



2015 Minerals Yearbook

CLAY AND SHALE [ADVANCE RELEASE]

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In 2015, domestic production (sold or used by producers) of all clays excluding attapulgite decreased slightly to 25.4 million metric tons (Mt) valued at \$1.49 billion from revised 25.6 Mt valued at \$1.57 billion in 2014 (table 1). Production remained low compared with the years prior to the 2008–9 recession, with sales in 2015 representing approximately 70% of the quantity sold and 85% of the sales value in 2007. Common clay and shale accounted for 48% of the sales tonnage in 2015, but kaolin accounted for 52% of the value (tables 1, 5, 8). Exports of all clays declined by 5% to 3.97 Mt valued at \$913 million in 2015 compared with 4.19 Mt valued at \$942 million during the prior year, and imports fell by 11% to 511,000 metric tons (t) valued at \$74.2 million from 576,000 t valued at \$96.9 million (table 1). World production of bentonite was 19.7 Mt, an increase of 8% relative to revised 18.2 Mt in 2014; world production of fuller's earth was 3.43 Mt, a slight increase from revised 3.4 Mt; and global kaolin production increased slightly to 35.6 Mt compared with revised 35.4 Mt in 2014 (tables 15–17).

Throughout the first three decades of the 20th century, total domestic clay production increased at a relatively steady pace, rising from 1.1 Mt in 1900 to 3.9 Mt in 1930. Production declined during the early 1930s, increased rapidly from about 1940 onward to a peak of 58.8 Mt in 1973, and then trended downward during the remainder of the 1970s into the early 1980s. The mid-1980s saw a resurgence in clay production, and annual domestic output plateaued at an average of approximately 41.5 Mt from the late 1980s into the mid-2000s. Production decreased sharply from 2006 to 2009 owing to the economic recession and has increased slightly since that time (fig. 1).

Since about 1940, common clay and shale have accounted for an annual average of roughly 60% of total clay production, and the trend in total U.S. clay production has paralleled that of common clay and shale. Fire clay was the dominant clay type prior to the early 1940s, representing nearly 70% of the clay sales tonnage from 1900 through 1939. Fire clay production grew rapidly beginning in the 1940s, plateaued in the 1950s and 1960s, and declined from the late 1960s onward. Production of fire clay in 2015 was 26% of that in 1900. In contrast to common clay and fire clay, production of ball clay, bentonite, fuller's earth, and kaolin mostly increased at a relatively steady pace throughout much of the 20th century, with few major fluctuations in output levels. Kaolin production trended downward since the late 1990s, bentonite production decreased in the early 1980s and has mostly increased since, and production of fuller's earth has fallen since 2003 (fig. 1).

In general, variations in sales of clay and shale since 1900 coincided with the rise and fall of the U.S. economy because much of the clay use was associated with construction.

A few specific factors that affected sales of clay and shale were increased oil drilling in the 1920s and its decline in the 1980s (mostly affecting bentonite), the Great Depression of the 1930s, economic growth that accompanied World War II, changes in refractory demands beginning in the 1960s (fire clay), decreased use of brick in housing beginning in the 1970s (common clay), the energy crisis of the 1970s (bentonite), as well as the popularity of clumping pet waste absorbents (fuller's earth) and the introduction of precipitated calcium carbonate into the domestic paper market (kaolin) in the 1990s.

The major clay markets in the early 1900s were for fire clay products, predominantly firebrick and refractory mortars. Other leading end uses included common brick, drain tile, sewer tile, and structural tile for fire clay and common clay. Sales of the other clay types were much smaller; primary uses were in ceramics (ball clay and kaolin), decolorizing oils and greases (bentonite and fuller's earth), foundry sand (bentonite), and paper (kaolin). In 2015, major clay markets included common brick (common clay and shale), drilling mud (bentonite), lightweight aggregate (common clay and shale), paper coating and filling (kaolin), pet waste absorbents (bentonite and fuller's earth), portland cement (common clay and shale), and refractories (kaolin and fire clay).

Production

The U.S. Geological Survey (USGS) has six classifications for clays mined in the United States: ball clay, bentonite, common clay, fire clay, fuller's earth, and kaolin. Ball clay consists primarily of kaolinite with minor to major amounts of illite, chlorite, smectite minerals, quartz, and organic materials. Bentonite comprises smectite minerals (usually montmorillonite) with minor amounts of feldspar, biotite, and quartz. Common clay contains illite and chlorite as major components. Fire clay comprises mainly kaolinite, halloysite, and (or) diaspore. Fuller's earth consists primarily of palygorskite (attapulgite) or calcium-rich montmorillonite nonplastic clays with quartz. Kaolin predominantly includes kaolinite or kaolin-group minerals, although smectite minerals, mica, quartz, and rutile are also components of kaolin deposits. Mineral composition, plasticity, color, absorption qualities, firing characteristics, and clarification properties are a few of the attributes used to distinguish between the various clay types.

Clay mineral terminology is often used inconsistently and can vary depending on geologic origin, mineralogy, and commercial application. For instance, bentonite was originally defined as a clay produced by chemical alteration of igneous rock (usually tuff or volcanic ash), yet clay from many deposits of nonvolcanic origin is sold as bentonite. Ball clay, fire clay, and kaolin are sometimes used interchangeably because the kaolinite

¹Deceased.

minerals in each can be distinguished only on the basis of particle size and degree of ordering within the atomic structure. The term fuller's earth has no mineralogical connotation and is often applied to any clay with absorptive qualities (Eisenhour and Reisch, 2006; McCuiston and Wilson, 2006; Pickering and Heivilin, 2006). Consequently, any data presented for one specific clay type will inevitably include at least one other variety of clay. The USGS does not attempt to precisely identify the clay types produced at U.S. operations and simply uses the terminology reported by the producing company.

Domestic production data for clays were developed by the USGS from a voluntary survey of U.S. operations. Responses to the survey and company production data available from other sources accounted for slightly more than 50% of the total clay and shale quantity reported in table 1 for 2015. Data for nonrespondents were estimated from company reports, trade literature, and (or) prior reported production adjusted by mine and mill employment hours published by the Mine Safety and Health Administration (MSHA).

Approximately 145 companies mined clay and shale in the United States during 2015 and produced a total of 25.4 Mt valued at \$1.49 billion (excluding attapulgite), a slight decrease from 25.6 Mt valued at \$1.57 billion in 2014 (table 1). The 20 leading companies, many with multiple operations, accounted for roughly 65% of the tonnage and nearly 85% of the value for all types of clay sold or used (excluding attapulgite). The 10 leading producer companies were, in alphabetical order, American Colloid Co./Minerals Technologies Inc. (bentonite); Ash Grove Cement Co. (common clay and shale); BASF Corp. (bentonite, fuller's earth, and kaolin); Bentonite Performance Minerals, LLC (bentonite); Imerys S.A. (ball clay and kaolin); KaMin LLC (kaolin); Nestlé S.A. (bentonite and fuller's earth); Thiele Kaolin Co. (kaolin); Trinity LW, LLC (common clay and shale); and Unimin Corp./SCR-Sibelco N.V. (ball clay and kaolin).

In 2015, clay production was reported or estimated in all States except Alaska, Delaware, Hawaii, Idaho, Minnesota, New Hampshire, New Jersey, Rhode Island, Vermont, and Wisconsin. Companies that mined clay for uses such as construction fill, landfill caps, and landscaping but did not operate mills or plants were not included in the USGS canvass of the clay and shale industry. These companies operated in most, if not all, States. The 10 leading producer States were, in decreasing order of tonnage, Georgia, Wyoming, Texas, Alabama, Missouri, Oklahoma, North Carolina, Tennessee, Oregon, and California. Excluding Oregon (in order to avoid disclosing company proprietary data), these States collectively accounted for approximately 70% of U.S. clay production (excluding attapulgite) by quantity (table 2).

Ball Clay

Production.—Four companies mined ball clay in five States during 2015. Domestic output (sold or used by producers) was estimated to be 1.03 Mt valued at \$47.5 million, unchanged in tonnage from that in 2014 (table 3). Estimated ball clay sales in 2015 represented 4% of the U.S. sales tonnage for all clay types and 3% of the sales value (excluding attapulgite). Tennessee was the leading producer State and accounted for an estimated 58%

of total U.S. ball clay production, followed by, in descending order of tonnage, Texas, Mississippi, Kentucky, and Indiana. An estimated 68% of ball clay production was airfloat, followed by unprocessed (23%), and water-slurried (9%). Responses to the USGS survey accounted for about 30% of the ball clay tonnage reported in table 3 for 2015.

In 2015, Unimin Corp. (New Canaan, CT), a subsidiary of SCR-Sibelco N.V. (Belgium), reported the sale of its ball clay facility and reserves in Weakley County, TN, to the Gleason Clay Co. LLC (Gleason, TN), an affiliate of Old Hickory Clay Co. (Mayfield, KY). The transaction was finalized in late August 2014 (Old Hickory Clay Co., 2016).

Consumption.—The two principal domestic markets for U.S. ball clay were ceramic floor and wall tile (an estimated 40% of U.S. and international sales combined) and sanitaryware (21%). Ball clay was also sold to manufacture bricks, electrical porcelain, fine china, pottery, refractory products, roofing granules, and other types of ceramics (table 3). Ball clay producers reported sales for fiberglass and filler, extender, and binder applications, but these were likely to have been kaolin mined or purchased by the ball clay operations.

Historical sales of U.S. ball clay have been strongly correlated with construction activity. In 2015, housing starts increased by 11% to 1.11 million units from 1 million units during 2014 (fig. 2), and construction spending rose by 4% to \$1.16 trillion from \$1.11 trillion (U.S. Census Bureau, 2017a, b), similar to an estimated increase of 25,000 t (13%) in sales of ball clay for sanitaryware. The Tile Council of North America also reported that U.S. shipments (excluding exports) of ceramic tile increased by 10% during 2015 (Whitmire, 2016), but the estimated quantity of ball clay sold domestically for floor and wall tile decreased slightly to 417,000 t compared with 422,000 t in 2014 (table 3). Overall, estimated total sales remained unchanged despite growth in the domestic construction and ceramic tile industries. Imports of ball clay quadrupled in 2015 relative to those in 2014 but represented less than 1% of domestic output. Actual ball clay sales consequently may have been greater than the estimates presented in table 3 (which are based on year-to-year changes in MSHA mill hours and previous reports for survey nonrespondents), but the available information was insufficient to confirm this inference.

Prices.—Estimated ex-works ball clay unit values for individual domestic operations ranged from \$29 to \$77 per ton, and the average unit value increased slightly to \$46 per ton from \$44 per ton in 2014 (table 3). The average free alongside ship (f.a.s.) value of exported ball clay reported by the U.S. Census Bureau was \$211 per ton in 2015 compared with \$225 per ton in 2014, and the average customs value for imported ball clay fell to \$207 per ton from \$314 per ton (tables 13, 14). Low-tonnage shipments of high-value ball clay resulted in much of the change in unit values for exports and imports.

Foreign Trade.—According to the U.S. Census Bureau, ball clay exports were 48,300 t valued at \$10.2 million in 2015 compared with 33,500 t valued at \$7.54 million in 2014 (table 13). Ball clay exports reported to the USGS by producers were withheld to avoid disclosing company proprietary data (table 3), but were significantly higher than those published by the U.S. Census Bureau. Most of the difference involved

shipments to Mexico, whose trade statistics suggested that imports of ball clay from the United States were reported under Mexico's Harmonized Tariff Schedule (HTS) code for kaolin and other kaolinic clays. Exports of ball clay were primarily shipped to Mexico (42%), Venezuela (11%), Japan and Guatemala (9% each), and Ecuador (8%). Ball clay imports totaled 2,200 t valued at \$457,000 compared with 551 t valued at \$173,000 in 2014 (table 14). The majority of imports originated from Ukraine (76%) and the United Kingdom (17%).

Bentonite

Production.—Twenty-two companies produced nonswelling and (or) swelling bentonite in 10 States during 2015. Seventeen companies mined swelling (sodium) bentonite in seven States, and seven companies mined nonswelling (calcium) bentonite in five States. About 4.04 Mt of swelling and nonswelling bentonite valued at \$298 million was sold or used, a 16% decrease in quantity from 4.80 Mt valued at \$323 million during 2014 (table 4). In 2015, approximately 16% of the total domestic clay tonnage and 20% of the total domestic value (excluding attapulgite) consisted of bentonite sales. Production of swelling bentonite fell by 17% to 3.86 Mt valued at \$281 million in 2015 compared with 4.64 Mt valued at \$311 million in 2014. Wyoming led all States in sales of swelling bentonite with more than 90% of the total, followed by, in descending order of tonnage, Utah, Montana, Texas, California, Nevada, and Oregon. Production of nonswelling bentonite in 2015 was 179,000 t valued at \$17 million, a 15% increase from 156,000 t valued at \$11.2 million in 2014. The State rankings for production of nonswelling bentonite, in descending order of tonnage, were Alabama, California, Mississippi, Nevada, and Arizona. Responses to the USGS survey and company production data available from other sources accounted for 75% of the bentonite tonnage reported in table 4 for 2015.

Tolsa Group (Spain) restarted operations at several bentonite mines and one plant in Natrona County, WY, during 2015. The assets were purchased in 2014 from U.S. Bentonite Inc. (Casper, WY), which went bankrupt in 2013. Tolsa planned to double the capacity of the operations and expand across Wyoming during the next several years (Richards, 2015). In addition, S&B Industrial Minerals S.A. (Luxembourg), a subsidiary of Imerys S.A. (France), submitted a plan of operation to the Montana Department of Environmental Quality in which it proposed to resume operations adjacent to a reclaimed bentonite mine near Glasgow, MT (Yang, 2015).

Consumption.—Decreased sales of U.S. bentonite to the domestic drilling mud and iron ore pelletizing markets outpaced increased sales to the pet waste absorbent industry in 2015. Sales within the United States for pet waste absorbent represented 38% of total bentonite sales (domestic and international) and rose by 10% to 1.52 Mt from 1.39 Mt in 2014 (table 4). This growth coincided with a reported increase of 4% in domestic consumer spending on pets (American Pet Products Association, 2016). Use of domestic bentonite in U.S. drilling mud (23% of total sales) declined by 25%, to 927,000 t from 1.24 Mt, whereas exports of bentonite for drilling mud increased by 10%, although the specific sales tonnage has been withheld to avoid disclosing company proprietary data. Drilling activity in the United States

decreased significantly during 2015; at yearend, 698 domestic rotary oil and gas rigs were operating, 62% less than 1,839 at the end of the previous year (Baker Hughes Inc., 2017). Domestic foundry sand and iron ore pelletizing were the third- and fourth-ranked applications for bentonite, respectively, and collectively accounted for more than 15% of total U.S. bentonite use (broadly rounded and combined to avoid disclosing company proprietary data). Sales of U.S. bentonite for domestic foundry sand production decreased slightly from those in 2014, and sales for iron ore pelletizing declined by 18%. These trends were consistent with industry developments; output from foundries fell by 4% in 2015 relative to that of 2014, and shipments of iron ore were 25% lower than in 2014 owing to the closure or idling of multiple iron ore mines (Federal Reserve Board, 2017; Tuck, 2016a). International sales of U.S. bentonite for foundry sand and iron ore pelletizing decreased by 37% and 29%, respectively, compared with those in 2014. About 12% of bentonite sales in 2015 consisted of exports.

The leading markets shown in table 4 are representative of those for swelling bentonite, which accounted for 96% of total bentonite sales in 2015. In decreasing order of tonnage, the domestic end-use rankings for nonswelling bentonite were foundry sand, water treatment and filtering, pet waste absorbents, desiccants, animal feed, unknown applications, miscellaneous ceramics, fertilizers, pesticides, and waterproofing and sealing. Nonswelling bentonite made up 100% of sales (domestic and international) for desiccants, 68% of sales for water treatment and filtering, and more than 50% of sales for fertilizers, but swelling bentonite dominated all other markets. Swelling bentonite accounted for 100% of sales for drilling mud and iron ore pelletizing, more than 90% of sales for pet waste absorbents, and more than 75% of sales for foundry sand.

Prices.—The average unit value (free on board mine or plant) for nonswelling bentonite was \$95 per ton in 2015, up from \$72 per ton in 2014, and that for swelling bentonite increased to \$73 per ton from \$67 per ton (table 4). Nonswelling bentonite prices for individual operations ranged from \$19 to \$129 per ton, and swelling bentonite prices ranged from \$12 to \$441 per ton, but values for most companies were between \$50 and \$90 per ton. The average f.a.s. value of exported bentonite was \$212 per ton in 2015, up from \$198 per ton in 2014 (table 13), and the average customs value of imported bentonite was \$580 per ton compared with \$1,140 per ton in 2014 (table 14). Small shipments of high-value bentonite affected the unit values for exports and imports.

At yearend 2015, prices reported in the trade literature for bentonite from Wyoming, ex-works, were as follows: bulk, crude form for iron ore pelletizing, \$55 to \$72 per ton; foundry grade (bagged and shipped in railcars), \$107 to \$137 per ton; pet waste absorbent grade, \$52 to \$64 per ton; and American Petroleum Institute grade (bagged and shipped in railcars), \$95 to \$138 per ton. List prices of bentonite for pet waste absorbent (crushed, dried, loose in bulk) that was shipped from Kandla, India, were \$32 to \$35 per ton (free on board). Prices for Ohio Cast Metals Association foundry-grade bentonite (crude and dried, in bulk, free on board) from Milos, Greece, ranged from approximately \$65 to \$87 per ton (Syrett, 2015).

Foreign Trade.—Bentonite exports reported by the U.S. Census Bureau increased by 4% to 938,000 t valued at \$199 million in 2015 from 901,000 t valued at \$179 million in 2014 (table 13), whereas exports reported by producers to the USGS decreased by 46% (table 4). Some discrepancy typically occurs between export data reported by producers and U.S. Census Bureau data because producers often include a portion of the exports destined for Canadian and Mexican markets under domestic sales. In addition, some bentonite is packaged domestically and then exported as a finished product, such as pet waste absorbent. Sales through U.S. mineral brokers, where producers do not know if the bentonite is exported or used domestically, could also contribute to the discrepancy. Companies in the United States mainly exported bentonite to Canada (41%), Japan (16%), and Saudi Arabia (13%).

Bentonite imports included untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite in 2015 were down by 28% to 16,100 t valued at \$9.35 million compared with 22,500 t valued at \$25.6 million in 2014. Imports of artificially activated material totaled 23,600 t valued at \$13.6 million in 2015 and 25,600 t valued at \$14 million in 2014 (table 14). United States companies primarily received import shipments of untreated bentonite from China (34%), Turkey (25%), Mexico (18%), and Canada (13%) and shipments of artificially activated material from Mexico (90%).

Common Clay and Shale

Production.—Common clay and shale were produced by nearly 100 companies for manufacturing products in 38 States during 2015. The quantity of common clay and shale sold or used increased by 7% to 12.2 Mt valued at \$164 million compared with 11.4 Mt valued at \$126 million in 2014 (fig. 2). Common clay and shale represented 48% of the total U.S. clay sales tonnage but only 11% of the total sales value (excluding attapulgite) in 2015. The 10 leading producer States were, in descending order of tonnage, Texas, Alabama, Oklahoma, North Carolina, Oregon, Ohio, New York, California, Arkansas, and Indiana (table 5). These 10 States combined accounted for 68% of common clay and shale sales. An undetermined amount of common clay and shale that was used for construction fill, landfill caps, and landscaping was also produced in most, if not all, States. Responses to the USGS survey and company production data available from other sources accounted for 51% of the common clay and shale tonnage reported in table 5 for 2015.

Consumption.—Brick manufacture remained the leading end use for U.S. common clay and shale in 2015, accounting for 41% of sales (table 5). The brick market share increased slightly for the second consecutive year, corresponding to growth in the domestic housing market, where housing starts increased by 11% in 2015 relative to those during the previous year (U.S. Census Bureau, 2017b). Prior to 2014, sales of common clay and shale for brick production had not increased since 2005 despite six successive years of rising housing starts (fig. 2). Brick demand has been hindered by shifts to the use of alternative materials, construction of multifamily dwellings, and a focus on entry-level housing (Boral Ltd., 2015, p. 11; 2016, p. 11, 15); sales for brick in 2015 were 66% lower than those in

2004 (Virta, 2007, p. 18.12). The lightweight aggregate industry (including concrete block, highway surfacing, and structural concrete) was the second-ranked consumer of common clay and shale in 2015 (26% of sales), and the third-ranked use was for the manufacture of portland cement (25%). Combined sales for lightweight aggregate and portland and other cements rose by 9% in 2015 compared with those of 2014, consistent with increases in cement shipments and clinker production during the year (van Oss, 2016, p. 1). Other applications for common clay and shale included ceramic floor and wall tile; fillers, extenders, and binders; miscellaneous ceramics; refractory products; and roofing granules.

Prices.—Unit values (free on board mine or plant) for all common clay and shale sold in the United States by domestic producers varied from less than \$1 to \$88 per ton in 2015, and the average unit value was \$13 per ton, up from \$11 per ton in 2014 (table 5). Estimated average unit values of common clay and shale used to produce specific products were as follows: building brick, approximately \$5 per ton in 2015 and 2014 (table 12); lightweight aggregate, \$37 per ton in 2015 compared with \$30 per ton in 2014; and cement, roughly \$4.50 per ton during each year. Prices for common clay and shale should be viewed with caution because most producers do not sell their clay directly but use it to manufacture products.

Fire Clay

Production.—In 2015, five firms were thought to mine fire clay in four States. Additional companies may have also produced fire clay because year-to-year output has become variable recently as common clay producers randomly entered and exited the market in response to short-term customer demands. Fire clay production (sold or used by producers) was relatively unchanged at 225,000 t valued at \$3.19 million in comparison with 222,000 t valued at \$3.88 million in 2014 (table 6). Fire clay accounted for less than 1% of the tonnage and value of all clays sold in the United States during 2015. Missouri was the leading producer State, followed by, in descending order of tonnage, Colorado, Ohio, and Texas. Responses to the USGS survey accounted for 62% of the fire clay tonnage reported in table 6 for 2015.

In November 2015, Christy Minerals Company, LLC (St. Louis, MO), was granted a permit to extract fire clay from a site near Gerald, MO. The company planned to initiate mining operations immediately on the property, which contained an estimated 13,600 t of fire clay (eMissourian.com, 2015).

Consumption.—Leading markets for U.S. fire clay were, in descending order of tonnage, portland cement, refractory grogs and calcines, ceramic floor and wall tile, firebrick, common brick, unclassified products, miscellaneous ceramics, pottery, and miscellaneous refractories. Detailed data for most end uses were withheld to avoid disclosing company proprietary data (table 6).

Prices.—The average ex-works fire clay unit value for domestic producers decreased to \$14 per ton in 2015 from \$17 per ton in 2014 (table 6). Unit values reported by individual operations ranged from \$13 to \$17 per ton. The average f.a.s. unit value of exported fire clay was \$187 per ton, down from \$222 per ton during the prior year (table 13), although the values

reported by the U.S. Census Bureau likely include significant tonnages of refractory-grade kaolin. Excluding shipments of fire clay from ports in Georgia and South Carolina, where reported exports were likely misreported kaolin, the average f.a.s. unit value of fire clay exports was \$102 per ton in 2015 and \$137 per ton in 2014. The average customs value of imported fire clay in 2015 was \$171 per ton, down from \$430 per ton (table 14). Small, high-value shipments for exports and imports affected the overall unit values.

Foreign Trade.—Exports of fire clay and refractory-grade kaolin appear to have been categorized under the same HTS code in recent years. In 2015, approximately 70% of the exports reported by the U.S. Census Bureau under the HTS code for fire clay were thought to be refractory-grade kaolin based on the locations of ports from which the material was shipped. Exports of fire clay and refractory-grade kaolin decreased by 9% to 217,000 t valued at \$40.6 million from 237,000 t valued at \$52.7 million in 2014 (table 13). The principal destinations for United States exports in 2015 were Mexico (32%), Luxembourg (30%), Japan (10%), and the Netherlands (8%).

Fire clay imports in 2015 totaled 40,300 t valued at \$6.9 million, up nearly sevenfold from 5,850 t valued at \$2.51 million in 2014 (table 14). Nearly all of the fire clay imported into the United States originated in China (90%) and Singapore (8%). The significant reported increase in imports of fire clay may be a result of misclassification of fire clay as refractory-grade kaolin. Exports of fire clay to the United States as reported by China to the United Nations (83,600 t in 2015 and 114,000 t in 2014) significantly differ from the U.S. Census Bureau data but suggest that fire clay imports decreased in 2015 compared with those in 2014 (United Nations, 2016).

Fuller's Earth

Production.—Ten companies operating mines in 10 States sold varieties of fuller's earth in 2015. Attapulgitite was produced by three companies in two States; gellant grades of attapulgitite were mined by two companies in western Florida and southwestern Georgia, and sorbent grades of attapulgitite were mined by one company in southwestern Georgia. One additional company mined gellant grades of attapulgitite in southern Nevada during 2014 but classified this output as nonswelling bentonite in 2015. Montmorillonite was produced by eight companies operating in nine States. To be consistent with past reporting, production and end-use data for sorbent grades of attapulgitite were grouped with montmorillonite-type fuller's earth, whose major market was also sorbent applications.

In 2015, domestic producers sold 1.93 Mt of the montmorillonite variety of fuller's earth, which was valued at \$205 million, slightly less by quantity than 1.98 Mt valued at \$169 million during 2014 (table 7). Sales of montmorillonite in 2015 represented 8% of the tonnage and 14% of the value of total domestic clay sales (excluding attapulgitite). Montmorillonite-type fuller's earth was produced, in decreasing order of tonnage, in Georgia, Missouri, Virginia, Mississippi, California, Tennessee, Illinois, Kansas, and Texas. The four leading States accounted for 83% of sales. Responses to the USGS survey accounted for 44% of the 2015 tonnage reported in table 7 for montmorillonite and sorbent-grade

attapulgitite. Attapulgitite production was withheld to avoid disclosing company proprietary data, but sales declined by an estimated 8% in 2015 compared with those of 2014. Florida was thought to be the leading attapulgitite-producing State, followed by Georgia.

Consumption.—Absorbents (pet waste absorbents, oil and grease absorbents, and miscellaneous absorbents, in decreasing order by tonnage) were the leading U.S. market for domestically mined montmorillonite (76% of domestic and international sales), followed by miscellaneous uses (17%); miscellaneous fillers, extenders, and binders (4%); and animal feed (3%). Miscellaneous uses included exports; filtering, clarifying, and decolorizing of mineral and vegetable oils and greases (the second-ranked end use for U.S. montmorillonite); and unspecified applications (table 7). The leading domestic market for gellant-grade attapulgitite was thought to be paint, followed by, in decreasing order of tonnage, fertilizers; miscellaneous fillers, extenders, and binders; animal feed; adhesives; plastics; pesticides; filtering, clarifying, and decolorizing; and medical, pharmaceutical, and cosmetics products. Montmorillonite dominated sales to most fuller's earth markets, but attapulgitite was thought to account for all sales of fuller's earth for adhesives, fertilizers, paint, and plastics.

Domestic sales of U.S. fuller's earth for absorbents decreased slightly in 2015 compared with those in the prior year, and sales of fillers, extenders, and binders decreased by 27% (table 7). Data for filtering, clarifying, and decolorizing of animal, mineral, and vegetable oils and greases were withheld to avoid disclosing company proprietary data, but sales for this application also fell compared with those in 2014. Sales declines for absorbents and filtering applications were consistent with a report from one major producer of decreased sales for fluid purification products (owing to natural variations in the quality of crops used to produce edible oils) and pet waste absorbents (owing to lower demand for coarse cat litter products) during the fiscal year ended July 31, 2015 (Oil-Dri Corp. of America, 2016, p. 29).

Prices.—In 2015, ex-works unit values for U.S. montmorillonite-type fuller's earth operations ranged from \$2 to \$287 per ton, with the bulk of the values varying from \$60 to \$200 per ton. The average value was \$106 per ton in 2015 compared with \$86 per ton in 2014 (table 7). The overall increase in unit value was driven by a threefold increase in that of one major operation that reported data to the USGS in 2014 and 2015. The average unit value of attapulgitite-type fuller's earth was withheld to avoid disclosing company proprietary data but was estimated to be unchanged from that of 2014. The average f.a.s. value of exported fuller's earth was \$412 per ton in 2015 and \$379 per ton in 2014 (table 13), and the average customs value of imported fuller's earth was \$46 per ton in 2015, down from \$50 per ton in 2014 (table 14). At yearend 2015, approximate ex-works prices for soda-ash-treated fuller's earth from South Africa were as follows: civil-engineering grade, \$74 to \$103 per ton; pet waste absorbent grade, \$43 to \$59 per ton; and foundry grade (bagged), \$89 to \$125 per ton (Syrett, 2015).

Foreign Trade.—Exports of fuller's earth decreased by 16% to 77,000 t valued at \$31.7 million in 2015 from 92,000 t valued

at \$34.9 million during the previous year. The Netherlands, Colombia, Japan, and Brazil were the primary destinations for exports from the United States (in decreasing order by quantity), collectively receiving 34% of the total tonnage (table 13). The remainder of the exports was distributed among 69 other countries. All imports of decolorizing earths and fuller's earth originated from Spain in 2015, and the imported tonnage fell to 2,220 t valued at \$101,000 from 3,670 t valued at \$183,000 in 2014 (table 14).

Kaolin

Production.—Fifteen companies mined kaolin in eight States during 2015. Estimated domestic production (sold or used by producers) decreased by 4% to 5.99 Mt valued at \$776 million from 6.25 Mt valued at \$901 million in 2014 (table 8). In 2015, kaolin production accounted for 24% of all clays produced in the United States by quantity and 52% by value (excluding attapulgite). Sales from Georgia represented an estimated 90% of the U.S. kaolin sales tonnage and South Carolina accounted for an estimated 6%, followed by, in descending order of tonnage, Alabama, Nevada, Arkansas, Texas, Florida, and California. Estimated output from Georgia declined by 5% to 5.39 Mt valued at \$727 million in 2015 compared with 5.66 Mt valued at \$853 million in 2014, and sales from South Carolina rose to 354,000 t valued at \$31.5 million from 345,000 t valued at \$30.2 million in 2014, an increase in quantity of 3%. Production of kaolin in all other States collectively rose by 3,000 t. Water-washed kaolin represented an estimated 52% of all kaolin sold in 2015, followed by airfloat, 19%; calcined, 14%; delaminated, 9%; and unprocessed, 6%. Responses to the USGS survey accounted for about 40% of the kaolin production reported in table 8 for 2015.

In 2015, BASF SE (Germany) sold its paper hydrous kaolin (PHK) business to Imerys, including patents, brands, customer relationships, contracts, and a mill in Wilkinson County, GA. Paper hydrous kaolin refers to processed kaolin that is used in paper products and retains its structural water or hydroxide component. BASF planned to focus on nonpaper applications for kaolin owing to declining demand for its use as a filler and coating pigment in graphical paper (Patel, 2015). KaMin LLC (Macon, GA) subsequently purchased the ultrafine-grade segment of Imerys' PHK business, and Imerys retained the rest of its PHK assets acquired in the BASF transaction. Ultrafine PHK is primarily sold to customers in Europe and Asia (Gyekye, 2015).

Consumption.—Paper coating was the predominant end use for kaolin, with domestic and export sales representing an estimated 16% and 21% of total sales, respectively (table 11). The domestic industries for refractory products (8%); miscellaneous ceramics (7%); fiberglass and mineral wool (6%); paint (5%); rubber (4%); miscellaneous fillers, extenders, and binders (4%); oil and gas refining catalysts (4%); heavy-clay products (2%); and paper filling (not listed in order, percentage withheld to avoid disclosing company proprietary data) were also important consumers of kaolin. Smaller but significant markets were thought to include floor and wall tile, plastics, and sanitaryware. Lightweight ceramic proppants for use in hydraulic fracturing are also a significant market for kaolin, but

available data were insufficient for a reliable estimate of the market size (Hughes, 2015).

The estimated market distribution for kaolin producers in Georgia was similar to that for all States (table 9). The estimated sales rankings for South Carolina operations were, in descending order of tonnage, rubber (39%), ceramics (34%), and other uses including adhesives, animal feed, common brick, paint, paper coating, plastics, and portland cement (27%, combined). Much of the data for individual markets was aggregated to avoid disclosing company proprietary data (table 10).

Kaolin sales to the domestic paper coating industry in 2015 fell by an estimated 289,000 t (23%) relative to those in 2014 (table 11), continuing a trend that has been ongoing since the late 1990s, when domestic paper usage began to decline owing to greater use of electronic media. Approximately 72.4 Mt of paper and paperboard was manufactured in the United States during 2015, 18% less than the alltime high of 88.7 Mt in 1999 (fig. 3) (Food and Agriculture Organization of the United Nations, 2016). Export sales to international paper coating markets decreased by 6%, to an estimated 1.24 Mt from 1.32 Mt in 2014, a reflection of increased substitution of calcium carbonate for kaolin in papermaking owing to its lower cost and higher brightness (Roskill Information Services Ltd., 2013, p. 257–258). Compared with those in 2014, sales of kaolin for miscellaneous ceramics declined by an estimated 26% in 2015, likely driven by reduced use of ceramic proppants owing to reduced oil and gas drilling resulting from low crude oil prices. Estimated refractory sales declined by 17%, to 492,000 t from 595,000 t in 2014, consistent with statements made by a representative of BASF, a major kaolin producer in Georgia (Patel, 2015). The magnitudes of sales changes to all other markets serviced by the kaolin industry were relatively small, with differences of about 25 t or less from those in 2014.

Prices.—Owing to decreased production of high-value calcined and delaminated kaolin, the estimated average unit value (free on board mine or plant) of all kaolin types in 2015 decreased to \$130 per ton compared with \$144 per ton in 2014 (table 8). Unit values for individual operations exhibited a high degree of variability, ranging from \$7 to \$346 per ton depending on the specific types of kaolin produced. The estimated average unit value for airfloat was about \$90 per ton in 2015 and 2014; calcined, \$161 per ton in 2015, down from \$207 per ton in 2014; delaminated, \$147 per ton in 2015, a decrease from \$167 per ton; unprocessed, \$44 per ton in 2015 and \$40 per ton in 2014; and water-washed, \$143 per ton in 2015 compared with \$151 per ton in 2014. The average f.a.s. value of exported kaolin was \$230 per ton in 2015, a slight increase from \$226 per ton in 2014 (table 13), and the average customs value of imported kaolin was \$103 per ton, down slightly from \$105 per ton (table 14). At yearend 2015, the ex-works price of number 1 and number 2 paper coating grades from a plant in Georgia ranged from \$151 to \$209 per ton and from \$130 to \$204 per ton, respectively, both unchanged from those at yearend 2014 (Syrett, 2015).

Foreign Trade.—Kaolin exports decreased by 8% in 2015 to 2.42 Mt valued at \$557 million from 2.64 Mt valued at \$596 million in 2014 (table 13). Japan received 17% of the United States export tonnage, followed by Mexico (15%), China

(14%), Finland (9%), and Canada (8%). A discrepancy between exports reported by the U.S. Census Bureau and those estimated by the USGS based on MSHA employment hours and producer reports (1.92 Mt) likely was the result of some of the kaolin exported to Canada and Mexico being reported by United States companies under domestic consumption. Sales through U.S. mineral brokers, where producers do not know if the kaolin is exported or used domestically, could also explain part of the difference. Imports of kaolin totaled 426,000 t valued at \$43.7 million in 2014, a decline of 18% from 518,000 t valued at \$54.4 million in 2014 (table 14). Nearly all (96%) of the kaolin imported into the United States originated in Brazil.

World Review

In 2015, world production of bentonite increased by 8% to an estimated 19.7 Mt from 18.2 Mt in 2014 (table 15). Global fuller's earth output was an estimated 3.43 Mt, about the same as the 3.4 Mt produced during the previous year (table 16), and an estimated 35.6 Mt of kaolin was produced worldwide, up slightly compared with 35.4 Mt (table 17). For some countries, bentonite production likely included fuller's earth, and kaolin production likely included ball clay. Considering processed clay for sale only, the United States continued to be the leading supplier of all three clay types, followed by Turkey, India, Greece, and Mexico for bentonite; Spain, Mexico, and Senegal for fuller's earth; and Germany, Brazil, Turkey, and Ukraine for kaolin. Conclusive data for the output of refined clays from China and Russia were not available, but China was also thought to be among the leading producers of bentonite and kaolin, and Russia was probably one of the leading producers of bentonite. Among less common varieties of fuller's earth, Spain led all countries in the production of sepiolite, and Senegal and the United States were the two leading producers of attapulgite (palygorskite).

Outlook

Construction activity in the United States has shown an upward trend in recent years. Housing starts in the United States increased each year since 2010, and domestic construction spending (private and public residential and nonresidential spending) increased in every year since 2012 (U.S. Census Bureau, 2017a, b). Some of the world's leading brick producers expected U.S. construction activity to continue to expand during 2016 (Boral Ltd., 2016, p. 17; Wienerberger AG, 2016, p. 117). These trends indicate that sales of ball clay and common clay, which are strongly linked to construction (fig. 2), will likely increase in 2016.

The American Pet Products Association (2016) estimated that domestic consumer spending on pets will increase by 4% in 2016. Although pet waste absorbents are the primary market for fuller's earth, sales for this clay type may decrease if demand for coarse cat litter products continues to decline (Oil-Dri Corp. of America, 2016, p. 5). Sales of bentonite, however, will likely benefit if this forecast proves to be accurate. Bentonite is also strongly linked to oil and gas production owing to its use in drilling mud for rotary systems, as well as the metal casting and iron ore industries, where it is used in foundry

sand and pelletizing of iron ore. The U.S. Energy Information Administration (2015) expected output of crude oil to continue to fall through most of 2016 and increase in 2017. The American Foundry Society predicted that casting shipments would grow between 1% and 4% through 2018 (Modern Casting, 2016), and shipments of domestic iron ore during the first quarter of 2016 were 11% less than those during the same period in 2015 (Tuck, 2016b). The mixed outlooks for the major bentonite markets suggest that sales may decrease slightly or remain relatively unchanged in 2016.

Sales of kaolin to the domestic paper industry have steadily decreased since the late 1990s (fig. 3), a pattern that will likely continue as more information exchange is conducted electronically, paper recycling rates continue to rise, and calcium carbonate increasingly replaces kaolin in paper filling and coating markets. Lightweight ceramic proppants for use in hydraulic fracturing have also become a significant market for kaolin, and sales to this industry will likely decrease in 2016 as a result of declining oil and gas drilling activity. Overall U.S. sales of kaolin are expected to fall in 2016 as a result of these trends, but kaolin use in construction products is likely to grow owing to the positive outlook for the construction industry.

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TABLE 1
SALIENT U.S. CLAY STATISTICS^{1,2}

(Thousand metric tons and thousand dollars)

	2011	2012	2013	2014	2015
Domestic clays sold or used by producers:					
Quantity	25,700	25,800	24,700	25,600 ^r	25,400
Value	1,540,000	1,540,000	1,530,000	1,570,000 ^r	1,490,000
Exports:					
Quantity	4,240	4,270	4,140	4,190	3,970
Value	988,000	870,000	892,000	942,000	913,000
Imports for consumption:					
Quantity	593	524	518	576	511
Value	97,400	108,000	86,900	96,900	74,200

^rRevised.

¹Excludes Puerto Rico.

²Data are rounded to no more than three significant digits.

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

(Thousand metric tons and thousand dollars)

State ³	2014		2015	
	Quantity	Value	Quantity	Value
Alabama	1,390 ^r	19,400 ^r	1,300	20,400
Arkansas	W	W	464	2,160
California	635	40,600	697	40,700
Colorado	W	W	247	5,130
Connecticut, Maine, and Massachusetts	50	747	56	814
Georgia	6,540	898,000	6,260	771,000
Indiana	314	8,160	447	8,990
Iowa	W	W	168	601
Kansas	347 ^r	3,010 ^r	327	2,930
Kentucky	220	6,570	203	6,610
Maryland and West Virginia	278	373	241	273
Mississippi	W	W	643	39,800
Missouri	1,090	34,900	1,080	31,300
Nebraska, North Dakota, and South Dakota	259	1,270	273	1,280
New York	512 ^r	24,000 ^r	528	25,400
North Carolina	808	17,900	923	26,700
Ohio	643	9,980	663	10,700
Oklahoma	906	2,760 ^r	948	2,850
Pennsylvania	229	2,070	237	2,220
South Carolina	501	31,100	532	32,500
Tennessee	813	32,700	767	33,100
Texas	2,090	44,200	2,490	68,600
Utah	W	W	376	12,400
Virginia	567	28,500	499	68,900
Wyoming	4,360	289,000	3,600	253,000
Other ⁴	3,090 ^r	72,500 ^r	1,430	24,700
Total	25,600 ^r	1,570,000 ^r	25,400	1,490,000

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

¹Excludes Puerto Rico and attapulgitte production.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Publishable totals used to avoid disclosing company proprietary data. Nonpublishable totals cannot be calculated from previously published data owing to data revisions. The table was revised in order to include production totals for all individual States with publishable data.

⁴Includes Arizona, Florida, Illinois, Louisiana, Michigan, Minnesota (2014), Montana, Nevada, New Mexico, Oregon, and Washington.

TABLE 3
ESTIMATED BALL CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE¹

(Thousand metric tons and thousand dollars)

Type and use	2014		2015	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	668	27,900	699	30,900
Unprocessed	258	12,400	237	11,700
Water-slurried	107	4,840	93	4,860
Total	1,030	45,200	1,030	47,500
Use:				
Fillers, extenders, and binders ²	38	NA	33	NA
Floor and wall tile	422	NA	417	NA
Miscellaneous ceramics ³	218 ^f	NA	229	NA
Pottery	4	NA	4	NA
Sanitaryware	188	NA	213	NA
Miscellaneous ⁴	163	NA	134	NA
Exports, reported by producers ⁵	W	NA	W	NA
Total	1,030	45,200	1,030	47,500

^fRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous ceramics."

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes adhesives; animal feed; asphalt emulsions; fertilizer carriers; paint; rubber; and other fillers, extenders, and binders.

³Includes catalysts (oil-refining), dinnerware and fine china, electrical porcelain, fiberglass, mineral wool, and roofing granules.

⁴Includes chemical manufacturing, heavy-clay products, refractories, and unknown uses.

⁵Includes miscellaneous ceramics and unknown uses.

TABLE 4
BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE¹

(Thousand metric tons and thousand dollars)

Type and use	2014		2015	
	Quantity	Value	Quantity	Value
Type:				
Nonswelling	156	11,200	179	17,000
Swelling	4,640 ^r	311,000 ^r	3,860	281,000
Total	4,800	323,000 ^r	4,040	298,000
Use:				
Domestic:				
Pet waste absorbents	1,390	NA	1,520	NA
Adhesives	W	NA	W	NA
Animal feed	77 ^r	NA	69	NA
Drilling mud	1,240	NA	927	NA
Filler and extender applications ²	35 ^r	NA	44	NA
Foundry sand	W	NA	W	NA
Pelletizing (iron ore)	W	NA	W	NA
Waterproofing and sealing	92	NA	115	NA
Miscellaneous civil engineering ³	110 ^r	NA	66	NA
Miscellaneous ⁴	921 ^r	NA	795	NA
Total	3,860	NA	3,540	NA
Exports, reported by producers:				
Drilling mud	(5)	NA	(5)	NA
Foundry sand	(5)	NA	(5)	NA
Other ⁶	940	NA	504	NA
Total	940	NA	504	NA
Grand total	4,800	323,000 ^r	4,040	298,000

^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes asphalt emulsions, asphalt tiles, cosmetics, fertilizers, ink, medical, paint, paper coating, paper filling, pesticides and related products, pharmaceuticals, plastics, and miscellaneous filler and extender applications.

³Includes water treatment and filtering and other civil engineering applications.

⁴Includes ceramics, chemical manufacturing, clarifying and decolorizing, heavy-clay products, oil and grease absorbents, refractories, and unknown uses.

⁵Withheld to avoid disclosing company proprietary data; included in "Other."

⁶Includes absorbents, fillers and extenders, iron ore pelletizing, refractories, and unknown uses.

TABLE 5
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS
IN THE UNITED STATES, BY STATE AND USE^{1,2,3}

(Thousand metric tons and thousand dollars)

State and use	2014		2015	
	Quantity	Value	Quantity	Value
State:				
Alabama	1,170 ^r	5,340 ^r	1,090	4,120
Arizona, Colorado, New Mexico, and Utah	408	8,750	482	9,100
Arkansas, Louisiana, and Mississippi	778	4,970	844	5,300
California and Oregon	1,150 ^r	12,500 ^r	1,240	13,500
Connecticut, Maine, and Massachusetts	50	747	56	814
Georgia and South Carolina	505	1,890	529	1,990
Illinois, Indiana, Iowa, Kansas, and Missouri	1,120	11,700	1,290	13,100
Kentucky and Tennessee	280	5,180	265	5,100
Montana and Wyoming	72	65	56	69
Nebraska, North Dakota, and South Dakota	259	1,270	273	1,280
New York	512 ^r	24,000 ^r	528	25,400
North Carolina	799	17,500	923	26,700
Ohio	643	9,980	653	10,600
Oklahoma	906	2,760 ^r	948	2,850
Pennsylvania	229	2,070	237	2,220
Texas	1,740	14,400	2,100	39,400
Other ⁴	734 ^r	2,800 ^r	663	2,380
Total	11,400 ^r	126,000 ^r	12,200	164,000
Use:				
Floor and wall tile ⁵	370	NA	411	NA
Heavy-clay products:				
Brick, extruded	4,310 ^r	NA	4,540	NA
Brick, other	544 ^r	NA	392	NA
Other ⁶	20	NA	9	NA
Lightweight aggregate:				
Concrete block	1,020	NA	1,160	NA
Highway surfacing	303	NA	489	NA
Structural concrete	678	NA	981	NA
Miscellaneous	554 ^r	NA	484	NA
Portland and other cements	3,160 ^r	NA	3,090	NA
Refractories ⁷	82 ^r	NA	162	NA
Miscellaneous ⁸	327 ^r	NA	456	NA
Total	11,400 ^r	126,000 ^r	12,200	164,000

^rRevised. NA Not available.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Excludes Puerto Rico.

³Includes only production for companies with mills or plants.

⁴Includes Maryland, Michigan, Minnesota (2014), Virginia, Washington (2015), and West Virginia.

⁵Includes ceramic tile, quarry tile, and miscellaneous floor and wall tiles.

⁶Includes drain tile, flowerpots, flue linings, sewer pipes, structural tile, and miscellaneous heavy-clay products.

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

⁸Includes exports reported by producers; miscellaneous civil engineering and sealings; miscellaneous fillers, extenders, and binders; pottery; roofing granules; and unknown uses.

TABLE 6
FIRE CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE¹

(Thousand metric tons and thousand dollars)

Use	2014		2015	
	Quantity	Value	Quantity	Value
Heavy-clay products and lightweight aggregates ²	111	NA	85	NA
Refractories:				
Firebrick, block, and shapes	W	NA	W	NA
Grog and calcines	W	NA	W	NA
Other refractories ³	W	NA	W	NA
Miscellaneous ⁴	111	NA	139	NA
Total	222	3,880	225	3,190

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes common brick, concrete block, portland cement, and structural concrete.

³Includes kiln furniture, mortar and cement, and miscellaneous refractories.

⁴Includes floor tile, pottery, wall tile, miscellaneous ceramics, and unknown uses.

TABLE 7
FULLER'S EARTH SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE¹

(Thousand metric tons and thousand dollars)

Type and use	2014		2015	
	Quantity	Value	Quantity	Value
Type:				
Attapulgitic	(2)	(2)	(2)	(2)
Montmorillonite	1,980	169,000	1,930	205,000
Total	1,980	169,000	1,930	205,000
Use:				
Absorbents ³	1,480	NA	1,470	NA
Animal feed	58	NA	55	NA
Fillers, extenders, and binders ⁴	100	NA	73	NA
Filtering, clarifying, and decolorizing ⁵	W	NA	W	NA
Miscellaneous ⁶	341 ^r	NA	337	NA
Exports, reported by producers ⁷	W	NA	W	NA
Total	1,980	169,000	1,930	205,000

^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Withheld to avoid disclosing company proprietary data. Primarily gellant-grade fuller's earth. More information can be found in the "Fuller's Earth" section of this report.

³Includes oil and grease absorbents, pet waste absorbents, and miscellaneous absorbents.

⁴Includes asphalt emulsions; medical, pharmaceuticals, and cosmetics; paints; pesticides and related products; and miscellaneous filler, extender, and binder applications.

⁵Includes mineral and vegetable oils and greases.

⁶Includes civil engineering, drilling mud, and unknown uses.

⁷Includes drilling mud, oil and grease absorbents, paint, pet waste absorbents, and unknown uses.

TABLE 8
ESTIMATED KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES,
BY STATE AND TYPE¹

(Thousand metric tons and thousand dollars)

State and type	2014		2015	
	Quantity	Value	Quantity	Value
State:				
Georgia	5,660	853,000	5,390	727,000
South Carolina	345	30,200	354	31,500
Other ²	240	17,700	243	17,400
Total	6,250	901,000	5,990	776,000
Type:				
Airfloat	1,180	106,000	1,170	104,000
Calcined ³	1,310	272,000	827	133,000
Delaminated	836	140,000	552	81,400
Unprocessed	520	20,700	353	15,600
Water washed	2,400	362,000	3,090	442,000
Total	6,250	901,000	5,990	776,000

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes Alabama, Arkansas, California, Florida, Nevada, and Texas.

³Includes pigment-grade kaolin (low-temperature calcined kaolin) and refractory-grade kaolin (high-temperature calcined kaolin).

TABLE 9
ESTIMATED GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY TYPE AND USE¹

(Thousand metric tons and thousand dollars)

Type and use	2014		2015	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	841	73,700	845	72,900
Calcined ²	1,260	263,000	772	125,000
Delaminated	836	140,000	552	81,400
Unprocessed	336	14,400	151	9,000
Water washed	2,390	362,000	3,070	439,000
Total	5,660	853,000	5,390	727,000
Use:				
Domestic:				
Ceramics:				
Catalysts (oil-refining)	W	NA	W	NA
Fiberglass, mineral wool	289	NA	289	NA
Roofing granules	W	NA	W	NA
Other ³	769	NA	607	NA
Fillers, extenders, and binders:				
Adhesives	23	NA	26	NA
Paint	238	NA	258	NA
Paper coating	1,230	NA	937	NA
Paper filling	W	NA	W	NA
Plastic	49	NA	50	NA
Rubber	139	NA	110	NA
Other ⁴	259	NA	233	NA
Heavy-clay products ⁵	(6)	NA	(6)	NA
Refractories ⁷	(6)	NA	(6)	NA
Undistributed ⁸	676	NA	971	NA
Total	3,670	NA	3,480	NA
Exports, reported by producers:				
Paint	W	NA	W	NA
Paper coating ⁹	1,320	NA	1,240	NA
Paper filling ⁹	W	NA	W	NA
Rubber	42	NA	W	NA
Undistributed ¹⁰	633	NA	667	NA
Total	2,000	NA	1,910	NA
Grand total	5,660	853,000	5,390	727,000

NA Not available. W Withheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes pigment- and refractory-grade calcined kaolin.

³Includes electrical porcelain, fine china and dinnerware, floor and wall tile, pottery, sanitaryware, miscellaneous ceramics, and withheld data under "Domestic: Ceramics."

⁴Includes animal feed; asphalt tile; fertilizers; medical, pharmaceuticals, and cosmetics; pesticides and related products; miscellaneous fillers, extenders, and binders; and withheld data under "Domestic: Fillers, extenders, and binders."

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

⁶Withheld to avoid disclosing company proprietary data; included in "Domestic: Undistributed."

⁷Includes block and shapes, firebrick, grogs and calcines, high-alumina specialties, kiln furniture, and miscellaneous refractories.

⁸Includes chemical manufacturing, waterproofing seals, and unknown uses.

⁹Some export sales by producers may be included with domestic sales.

¹⁰Includes miscellaneous ceramics; miscellaneous fillers, extenders, and binders; unknown uses; and withheld data under "Exports, reported by producers."

TABLE 10
 ESTIMATED SOUTH CAROLINA KAOLIN SOLD OR USED BY PRODUCERS, BY USE^{1,2}

(Thousand metric tons and thousand dollars)

Use	2014		2015	
	Quantity	Value	Quantity	Value
Ceramics ³	118	NA	120	NA
Rubber (includes exports)	133	NA	137	NA
Other ⁴	95	NA	96	NA
Total	345	30,200	354	31,500

NA Not available.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes airfloat, calcined, and unprocessed kaolin.

³Includes catalysts (oil-refining), fiberglass, roofing granules, and sanitaryware.

⁴Includes adhesives, animal feed, brick (common), floor and wall tile, paint, paper coating, plastics, portland cement, and refractories.

TABLE 11
ESTIMATED KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE¹

(Thousand metric tons)

Use	2014	2015
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	243	234
Fiberglass, mineral wool	344	347
Fine china and dinnerware	8	8
Floor and wall tile	56	54
Pottery	W	W
Roofing granules	W	W
Sanitaryware	58	57
Miscellaneous ²	573	422
Chemical manufacture	(3)	(3)
Fillers, extenders, binders:		
Adhesives	25	28
Paint	259	271
Paper coating	1,230	944
Paper filling	W	W
Pesticide	W	W
Plastics	51	52
Rubber	266	242
Miscellaneous ⁴	260	234
Heavy-clay products ⁵	111	136
Refractories ⁶	595	492
Miscellaneous applications	165	544
Total	4,250	4,070
Exports, reported by producers:		
Ceramics	W	W
Paint	W	129
Paper coating	1,320	1,240
Paper filling	W	W
Rubber	48	44
Unknown uses ⁷	634	507
Total	2,000	1,920
Grand total	6,250	5,990

W Withheld to avoid disclosing company proprietary data.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes electrical porcelain, miscellaneous ceramics, and withheld data under "Domestic: Ceramics."

³Withheld to avoid disclosing company proprietary data; included in "Domestic: Miscellaneous applications."

⁴Includes animal feed; medical, pharmaceuticals, and cosmetics; miscellaneous fillers, extenders, and binders; and withheld data under "Domestic: Fillers, extenders, binders."

⁵Includes brick (common) and portland and other cements.

⁶Includes block and shapes, firebrick, grogs and calcines, kiln furniture, and miscellaneous refractories.

⁷Includes withheld data under "Exports, reported by producers."

TABLE 12
COMMON CLAY AND SHALE USED IN BUILDING BRICK
PRODUCTION IN THE UNITED STATES, BY STATE^{1,2}

(Thousand metric tons and thousand dollars)

State	2014		2015	
	Quantity	Value ^c	Quantity	Value ^c
Alabama	392	2,380 ^r	255	810
Arkansas, Louisiana, and Mississippi	436	2,920	466	3,090
California and Washington	W	W	133	455
Colorado, New Mexico, Utah, and Wyoming	116	447	159	644
Georgia and South Carolina	497	1,850	522	1,950
Illinois, Indiana, Iowa, Kansas, and Missouri	264	1,390	278	1,470
Kentucky and Tennessee	152	720	161	755
Maryland, Virginia, and West Virginia	454	1,660	390	1,260
Nebraska and North Dakota	134	710	132	813
North Carolina	391	1,790	424	1,950
Ohio	327	1,830	310	1,720
Oklahoma	711	2,150 ^r	738	2,190
Pennsylvania	188	1,220	192	1,250
Texas	607	3,000	685	3,370
Other ³	182 ^r	1,510 ^r	91	990
Total	4,850 ^r	23,600 ^r	4,940	22,700

^cEstimated. ^rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other."

¹Includes extruded and other brick.

²Data are rounded to no more than three significant digits; may not add to totals shown.

³Includes Connecticut, Maine, Massachusetts, Michigan, and Minnesota (2014).

TABLE 13
U.S. EXPORTS OF CLAYS, BY TYPE¹

(Thousand metric tons and thousand dollars)

Type of clay	2014		2015		Principal destinations in 2015
	Quantity	Value	Quantity	Value	
Ball clay	33	7,540 ^r	48	10,200	Mexico, 42%; Venezuela, 11%; Japan, 9%; Guatemala, 9%; Ecuador, 8%.
Bentonite	901	179,000 ^r	938	199,000	Canada, 41%; Japan, 16%; Saudi Arabia, 13%; China, 5%.
Fire clay	237	52,700	217	40,600	Mexico, 32%; Luxembourg, 30%; Japan, 10%; Netherlands, 8%; Taiwan 5%.
Fuller's earth	92	34,900	77	31,700	Netherlands, 12%; Colombia, 9%; Japan, 7%; Brazil, 6%; South Africa, 5%.
Kaolin	2,640	596,000	2,420	557,000	Japan, 17%; Mexico, 15%; China, 14%; Finland, 9%; Canada, 8%; Taiwan 5%.
Clays ²	282	72,000	268	73,600	Canada, 73%; Mexico, 6%.
Total	4,190	942,000	3,970	913,000	

¹Revised.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Not elsewhere classified.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF CLAYS, BY TYPE¹

(Thousand metric tons and thousand dollars)

Type of clay	2014		2015		Principal sources in 2015
	Quantity	Value	Quantity	Value	
Artificially activated clay and earth	26	14,000	24	13,600	Mexico, 90%; Germany, 6%.
Ball clay	1	173	2	457	Ukraine, 76%; United Kingdom, 17%; France, 5%.
Bentonite	22	25,600	16	9,350	China, 34%; Turkey, 25%; Mexico, 18%; Canada, 13%.
Chamotte or Dina's Earth	(2)	124	(2)	163	Czech Republic, 70%; United Kingdom, 15%; Sweden, 10%.
China clay or kaolin	518	54,400	426	43,700	Brazil, 96%.
Fire clay	6	2,510	40	6,900	China, 90%; Singapore, 8%.
Fuller's earth	4	183	2	101	Spain, 100%.
Total	576	96,900	511	74,200	

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Less than ½ unit.

Source: U.S. Census Bureau; data adjusted by U.S. Geological Survey.

TABLE 15
BENTONITE: WORLD PRODUCTION, BY COUNTRY^{1, 2, 3}

(Metric tons)

Country ⁴	2011	2012	2013	2014	2015 ^c
Algeria	29,000	26,278	27,668	31,510	33,500
Argentina	228,357	193,795	262,899	225,000 ^c	225,000
Armenia	835	4,987	15,387	798	1,592 ⁵
Australia ^c	230,000	230,000	230,000	230,000	230,000
Azerbaijan	20,700	157,875	91,958	76,512	53,958 ⁵
Bolivia	591	745	182	886	890
Bosnia and Herzegovina	17,662	18,000	18,808	80,952	67,261 ⁵
Brazil, beneficiated	566,267	512,975	403,351 ^r	405,169 ^r	405,000
Bulgaria	54,000	110,000 ^r	-- ^r	411,000 ^r	--
Burma	NA	--	1,552	NA ^r	700 ⁵
Canada	2,266	2,015	3,451	2,083	2,000
Chile	1,255	893	3,313	1,083	1,434 ⁵
China ^c	3,500,000	4,000,000 ^r	4,500,000 ^r	5,000,000 ^r	5,600,000
Colombia ^c	8,500	8,500	9,056 ⁵	9,000	9,000
Cuba	1,244	670	335	700	500 ⁵
Cyprus	160,625	160,180	158,386	140,174	127,036 ⁵
Czech Republic	160,000	221,000	226,000	301,000	369,000 ⁵
Denmark	38,300	30,330	56,355	66,388	66,000
Egypt	33,132	17,709 ^r	4,600 ^r	3,615 ^r	40,244 ⁵
Georgia ^c	4,800	4,900	5,000	5,000	5,300
Germany	375,332	366,220	358,854	395,000	395,000
Greece, processed ^c	730,000 ^r	730,000 ^r	730,000 ^r	850,000 ^r	807,550 ⁵
Guatemala	12,270	16,183	18,377	38,368	38,000
Hungary, crude	27,800 ^r	1,100 ^r	9,900 ^r	12,500 ^r	13,600
India ^c	739,000	996,000	1,100,000	1,100,000	1,100,000
Indonesia ^c	6,500	7,000	6,000	6,000	6,000
Iran	422,000	427,000	397,100	419,700	420,000
Iraq	6,452	6,530	6,288	255	--
Italy	102,000	144,000	103,000	100,000 ^c	100,000
Japan ^c	425,000	420,000	420,000	420,000	420,000
Kenya ^c	70	75	80	110	110
Korea, Republic of	94,987	88,543	80,188	71,850	72,000
Macedonia	14,463	6,900	26,820	19,166	19,000
Malawi ^c	2,450 ⁵	-- ⁵	--	--	--
Mexico	563,795	956,224	826,886	474,025	470,000
Morocco	97,071	91,200	105,240	98,757	92,290 ⁵
Mozambique, processed	493	1,459	968	1,250	1,300
New Zealand	--	2,263	762	--	--
Pakistan	26,336	19,997	25,117	44,115	44,000
Peru	27,534	22,977	47,744	37,375	37,000
Philippines	2,087	2,699	3,329	3,369	3,400
Poland, crude	900	800	1,018	650 ^r	450 ⁵
Romania	18,008	18,127	21,051	19,171 ^r	16,511 ⁵
Russia ^c	500,000	550,000	550,000	560,000	560,000
Slovakia	119,323	129,930	129,877	134,131 ^r	163,877 ⁵
Slovenia	168	98	143	199	232 ⁵
South Africa	120,417	120,592	177,187	171,119 ^r	165,535 ⁵
Spain	110,731	96,605	112,887	113,000 ^c	113,000
Thailand	55,220	141,000	150	--	-- ⁵
Turkey	490,458 ^r	1,032,325 ^r	731,936 ^r	1,098,817 ^r	3,134,911 ⁵
Turkmenistan ^c	50,000	50,000	50,000	7,387 ⁵	8,000
Ukraine ^c	211,000	219,000	220,000	210,000	210,000
United States	4,990,000	4,980,000	4,350,000	4,800,000	4,040,000 ⁵
Uruguay	1,210	5,530	8,990 ^r	7,800	8,000
Uzbekistan ^c	25,000	25,000	26,000	26,000	26,000
Total	15,400,000 ^r	17,400,000	16,700,000 ^r	18,200,000 ^r	19,700,000

See footnotes at end of table.

TABLE 15—Continued
BENTONITE: WORLD PRODUCTION, BY COUNTRY^{1,2,3}

⁶Estimated. ⁷Revised. NA Not available. -- Zero.

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

²Includes data available through November 8, 2017.

³Production may include fuller's earth for some countries.

⁴In addition to the countries listed, France and Vietnam are thought to have produced bentonite, but output was not reported, and available information was inadequate to make reliable estimates of output.

⁵Reported figure.

TABLE 16
FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country ³	2011	2012	2013	2014	2015 ^c
Australia, attapulgite ^c	8,000	10,000	10,543 ⁴	10,176 ⁴	10,000
Greece, attapulgite	37,000	19,800	32,400	45,000	107,740 ⁴
India ^c	5,600	5,600	5,600	5,600	5,600
Japan ^c	110,000	110,000	110,000	110,000	110,000
Korea, Republic of	46,623	57,787	51,309	54,001	54,000
Mexico	107,436	227,496	306,507	245,147	250,000
Morocco, smectite	103,682	81,800	59,000	73,500	84,570 ⁴
Pakistan	4,686	7,666	4,442	9,914	10,000
Senegal, attapulgite	181,000	180,000 ^c	235,000	191,000	190,000
South Africa, attapulgite	14,448	15,019	21,233	17,668 ^r	17,627 ⁴
Spain: ^c					
Attapulgite	26,021 ⁴	23,537 ⁴	25,439 ⁴	25,400	25,000
Sepiolite	566,270 ⁴	622,000 ⁴	622,000	622,000	622,000
Turkey, sepiolite ^c	10,000	10,000	10,000	10,000	10,000
United States ⁵	1,950,000	1,980,000	1,990,000	1,980,000	1,930,000 ⁴
Total	3,170,000 ^r	3,350,000 ^r	3,480,000 ^r	3,400,000 ^r	3,430,000

^cEstimated. ^rRevised.

¹Does not include centrally planned economy countries and former such countries, some of which presumably produced fuller's earth but for which no information was available. Includes data available through February 27, 2017.

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

³In addition to the market-economy countries listed, Algeria, France, Iran, and Italy have reportedly produced fuller's earth in the past and may continue to do so, but output was not reported, and available information was inadequate to make reliable estimates of output.

⁴Reported figure.

⁵Does not include attapulgite.

TABLE 17
KAOLIN: WORLD PRODUCTION, BY COUNTRY^{1,2,3}

(Metric tons)

Country ⁴	2011	2012	2013	2014	2015 ⁵
Algeria	71,065	100,970	42,504	181,068	192,000
Argentina	54,166	66,574	75,863	75,000 ^e	75,000
Australia	46,388	89,229	204,521	210,000 ^c	210,000
Austria, crude	56,976	43,174	40,055	36,334	32,126 ⁵
Bosnia and Herzegovina, crude	232,147	149,495	44,940	21,610	252,268 ⁵
Brazil, beneficiated	1,927,000	2,189,000	2,200,000 ^r	2,055,000 ^r	2,100,000
Bulgaria, crude	200,000 ^r	252,100 ^r	281,600 ^r	321,700 ^r	--
Chile ^c	59,912 ⁵	60,429 ⁵	60,000	60,000	60,000
China ^c	3,200,000	3,300,000	3,300,000	3,200,000 ^r	3,200,000
Cuba	3,000	4,000	3,600	1,700	1,500 ⁵
Czech Republic, crude	3,606,000	3,318,000	3,108,000	3,281,000	3,454,000 ⁵
Ecuador	95,062	42,564	100,195	40,236	63,829 ⁵
Egypt ^c	300,000	300,000	300,000	300,000	232,351 ⁵
Eritrea ^c	240	250	260	260	260
Ethiopia ⁶	4,000	4,200 ^r	4,400 ^r	4,530 ^r	4,600
France, marketable ^c	315,000	315,000	267,000 ⁵	317,000 ⁵	320,000
Germany	4,898,516	4,398,796	4,290,000	4,275,000	4,300,000
Greece	7,250	6,268	--	--	--
Guatemala	4,057	1,866	2,953	1,285	1,300
Hungary, beneficiated	-- ^r	-- ^r	90 ^r	500 ^r	2,700 ⁵
India: ^c					
Processed	76,000	101,000	78,000	67,000	67,000
Salable crude	2,900,000	3,400,000	4,400,000	4,700,000	4,700,000
Indonesia ^c	175,000	180,000	180,000	180,000	180,000
Iran	762,000	800,000	946,400	820,100	850,000
Italy ^c	8,000	8,000	8,000	8,000	8,000
Japan ^c	13,000	13,000	13,000	13,000	13,000
Jordan ^c	89,903 ⁵	76,194 ⁵	80,000	80,000	80,000
Kenya ^c	1,000	1,000	1,100	1,600	1,600
Korea, Republic of	798,690	514,841	532,050	429,081	430,000
Kyrgyzstan	108,900	113,900	133,500	1,121,800	1,332,600 ⁵
Madagascar ^c	260	230 ⁵	200 ⁵	200	200
Malaysia	405,717 ^r	424,622 ^r	263,339 ^r	207,694 ^r	255,448 ⁵
Mexico	120,003	163,148	379,110	342,917	320,078 ⁵
New Zealand	21,545	11,578	13,066	61,382	13,659 ⁵
Pakistan	16,481	25,497	20,156	13,803	14,000
Peru	18,169	34,585	32,249	19,964	20,000
Philippines	NA	NA	6,568	7,050	7,000
Poland, beneficiated	164,000 ^r	138,000 ^r	166,000 ^r	164,000 ^{r,e}	169,000
Portugal, washed and unwashed	322,091	321,039	248,008	269,073 ^r	260,000
Romania	--	--	32,722 ^r	30,638 ^r	31,000
Russia	297,000	283,000	711,000	779,000	780,000
Saudi Arabia	65,000	137,000	101,000	106,000	120,000 ⁵
Serbia	379,000	155,000	156,000	214,000	216,210 ⁵
Slovakia ^c	4,000	3,000	6,000	6,000	6,000
South Africa	15,220	20,791	22,295	27,258	20,150 ⁵
Spain, marketable, crude and washed ^c	195,000 ⁵	247,000 ⁵	247,000	247,000	247,000
Sri Lanka	11,157	11,805	12,990	13,000 ^e	13,500
Sudan	15,096	11,579	26,000	33,770	14,490 ⁵
Taiwan	16,936	26,376	15,963	1,808	732 ⁵
Tanzania	178	2,161	1,816	3,809	1,953 ⁵
Thailand, beneficiated	163,881	141,764	119,512	124,094	102,763 ⁵
Turkey	1,229,352	988,081	1,168,441	2,032,103	1,887,302 ⁵
Uganda	20,883	42,886	43,875	46,286	34,697 ⁵
Ukraine	1,317,000	1,218,000	1,179,000	1,426,000	1,815,000 ⁵

See footnotes at end of table.

TABLE 17—Continued
 KAOLIN: WORLD PRODUCTION, BY COUNTRY^{1,2,3}

(Metric tons)

Country ⁴	2011	2012	2013	2014	2015 ^e
United Kingdom ^e	1,290,000	1,150,000	1,110,000	1,090,000	1,010,000
United States	5,950,000	5,900,000	5,950,000 ^r	6,250,000	5,990,000 ⁵
Uzbekistan ^e	300,000	300,000	70,286 ⁵	64,605 ⁵	65,000
Venezuela	1,482	2,447	2,793	2,500 ^r	2,400
Total	32,300,000 ^r	31,600,000 ^r	32,800,000 ^r	35,400,000 ^r	35,600,000

^eEstimated. ^rRevised. NA Not available. -- Zero.

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

²Includes data available through November 8, 2017.

³Production may include ball clay for some countries.

⁴In addition to the countries listed, Belgium, Denmark, Nigeria, Paraguay, Vietnam, and Zambia are thought to have produced kaolin, but output was not reported, and available information was inadequate to make reliable estimates of output.

⁵Reported figure.

⁶Data are for the fiscal year ending July 7 of the year listed.

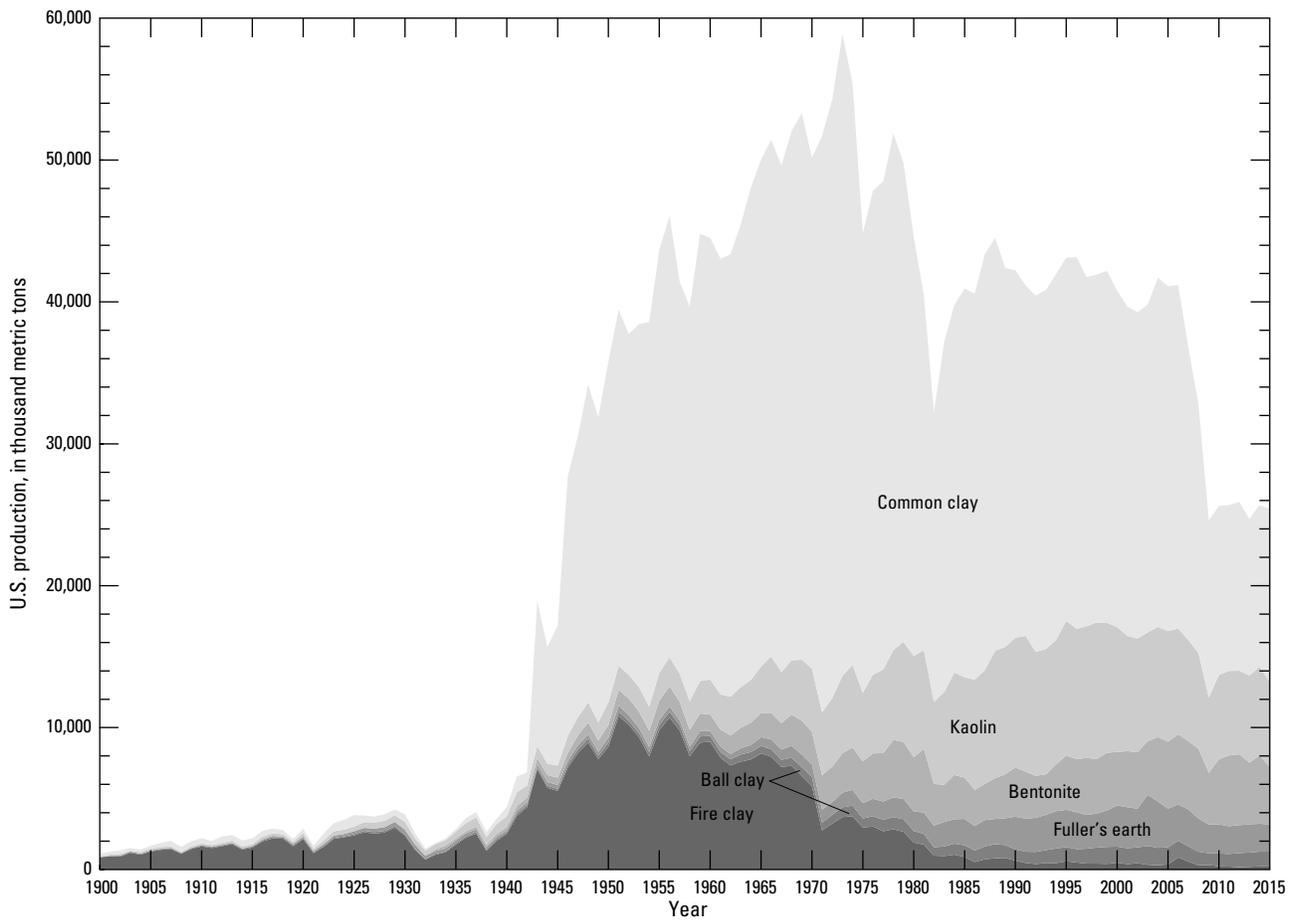


Figure 1. U.S. production (sold or used by producers) of all clay types from 1900 through 2015. Source: U.S. Geological Survey.

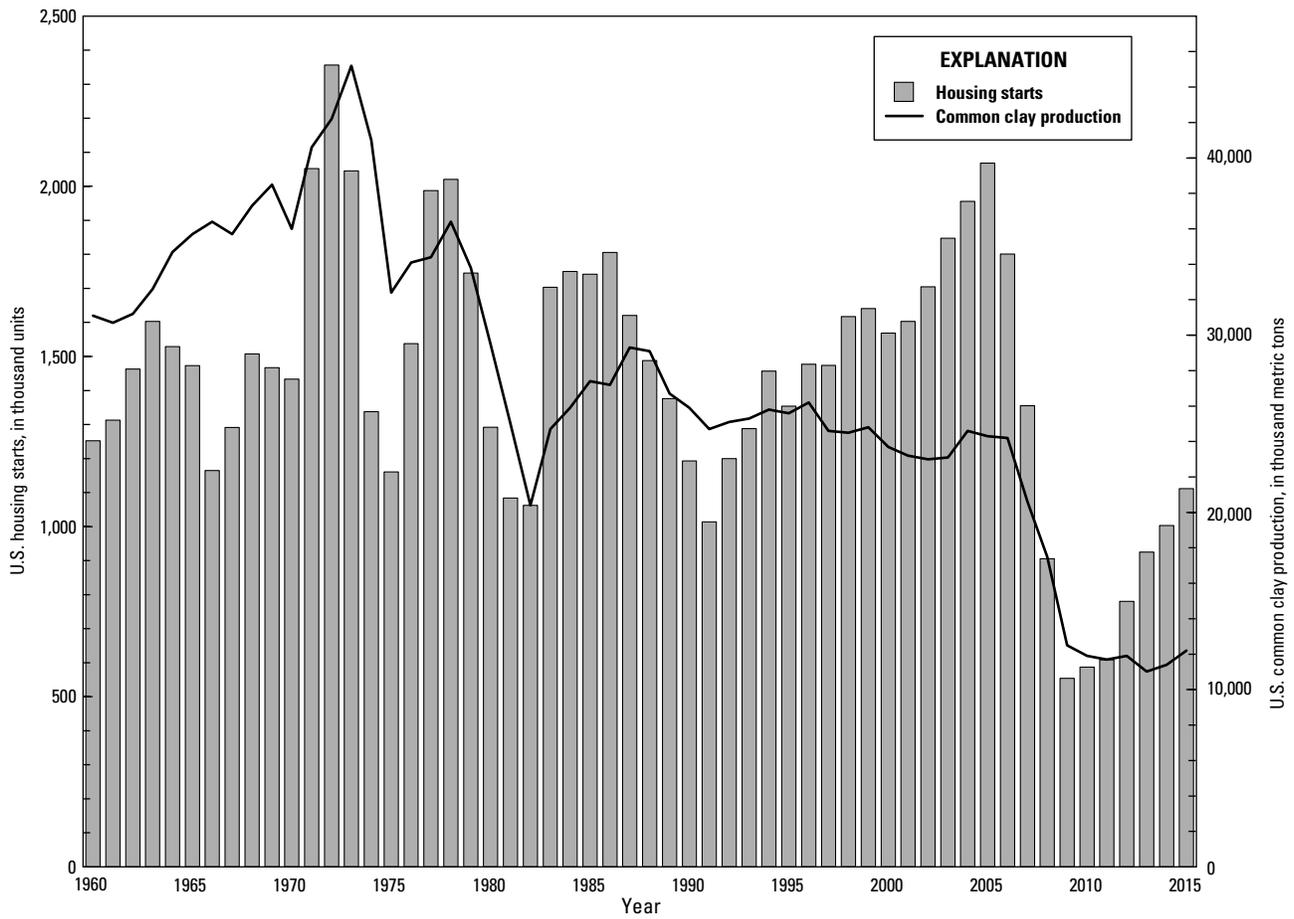


Figure 2. U.S. housing starts and U.S. production (sold or used by producers) of common clay and shale from 1960 through 2015. Sources: U.S. Census Bureau (2017b), U.S. Geological Survey.

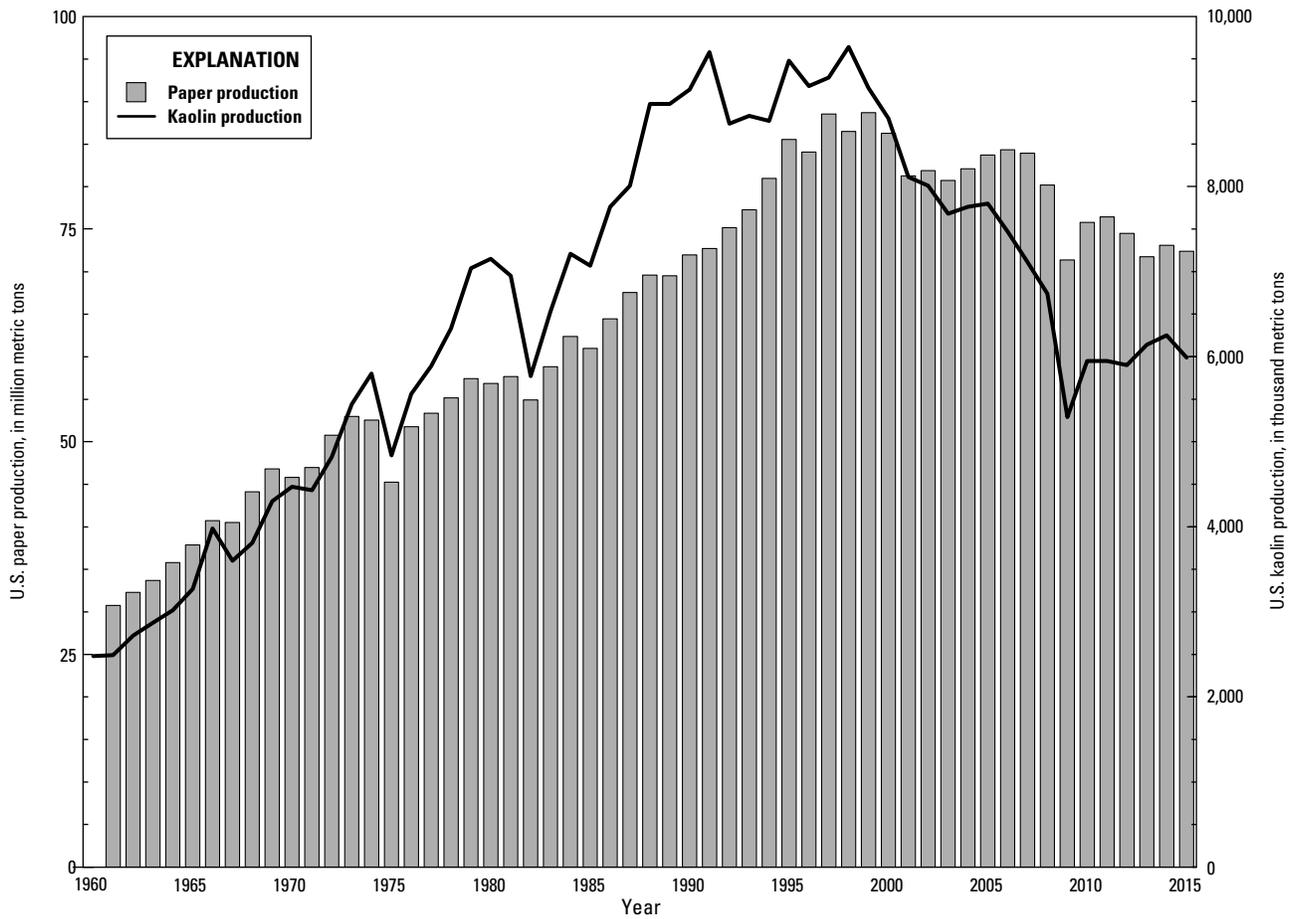


Figure 3. U.S. production of paper and kaolin (sold or used by producers) from 1960 through 2015. Sources: Food and Agriculture Organization of the United Nations (2016), U.S. Geological Survey.