17                     | 3                    | 10    | 327<br>r/1,803            |
| Total 1/.....                         | 2,524                | 786                    | 268                  | 227   | 3,804<br>r/28,918         |
| 1991                                  |                      |                        |                      |       |                           |
| Alabama and Arkansas.....             | 786                  | 92                     | 11                   | 9     | 898<br>13,158             |
| California.....                       | 78                   | 99                     | --                   | --    | 177<br>731                |
| Florida and Indiana.....              | 227                  | 23                     | --                   | --    | 250<br>1,616              |
| Kansas, Kentucky, and Louisiana.....  | 304                  | 112                    | 15                   | 35    | 465<br>1,439              |
| Mississippi and Missouri.....         | 89                   | 8                      | 14                   | 105   | 216<br>1,518              |
| New York and Montana.....             | 175                  | 92                     | --                   | --    | 267<br>1,678              |
| North Carolina.....                   | 245                  | 82                     | --                   | --    | 327<br>3,696              |
| Ohio, Oklahoma, and Pennsylvania..... | 242                  | 28                     | 5                    | --    | 276<br>2,188              |
| Texas.....                            | 49                   | 157                    | 222                  | 31    | 459<br>2,518              |
| Utah and Virginia.....                | 243                  | 15                     | 6                    | --    | 264<br>1,472              |
| Total 1/.....                         | 2,438                | 707                    | 274                  | 180   | 3,599<br>30,014           |

r/ Revision.

1/ Data may not add to totals shown because of independent rounding.

Table 25.--Shipments of refractories in the United States, by product

| Product                                                                                                                                                | Unit of quantity         | Value (thou-<br>sands) | quan-<br>tity | Value (thou-<br>sands) | quan-<br>tity | 1990      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|------------------------|---------------|------------------------|---------------|-----------|
| CLAY REFRACTORIES                                                                                                                                      |                          |                        |               |                        |               |           |
| Superduty fire clay brick and shapes-----                                                                                                              | 1,000 9-inch equivalent. |                        |               |                        |               |           |
| other fire clay, including semisilica brick and shapes, glasshouse pots, tank blocks, feeder parts, upper structure parts used only for glass tanks.   |                          | 59,725                 | 49,177        | 55,536                 |               |           |
| High-alumina (50% to 60% Al2O3) brick and shapes made of calcined diaspor or bauxite                                                                   |                          | 92,082                 | 163,719       | 92,590                 |               | 168,559   |
| Insulating firebrick and shapes-----                                                                                                                   |                          | 49,006                 | 57,879        | 48,587                 |               | 53,985    |
| Ladle brick-----                                                                                                                                       |                          |                        |               |                        |               |           |
| Sleeves, nozzles, runner brick, tuyeres-----                                                                                                           |                          |                        |               |                        |               |           |
| Hot-top refractories-----                                                                                                                              | short tons--             | 62,972                 | 48,839        | 56,072                 |               | 47,316    |
| Kiln furniture, radiant heater elements, potter's supplies, other miscellaneous-shaped refractory items-----                                           |                          | 35,701                 | 37,261        | 32,975                 |               | 37,997    |
| Refractory bonding mortars-----                                                                                                                        |                          | 80,139                 | 43,189        | 81,175                 |               | 73,595    |
| Plastic refractories and ramming mixes, containing up to 87.5% Al2O3-----                                                                              |                          | 227,633                | 92,779        | 228,599                |               | 96,388    |
| Castable mixes-----                                                                                                                                    |                          | 299,292                | 128,721       | 283,500                |               | 114,323   |
| Gunning mixes-----                                                                                                                                     |                          | 171,453                | 49,928        | 158,261                |               | 46,980    |
| Other clay refractory materials sold in lump or ground form-----                                                                                       |                          | 412,907                | 86,937        | 352,763                |               | 72,523    |
| Miscellaneous refractories-----                                                                                                                        |                          |                        | 64,837        |                        |               | 40,779    |
| Total clay refractories-----                                                                                                                           |                          |                        | 823,266       |                        |               | 802,530   |
| NONCLAY REFRACTORIES                                                                                                                                   |                          |                        |               |                        |               |           |
| Silica brick and shapes-----                                                                                                                           | 1,000 9-inch equivalent. | 12,823                 | 24,252        | 18,340                 |               | 26,933    |
| Magnesite and magnesite-chrome brick and shapes-----                                                                                                   |                          |                        | (1/)          | (1/)                   |               | (1/)      |
| Chrome and chrome-chrome brick and shapes-----                                                                                                         |                          |                        | (1/)          | (1/)                   |               | (1/)      |
| Shaped refractories containing natural graphite---                                                                                                     | short tons               | 23,197                 | 44,575        | 21,145                 |               | 47,778    |
| Zircon and zirconia brick and shapes; other carbon refractories: forsterite, pyrophyllite, dolomite-magnesite molten-cast, other brick and shapes----- | 1,000 9-inch equivalent. | 31,341                 | 183,446       | 33,484                 |               | 200,074   |
| Other mullite, kyanite, sillimanite, or andalusite brick and shapes-----                                                                               |                          | 3,231                  | 26,279        | 3,269                  |               | 25,809    |
| Other extra-high (over 60% alumina) brick and fused bauxite, fused alumina, dense-sintered alumina shapes-----                                         |                          | 6,679                  | 103,387       | 5,753                  |               | 96,576    |
| Silicon carbide brick, shapes, kiln furniture-----                                                                                                     |                          | 1,688                  | 44,579        | 1,558                  |               | 45,823    |
| Refractory bonding mortar-----                                                                                                                         | short tons               |                        | 19,474        |                        |               | 19,068    |
| Hydraulic-setting nonclay refractory castables-----                                                                                                    |                          | 31,022                 | 32,778        | 30,538                 |               | 40,293    |
| Plastic refractories and ramming mixes-----                                                                                                            |                          | 123,934                | 90,462        | 123,199                |               | 92,333    |
| Gunning mixes-----                                                                                                                                     |                          |                        |               |                        |               |           |
| Dead-burned magnesite or magnesite-----                                                                                                                |                          | 322,023                | 82,736        | 295,167                |               | 79,185    |
| Dead-burned dolomite-----                                                                                                                              |                          | 202,692                | 12,073        | 224,280                |               | 13,457    |
| Other nonclay refractory material sold in lump or ground form-----                                                                                     |                          | 310,878                | 110,423       | 329,589                |               | 109,608   |
| Miscellaneous nonclay refractories-----                                                                                                                |                          |                        | 413,219       |                        |               | 426,575   |
| Total nonclay refractories-----                                                                                                                        |                          |                        | 1,187,681     |                        |               | 1,223,512 |
| Grand total refractories-----                                                                                                                          |                          |                        | 2,010,947     |                        |               | 2,026,042 |

Withheld to avoid disclosing company proprietary data, value included in total. XX Not applicable.  
 1/Included in miscellaneous nonclay refractories.

Source: Bureau of Census Report Form MA32C(90)-1, Current Industrial Reports--Refractory.

TABLE 26.--U.S. EXPORTS OF CLAYS IN 1991, BY COUNTRY  
(Thousand metric tons and thousand dollars)

| Country                           | Ball clay |       | Bentonite |        | Fire clay |        | Fuller's earth |       | Kaolin   |         | Clays, n.e.c.1/ |        | Total2/  |         |
|-----------------------------------|-----------|-------|-----------|--------|-----------|--------|----------------|-------|----------|---------|-----------------|--------|----------|---------|
|                                   | Quantity  | Value | Quantity  | Value  | Quantity  | Value  | Quantity       | Value | Quantity | Value   | Quantity        | Value  | Quantity | Value   |
| Argentina.....                    | --        | --    | (3/)      | 15     | (3/)      | 8      | --             | --    | 6        | 1,795   | (3/)            | 568    | 7        | 2,386   |
| Australia.....                    | --        | --    | 28        | 1,910  | 23        | 1,603  | (3/)           | 22    | 9        | 3,482   | 1               | 1,857  | 61       | 8,873   |
| Belgium-Luxemburg.....            | --        | --    | 9         | 1,922  | (3/)      | 51     | (3/)           | 39    | 102      | 17,006  | 3               | 2,388  | 114      | 21,405  |
| Brazil.....                       | (3/)      | 27    | 1         | 205    | (3/)      | 8      | (3/)           | 36    | 2        | 1,125   | 1               | 1,762  | 4        | 3,163   |
| Canada.....                       | --        | --    | 147       | 8,577  | 9         | 1,908  | 6              | 821   | 660      | 61,560  | 100             | 22,414 | 921      | 95,280  |
| Chile.....                        | 1         | 58    | 3         | 542    | --        | --     | --             | --    | 8        | 2,847   | (3/)            | 259    | 12       | 3,705   |
| Colombia.....                     | --        | --    | 7         | 525    | (3/)      | 34     | --             | --    | 11       | 2,918   | 1               | 448    | 20       | 3,925   |
| Ecuador.....                      | --        | --    | 1         | 138    | --        | --     | --             | --    | 4        | 561     | 1               | 307    | 6        | 1,007   |
| Finland.....                      | --        | --    | 2         | 183    | --        | --     | (3/)           | 4     | 245      | 36,475  | 6               | 487    | 253      | 37,149  |
| France.....                       | --        | --    | 1         | 543    | (3/)      | 181    | (3/)           | 64    | 10       | 2,118   | 1               | 454    | 13       | 3,361   |
| Germany, Federal Republic of..... | (3/)      | 9     | 13        | 1,162  | (3/)      | 52     | (3/)           | 53    | 47       | 8,780   | 6               | 5,623  | 66       | 15,680  |
| Hong Kong.....                    | 1         | 59    | 1         | 505    | (3/)      | 20     | --             | --    | 3        | 817     | 1               | 220    | 6        | 1,621   |
| Italy.....                        | --        | --    | 2         | 913    | 3         | 321    | (3/)           | 108   | 182      | 24,030  | 3               | 876    | 189      | 26,248  |
| Japan.....                        | 1         | 198   | 242       | 20,094 | 25        | 4,299  | (3/)           | 36    | 790      | 130,464 | 5               | 4,557  | 1,064    | 159,648 |
| Korea, Republic of.....           | (3/)      | 5     | 6         | 2,058  | 1         | 337    | (3/)           | 44    | 108      | 23,559  | 2               | 1,199  | 117      | 27,203  |
| Mexico.....                       | 46        | 1,683 | 9         | 1,370  | 43        | 2,919  | 1              | 136   | 116      | 13,642  | 9               | 2,030  | 223      | 21,780  |
| Netherlands.....                  | 2         | 65    | 11        | 2,123  | 76        | 5,799  | 9              | 638   | 227      | 32,449  | 7               | 2,406  | 332      | 43,480  |
| Peru.....                         | --        | --    | (3/)      | 42     | (3/)      | 8      | --             | --    | 1        | 207     | 1               | 213    | 3        | 469     |
| Philippines.....                  | 2         | 138   | 2         | 459    | --        | --     | --             | --    | 3        | 743     | 1               | 549    | 9        | 1,888   |
| Saudi Arabia.....                 | --        | --    | 12        | 659    | (3/)      | 28     | --             | --    | (3/)     | 130     | (3/)            | 222    | 13       | 1,038   |
| Singapore.....                    | --        | --    | 15        | 1,693  | --        | --     | 2              | 341   | 2        | 467     | 4               | 1,506  | 22       | 4,007   |
| South Africa, Republic of.....    | --        | --    | 2         | 209    | (3/)      | 4      | 1              | 213   | 21       | 5,148   | 1               | 644    | 25       | 6,217   |
| Spain.....                        | --        | --    | 1         | 229    | --        | --     | 1              | 208   | 7        | 1,667   | (3/)            | 232    | 9        | 2,336   |
| Sweden.....                       | (3/)      | 10    | (3/)      | 103    | --        | --     | --             | --    | 68       | 13,731  | 12              | 2,786  | 80       | 16,630  |
| Switzerland.....                  | --        | --    | --        | --     | 2         | 99     | (3/)           | 3     | 1        | 106     | (3/)            | 31     | 2        | 239     |
| Taiwan.....                       | (3/)      | 11    | 39        | 3,599  | 11        | 727    | --             | --    | 100      | 17,598  | 2               | 776    | 153      | 22,711  |
| Thailand.....                     | --        | --    | 5         | 686    | --        | --     | --             | --    | 14       | 3,140   | (3/)            | 549    | 20       | 4,375   |
| United Kingdom.....               | --        | --    | 38        | 5,186  | 4         | 287    | 1              | 218   | 42       | 6,200   | 8               | 5,573  | 93       | 17,464  |
| Venezuela.....                    | (3/)      | 94    | 29        | 2,023  | 1         | 66     | --             | --    | 14       | 2,966   | 7               | 2,208  | 51       | 7,356   |
| Other.....                        | 5         | 566   | 33        | 5,892  | 1         | 221    | 4              | 1,455 | 48       | 14,556  | 8               | 6,811  | 106      | 29,531  |
| Total2/.....                      | 58        | 2,924 | 660       | 63,571 | 199       | 19,000 | 27             | 4,440 | 2,855    | 430,287 | 197             | 69,952 | 3,997    | 590,174 |

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

2/Data may not add to totals shown because of independent rounding.

3/Less than 1/2 unit.

Source: U.S. Department of Commerce.

Table 27.--U.S. imports for consumption of clays in 1991, by kind

| Kind                                             | Quantity<br>(metric<br>tons) | Value<br>(thou-<br>sands) |
|--------------------------------------------------|------------------------------|---------------------------|
| China clay or kaolin:                            |                              |                           |
| Canada                                           | 252                          | 36                        |
| China                                            | 255                          | 93                        |
| France                                           | 1                            | 1                         |
| Germany, Federal Republic of                     | 128                          | 52                        |
| Italy                                            | 3                            | 4                         |
| Japan                                            | 119                          | 120                       |
| Korea, Republic of                               | 1                            | 2                         |
| New Zealand                                      | 40                           | 23                        |
| United Kingdom                                   | 2,574                        | 1,276                     |
| Total                                            | 3,373                        | 1,607                     |
| Fire clay:                                       |                              |                           |
| Canada                                           | 230                          | 49                        |
| China                                            | 195                          | 31                        |
| Total                                            | 425                          | 80                        |
| Decolorizing earths and fuller's earth:          |                              |                           |
| Canada                                           | 26                           | 10                        |
| Germany, Federal Republic of                     | 46                           | 24                        |
| Spain                                            | 9                            | 11                        |
| United Kingdom                                   | 1                            | 2                         |
| Total                                            | 82                           | 47                        |
| Bentonite:                                       |                              |                           |
| Canada                                           | 1,037                        | 387                       |
| Germany, Federal Republic of                     | 248                          | 605                       |
| Japan                                            | 27                           | 72                        |
| Mexico                                           | 618                          | 46                        |
| United Kingdom                                   | 294                          | 161                       |
| Total                                            | 2,224                        | 1,172                     |
| Common blue clay and other ball clay:            |                              |                           |
| France                                           | 3                            | 5                         |
| United Kingdom                                   | 750                          | 257                       |
| Total                                            | 753                          | 262                       |
| Other clay:                                      |                              |                           |
| Canada                                           | 8,181                        | 1,738                     |
| France                                           | 2                            | 3                         |
| Germany, Federal Republic of                     | 12                           | 49                        |
| Italy                                            | 19                           | 22                        |
| Japan                                            | 12                           | 44                        |
| Thailand                                         | 6                            | 6                         |
| United Kingdom                                   | 5,883                        | 1,056                     |
| Total                                            | 14,115                       | 2,918                     |
| Chamotte or dina's earth:                        |                              |                           |
| France                                           | 6                            | 3                         |
| Total                                            | 6                            | 3                         |
| Artificially activated clay and activated earth: |                              |                           |
| Austria                                          | --                           | 8                         |
| Belgium                                          | 10                           | 10                        |
| Canada                                           | 226                          | 204                       |
| Denmark                                          | 34                           | 17                        |
| Germany, Federal Republic of                     | 1,105                        | 1,869                     |
| Japan                                            | 20                           | 47                        |
| Mexico                                           | 12,808                       | 4,608                     |
| Norway                                           | 6                            | 10                        |
| Netherlands                                      | 10                           | 10                        |
| Switzerland                                      | 14                           | 18                        |

|                     |          |        |
|---------------------|----------|--------|
| United Kingdom----- | 62       | 219    |
| Venezuela-----      | 52       | 11     |
| Total-----          | 1/14,346 | 7,031  |
| Grand total-----    | 1/35,341 | 13,249 |

1/Data do not add to total shown because of independent rounding.

Source: U.S. Department of Commerce.

Table 28.--Clays: U.S. Annual Production Capacity,  
December 31, 1991, by kind and type  
(Thousand metric tons)

| Kind and type                | Rated capacity <sup>1/</sup> |
|------------------------------|------------------------------|
| Ball clay:                   |                              |
| Air-float-----               | 635                          |
| Waterslurried-----           | 115                          |
| Unprocessed-----             | 300                          |
| Total-----                   | 1,050                        |
| Bentonite:                   |                              |
| Nonswelling-----             | 555                          |
| Swelling-----                | 2,000                        |
| Total-----                   | 2,555                        |
| Common clay and shale:       |                              |
| Fire clay:                   | 38,000                       |
| Fuller's earth:              | 1,100                        |
| Attapulgite-----             | 700                          |
| Montmorillonite-----         | 2,250                        |
| Total-----                   | 42,050                       |
| Kaolin:                      |                              |
| Air-float-----               | 1,500                        |
| Calcined <sup>2/</sup> ----- | 555                          |
| Calcined <sup>3/</sup> ----- | 700                          |
| Delaminated-----             | 1,100                        |
| Unprocessed-----             | 1,000                        |
| Water-washed-----            | 4,100                        |
| Total-----                   | 8,955                        |
| Grand total-----             | 54,610                       |

<sup>1/</sup>Includes capacity at operating plants as well as at plants on standby basis.

<sup>2/</sup>Low-temperature, filter.

<sup>3/</sup>High-temperature, refractory.

Table 29.--Kaolin: World annual production capacity,  
December 31, 1991, rated capacity1/  
(Thousand metric tons)

| Country                           | Capacity |
|-----------------------------------|----------|
| Algeria-----                      | 16       |
| Argentina-----                    | 140      |
| Australia-----                    | 230      |
| Austria-----                      | 110      |
| Bangladesh-----                   | 14       |
| Belgium-----                      | 73       |
| Brazil-----                       | 820      |
| Bulgaria-----                     | 300      |
| Burundi-----                      | e/6      |
| Chile-----                        | 54       |
| Colombia-----                     | 1,360    |
| Costa Rica-----                   | 1        |
| Czechoslovakia-----               | 730      |
| Denmark-----                      | 14       |
| Ecuador-----                      | 3        |
| Egypt-----                        | 140      |
| Ethiopia (including Eritrea)----- | e/5      |
| France-----                       | 1,450    |
| German, Federal Republic of:      |          |
| Eastern States-----               | 650      |
| Western States-----               | 180      |
| Greece-----                       | 160      |
| Guatemala-----                    | 5        |
| Hong Kong-----                    | 9        |
| Hungary-----                      | 41       |
| India-----                        | 740      |
| Indonesia-----                    | 150      |
| Iran-----                         | e/120    |
| Israel-----                       | 32       |
| Italy-----                        | 90       |
| Japan-----                        | 230      |
| Kenya-----                        | e/1      |
| Korea, Republic of-----           | 910      |
| Madagascar-----                   | 6        |
| Malaysia-----                     | 115      |
| Mexico-----                       | 270      |
| Mozambique-----                   | e/1      |
| Nigeria-----                      | 1        |
| Pakistan-----                     | 45       |
| Paraguay-----                     | 64       |
| Peru-----                         | 9        |
| Poland-----                       | 55       |
| Portugal-----                     | 110      |
| Romania-----                      | 450      |
| South Africa, Republic of-----    | 200      |
| Spain-----                        | 500      |
| Sri Lanka-----                    | 11       |
| Sweden-----                       | 1        |
| Taiwan-----                       | 90       |
| Tanzania-----                     | e/2      |
| Thailand-----                     | 275      |
| Turkey-----                       | e/250    |
| U.S.S.R.-----                     | 3,100    |
| United Kingdom-----               | 3,700    |
| United States-----                | 8,955    |
| Venezuela-----                    | 27       |
| Vietnam-----                      | 1        |
| Yugoslavia-----                   | 270      |
| Zimbabwe-----                     | e/1      |
| Total-----                        | 27,293   |

e/Estimated.

1/Includes capacity at operating plants as well as at plants on standby basis.

Table 30.-- Fuller's earth: World annual production capacity,  
December 31, 1991, rated capacity<sup>1/</sup>  
(Metric tons)

| Country                      | Capacity         |
|------------------------------|------------------|
| Algeria-----                 | 4,000            |
| Argentina-----               | 2,300            |
| Australia (attapulgate)----- | 16,000           |
| Italy-----                   | 41,000           |
| Mexico-----                  | 55,000           |
| Morocco (smectite)-----      | 55,000           |
| Pakistan-----                | 23,000           |
| Senegal (attapulgate)-----   | 120,000          |
| Spain (attapulgate)-----     | 70,000           |
| United Kingdom-----          | 300,000          |
| United States-----           | 2,950,000        |
| <b>Total-----</b>            | <b>3,636,300</b> |

<sup>1/</sup>Includes capacity at operating plants as well as at  
plants on standby basis.

Table 32.-Kaolin: World production, by country1/  
(Metric tons)

78

| Country2/                                                   | 1987        | 1988      | 1989      | 1990        | 1991e/      |
|-------------------------------------------------------------|-------------|-----------|-----------|-------------|-------------|
| Algeria-----                                                | 16,000      | 17,800    | e/18,000  | r/ e/20,000 | 3/21,460    |
| Argentina-----                                              | r/100,128   | r/93,871  | r/45,598  | r/ e/50,000 | 50,000      |
| Australia4/-                                                | 176,958     | 159,067   | e/185,000 | e/200,000   | 190,000     |
| Austria (marketable)-----                                   | 92,186      | 89,491    | r/85,312  | r/81,265    | 80,000      |
| Bangladesh5/-                                               | 12,272      | 10,097    | 7,092     | e/7,000     | 7,000       |
| Belgium/-                                                   | 45,000      | 40,000    | 35,000    | 35,000      | 30,000      |
| Brazil (beneficiated plus direct sales and direct use)----- | 802,586     | 940,518   | r/974,000 | r/880,000   | 900,000     |
| Bulgaria-----                                               | 281,000     | 220,000   | e/220,000 | 186,467     | 180,000     |
| Burundi-----                                                | 5,290       | 4,021     | 4,305     | 5,281       | 5,000       |
| Chile-----                                                  | 44,533      | 54,464    | 58,512    | 32,416      | 3/62,991    |
| Colombia-----                                               | 366,300     | 408,141   | 540,000   | e/540,000   | 1,800,000   |
| Czechoslovakia-----                                         | 697,000     | 685,958   | 698,000   | 670,550     | 650,000     |
| Denmark (sales)-----                                        | 9,304       | 39,324    | 16,029    | 17,423      | 17,000      |
| Ecuador-----                                                | r/11,017    | r/16,700  | 22,576    | 15,580      | 25,000      |
| Egypt-----                                                  | 125,256     | 124,122   | 121,515   | 49,032      | 50,000      |
| Ethiopia (including Eritrea)e/ 6/                           | 2,500       | 750       | r/390     | r/670       | 570         |
| France (Marketable) e/ 7/-----                              | r/309,000   | r/338,000 | r/346,000 | r/367,000   | 370,000     |
| Germany:                                                    |             |           |           |             |             |
| Eastern states (marketable)e/--                             | 150,000     | 165,000   | 150,000   | 115,000     | NA          |
| Western states (marketable)----                             | 588,000     | 673,000   | 777,000   | r/684,000   | NA          |
| Totale/-----                                                | 738,000     | 838,000   | 927,000   | 799,000     | 750,000     |
| Greece-----                                                 | 144,634     | r/127,395 | 67,234    | r/90,000    | 90,000      |
| Guatemala-----                                              | 1,880       | 3,459     | 2,573     | 2,050       | 2,000       |
| Hungary-----                                                | 33,289      | 29,572    | 24,824    | e/18,000    | 18,000      |
| India:                                                      |             |           |           |             |             |
| Saleable crude-----                                         | 602,000     | 471,000   | 464,000   | r/631,000   | 3/628,000   |
| Processed-----                                              | 93,720      | 107,381   | 110,505   | r/104,000   | 110,000     |
| Indonesia-----                                              | 122,046     | 147,109   | 157,122   | r/160,098   | 3/139,915   |
| Iran/-                                                      | 70,000      | r/100,000 | r/90,000  | r/45,000    | 60,000      |
| Israel-----                                                 | r/ e/29,000 | r/30,600  | r/33,280  | r/42,212    | 40,000      |
| Italy:                                                      |             |           |           |             |             |
| Crude-----                                                  | r/57,074    | r/71,522  | r/64,196  | r/67,321    | 67,500      |
| Kaolinitic earth-----                                       | 22,194      | r/18,636  | r/18,924  | 17,946      | 17,500      |
| Japan-----                                                  | 172,781     | r/167,771 | r/155,073 | r/164,802   | 3/129,942   |
| Kenya-----                                                  | 40          | 42        | 42        | --          | 3/--        |
| Korea, Republic of-----                                     | 630,945     | 832,110   | 1,219,174 | 1,446,598   | 3/1,755,255 |
| Madagascar-----                                             | 1,427       | 365       | 1,315     | 485         | 500         |
| Malaysia-----                                               | 96,882      | 116,869   | 108,347   | 152,972     | 3/186,699   |
| Mexico-----                                                 | 151,104     | 162,415   | 141,519   | r/156,140   | 3/166,640   |
| Mozambique/-                                                | 151         | 200       | 200       | 3/--        | --          |
| New Zealand-----                                            | 25,548      | 29,649    | 26,324    | e/30,000    | 25,000      |
| Nigeria-----                                                | e/250       | e/250     | 550       | 1,356       | 1,300       |
| Pakistan-----                                               | 32,208      | 41,968    | 39,907    | 61,630      | 62,000      |
| Paraguay/-                                                  | 72,000      | 76,000    | 74,000    | 74,000      | 74,000      |
| Peru-----                                                   | 626         | 8,849     | e/7,000   | e/8,000     | 8,000       |
| Poland-----                                                 | 49,000      | r/59,000  | 50,000    | r/48,000    | 45,000      |

Table 32.-Kaolin: World production, by country1/--continued  
(Metric tons)

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| Country2/                      | 1987         | 1988         | 1989         | 1990         | 1991e/      |
|--------------------------------|--------------|--------------|--------------|--------------|-------------|
| Portugal-----                  | 66,763       | 71,200       | 58,297       | 73,849       | 74,000      |
| Romania/-----                  | 400,000      | 400,000      | 400,000      | r/250,000    | 200,000     |
| South Africa, Republic of----- | 151,730      | r/152,500    | 139,711      | 132,421      | 3/133,674   |
| Spain (marketable)8/-----      | 433,077      | 438,160      | r/436,335    | e/435,000    | 400,000     |
| Sri Lanka-----                 | 6,869        | 7,100        | 7,761        | 7,731        | 3/7,737     |
| Sweden-----                    | 100          | 92           | e/100        | e/100        | 100         |
| Taiwan-----                    | 67,525       | 81,879       | 98,115       | r/105,084    | 3/92,970    |
| Tanzania-----                  | 1,446        | 528          | 1,554        | r/2,021      | 2,000       |
| Thailand-----                  | 206,568      | 269,976      | 328,824      | 347,690      | 3/381,839   |
| Turkey-----                    | 126,119      | 204,478      | r/238,251    | 230,000      | 240,000     |
| U.S.S.R.e/-----                | 2,000,000    | 2,000,000    | 2,000,000    | 1,800,000    | 1,600,000   |
| United Kingdom-----            | 3,058,821    | 3,276,795    | r/3,139,672  | r/3,037,486  | 3,000,000   |
| United States9/-----           | 8,007,919    | 8,973,097    | 8,973,668    | 9,761,775    | 3/9,575,000 |
| Venezuela-----                 | 30,000       | r/28,000     | 15,000       | 12,000       | 3/39,000    |
| Vietnam/-----                  | 1,000        | 700          | 750          | 750          | 800         |
| Yugoslavia-----                | 218,851      | 218,673      | r/260,141    | r/198,513    | 170,000     |
| Zimbabwe-----                  | 780          | 95           | 15           | --           | --          |
| Total-----                     | r/21,020,697 | r/22,805,759 | r/23,258,632 | r/23,672,714 | 24,733,392  |

e/Estimated. r/Revised. NA Not Available.

1/Table includes data available through July 20, 1992.

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

3/Reported figure.

4/May include ball clay and other clays grouped for statistical purposes as kaolin.

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

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

7/Includes kaolinitic clay.

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

9/Kaolin sold or used by producers.

Table 33.--Bentonites: World production, by country1/  
(Metric tons)

| Country2/                        | 1987        | 1988        | 1989        | 1990           | 1991e/    |
|----------------------------------|-------------|-------------|-------------|----------------|-----------|
| Algeria3/-----                   | r/24,600    | r/25,600    | r/39,200    | r/41,600       | 4/25,806  |
| Argentina-----                   | 108,595     | 173,930     | e/150,000   | e/150,000      | 100,000   |
| Australia3/-----                 | 30,392      | 35,671      | e/35,000    | e/35,000       | 35,000    |
| Brazil-----                      | 216,591     | r/147,149   | 146,550     | r/167,618      | 160,000   |
| Burma-----                       | 297         | 418         | 711         | e/700          | 700       |
| Chile-----                       | --          | 529         | 2,005       | r/2,207        | 4/1,054   |
| Cyprus-----                      | 79,600      | 90,300      | r/59,744    | r/81,800       | 4/58,500  |
| Egypt-----                       | 3,827       | 3,166       | 3,512       | e/3,500        | 3,500     |
| Francee/-----                    | 8,000       | 8,000       | 8,000       | 10,000         | 10,000    |
| Germany: Western states-----     | 167,000     | 197,000     | 200,000     | r/230,000      | 230,000   |
| Greece-----                      | 1,300,525   | 730,501     | r/1,096,177 | r/ e/1,000,000 | 1,000,000 |
| Guatemala-----                   | 24,782      | 973         | 8,236       | e/9,000        | 12,000    |
| Hungary-----                     | 98,331      | 66,014      | 59,973      | e/36,600       | 35,000    |
| Indonesia-----                   | 7,962       | 8,266       | 3,863       | 5,914          | 4/21,512  |
| Iran5/-----                      | r/52,523    | r/37,028    | r/31,547    | r/51,096       | 52,000    |
| Israel (metabentonite)e/-----    | r/4,500     | r/3,000     | r/3,500     | r/3,500        | 3,500     |
| Italy-----                       | r/305,622   | r/319,127   | r/234,212   | r/228,153      | 230,000   |
| Japan-----                       | 468,705     | 455,137     | 526,131     | 549,414        | 4/554,145 |
| Kenyae/-----                     | 200         | 200         | --          | --             | --        |
| Mexico-----                      | 129,596     | 163,916     | 123,927     | r/144,895      | 4/134,384 |
| Morocco-----                     | 2,948       | 3,445       | 3,970       | e/3,900        | 3,900     |
| Mozambique-----                  | 936         | 986         | 126         | r/--           | --        |
| New Zealand (processed)-----     | --          | 1,255       | 1,342       | r/1,393        | 1,500     |
| Pakistan-----                    | 2,537       | 4,880       | 5,466       | 3,235          | 3,500     |
| Peru-----                        | 16,194      | 50,741      | r/ e/40,000 | r/ e/40,000    | 55,000    |
| Philippines-----                 | 759         | 2,030       | 2,782       | 16,484         | 16,000    |
| Polande/-----                    | 75,000      | 80,000      | 80,000      | 80,000         | 70,000    |
| Romaniae/-----                   | 180,000     | 180,000     | 180,000     | r/150,000      | 120,000   |
| South Africa, Republic of6/----- | 48,953      | 66,750      | 62,987      | 66,059         | 4/64,600  |
| Spain-----                       | 103,420     | 103,753     | r/143,398   | r/ e/145,000   | 145,000   |
| Tanzaniae/-----                  | 75          | 75          | 75          | 75             | 75        |
| Turkey-----                      | 89,262      | 80,218      | r/93,256    | e/100,000      | 100,000   |
| U.S.S.R.e/-----                  | 2,900,000   | 2,900,000   | 2,900,000   | 2,700,000      | 2,400,000 |
| United States-----               | 2,545,775   | 2,870,971   | 3,112,365   | 3,473,595      | 3,432,000 |
| Yugoslavia-----                  | 154,288     | 125,069     | r/128,593   | r/102,681      | 85,000    |
| Zimbabwe6/-----                  | 116,802     | 113,157     | 104,865     | 99,854         | 100,000   |
| Total-----                       | r/9,268,597 | r/9,049,255 | r/9,591,513 | r/9,733,273    | 9,263,676 |

e/Estimated. r/Revised.

1/Table includes data available through July 20, 1992.

2/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.

3/Includes bentonitic clays.

4/Reported figure.

5/Year beginning Mar. 21 of that stated.

6/May include other clays.

Table 34.-Fuller's earth: World production, by country1/  
(Metric tons)

81

| Country2/                                       | 1987        | 1988        | 1989        | 1990        | 1991e/    |
|-------------------------------------------------|-------------|-------------|-------------|-------------|-----------|
| Algeriae/-----                                  | 3,500       | 3,500       | 3,500       | r/ 3/7,840  | 4/4,526   |
| Argentinae/-----                                | 2,000       | 2,000       | 2,000       | 2,000       | 2,000     |
| Australia (attapulgit)e/-----                   | 4/10,960    | 15,000      | 15,000      | 20,000      | 15,000    |
| Germany: Western states<br>(unprocessed)-----   | 677,000     | 670,000     | r/636,000   | r/653,000   | 760,000   |
| Italy-----                                      | r/38,150    | 38,955      | 43,550      | r/45,800    | 45,000    |
| Mexico-----                                     | 49,112      | 37,226      | 24,603      | r/29,865    | 4/27,800  |
| Morocco (smectite)-----                         | 46,271      | 52,694      | 48,820      | 45,230      | 45,000    |
| Pakistan-----                                   | 17,945      | 12,395      | 15,436      | 16,489      | 17,000    |
| Senegal (attapulgit)e-----                      | 111,048     | 118,725     | 98,882      | r/114,610   | 115,000   |
| South Africa, Republic of<br>(attapulgit)e----- | 6,026       | 7,161       | 6,609       | 7,628       | 4/8,109   |
| Spain (attapulgit)e-----                        | 40,818      | 43,585      | r/23,990    | r/ e/25,000 | 25,000    |
| United Kingdome/-----                           | 213,000     | r/213,000   | 210,000     | 205,000     | 208,000   |
| United States4/-----                            | 1,865,890   | 1,792,232   | 1,881,511   | 2,307,475   | 2,740,000 |
| Total-----                                      | r/3,081,720 | r/3,006,473 | r/3,009,901 | r/3,479,937 | 4,012,435 |

e/Estimated. r/Revised.

1/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 20, 1992.

2/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.

3/Reported figure.

4/Sold or used by producers.

**FIGURE 1**  
**KAOLIN SOLD OR USED BY DOMESTIC**  
**PRODUCERS FOR SPECIFIED USES**

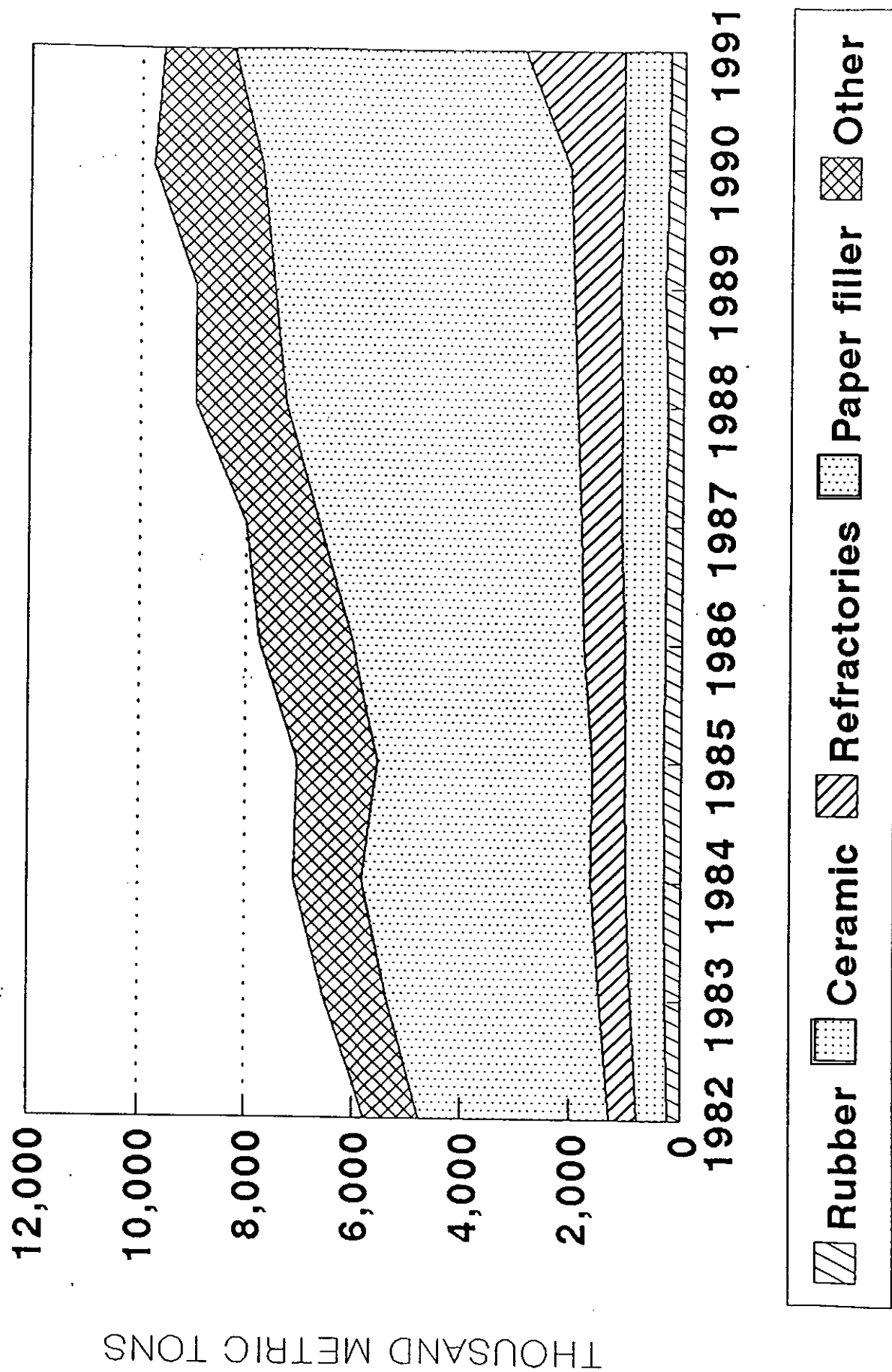


FIGURE 2

# BENTONITE SOLD OR USED BY DOMESTIC PRODUCERS FOR SPECIFIED USES

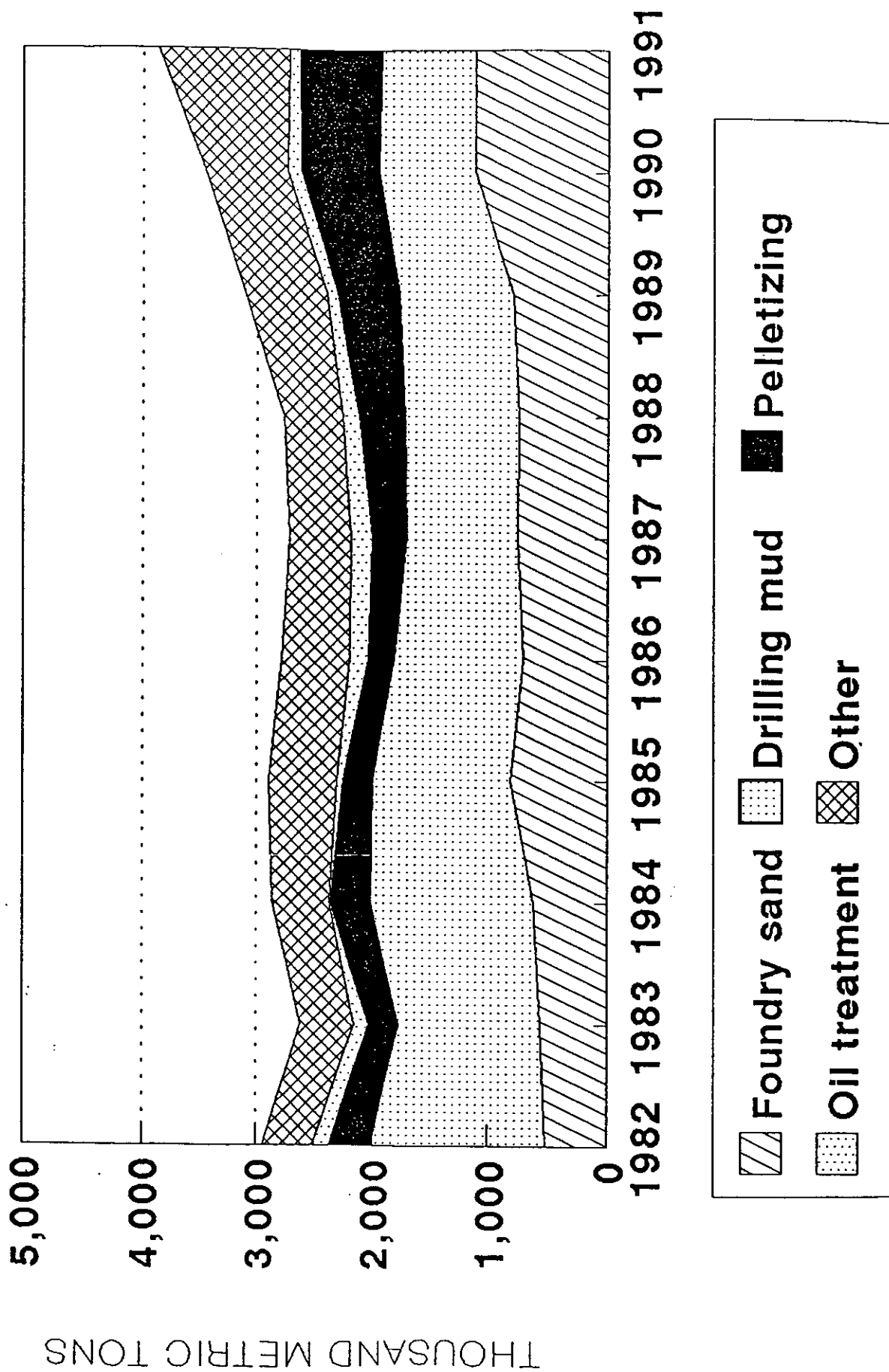


FIGURE 3

# FULLER'S EARTH SOLD OR USED BY DOMESTIC PRODUCERS FOR SPECIFIED USES

