



2016 Minerals Yearbook

CLAY AND SHALE [ADVANCE RELEASE]

CLAY AND SHALE

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In 2016, domestic production (sold or used by producers) of clay not including attapulgite decreased slightly to 23.9 million metric tons (Mt) valued at \$1.49 billion from revised production of 24.5 Mt valued at \$1.56 billion in 2015 (table 1). Common clay and shale accounted for 49% of the sales tonnage in 2016, but kaolin accounted for 56% of the value (tables 1, 5, 8). Exports of clay declined by 8% to 3.8 Mt valued at \$934 million in 2016 compared with 4.14 Mt valued at \$1.0 billion during the prior year, and imports fell by 9% to 473,000 metric tons (t) valued at \$78.5 million from 520,000 t valued at \$79.5 million (table 1). World production of bentonite was 19.0 Mt, a slight decrease compared with revised production of 19.5 Mt in 2015. World production of fuller's earth was 3.37 Mt, a slight decrease from revised production of 3.46 Mt, and global kaolin production decreased slightly to 37.5 Mt compared with revised production of 37.8 Mt in 2015 (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).

Production

The U.S. Geological Survey (USGS) has six classifications for clay 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 different 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 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, data presented for one specific clay type may include one or more other varieties. The USGS does not attempt to precisely identify clay types produced at U.S. operations, but rather uses the terminology as reported.

Domestic production data for clay were developed by the USGS from a voluntary survey of U.S. operations. Responses to the survey and company production data available from public sources accounted for almost 70% of the total clay and shale quantity reported in table 1 for 2016. 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).

Clay and shale production (not including attapulgite) was reported by 145 companies in the United States during 2016 that produced a total of 23.9 Mt valued at \$1.49 billion, a slight decrease from revised production of 24.5 Mt valued at \$1.56 billion in 2015 (table 1). The 20 leading companies, many with multiple operations, accounted for about 65% of the tonnage and nearly 85% of the value for all types of clay sold or used (not including 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 2016, clay production was reported or estimated for all States except Alaska, Delaware, Hawaii, Idaho, Minnesota, New Hampshire, New Jersey, Rhode Island, Vermont, and Wisconsin (table 2). 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, North Carolina and Virginia combined, Missouri, Oklahoma, Tennessee, and Mississippi. These States collectively accounted for 73% of total U.S. clay production (not including attapulgite) by quantity (table 2).

Ball Clay

Production.—Four companies mined ball clay in five States during 2016. Domestic output (sold or used by producers) was estimated to be 975,000 t valued at \$44.0 million, a 5% decrease in tonnage from that in 2015 (table 3). Estimated ball clay sales in 2016 represented 4% of the U.S. sales tonnage for all clay types and 3% of the sales value (not including attapulgitite). 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. Estimated ball clay production consisted of unprocessed (46%), airfloat (45%), and water-slurried (8%). Responses to the USGS survey accounted for about 30% of the ball clay tonnage reported in table 3 for 2016.

Consumption.—The two principal domestic markets for U.S. ball clay were ceramic floor and wall tile (an estimated 54% of U.S. and international sales combined) and sanitaryware (18%). Ball clay also was 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.

Prices.—The estimated price of the material at the production site (ex-works) for ball clay unit for individual domestic operations ranged from \$29 to \$74 per ton, and the average unit value decreased slightly to \$45 per ton from \$46 per ton in 2015 (table 3). The average free alongside ship (f.a.s.) value of exported ball clay reported by the U.S. Census Bureau was \$227 per ton in 2016 compared with \$211 per ton in 2015, and the average customs value for imported ball clay rose to \$296 per ton from \$207 per ton (tables 13, 14). Low-tonnage shipments of high-value ball clay accounted for much of the change in unit values for exports and imports.

Foreign Trade.—According to the U.S. Census Bureau, ball clay exports were 40,600 t valued at \$9.32 million in 2016 compared with 48,300 t valued at \$10.2 million in 2015 (table 13). Exports of ball clay were shipped primarily to Mexico (61%), Japan (7%), and Venezuela, India, and China (5% each). Ball clay imports totaled 347 t valued at \$103,000 compared with 2,200 t valued at \$457,000 in 2015 (table 14). Nearly all imports were from the United Kingdom (87%) and Germany (12%).

Bentonite

Production.—During 2016, 20 companies produced nonswelling and (or) swelling bentonite in 10 States. Swelling (sodium) bentonite was mined by 16 companies in seven States, and nonswelling (calcium) bentonite was mined by 6 companies in five States. Total bentonite sales and use was 3.60 Mt valued at \$270 million in 2016, an 11% decrease in quantity from the revised quantity of 4.05 Mt valued at \$299 million during 2015 (table 4). In 2016, 15% of the total domestic clay tonnage and 18% of the total domestic value (not including attapulgitite) consisted of bentonite sales. Production of swelling bentonite decreased by 12% to 3.41 Mt valued at \$252 million in 2016 compared with 3.87 Mt valued at \$281 million in 2015.

Production of nonswelling bentonite in 2016 was 183,000 t valued at \$18.1 million, a slight increase from the revised production of 180,000 t valued at \$18.1 million in 2015. The State rankings for total production of bentonite were, in descending order of tonnage, Wyoming, Utah, Alabama, Mississippi, Arizona, Texas, California, Montana, Oregon, and Nevada. Responses to the USGS survey and company production data available from public sources accounted for 97% of the bentonite tonnage reported in table 4 for 2016.

Consumption.—Decreased sales of U.S. bentonite to the domestic drilling mud and pet waste absorbent markets outpaced increased sales to the iron ore pelletizing industry in 2016. Sales within the United States for pet waste absorbent represented 40% of total bentonite sales (domestic and international) and declined by 3% to 1.45 Mt from revised sales of 1.49 Mt in 2015 (table 4). Use of domestic bentonite in U.S. drilling mud (23% of domestic sales) declined by 17% to 768,000 t from revised sales of 929,000 t, and exports of bentonite for drilling mud decreased by 50%, although the specific sales tonnage has been withheld to avoid disclosing company proprietary data. Oil-and-gas-well-drilling activity in the United States decreased significantly during 2016. At yearend, 658 domestic rotary oil and gas rigs were operating, which was only 6% less than the 698 rigs at the end of 2015; however, the rig count was much lower during much of the year, reaching a low of 404 rigs in May and recovering slowly through the rest of the year (Baker Hughes Inc., 2017). Domestic iron ore pelletizing and foundry sand were the third- and fourth-ranked applications for bentonite, respectively, and collectively accounted for about 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 by 31% from those in 2015, and sales for iron ore pelletizing increased by 28%. About 8% of bentonite sales in 2016 consisted of exports.

The leading markets shown in table 4 are representative of those for swelling bentonite, which accounted for 95% of total bentonite sales in 2016. In decreasing order of tonnage, the domestic end-use rankings for swelling bentonite were pet waste absorbents, drilling mud, foundry sand, waterproofing and sealing, water treatment and filtering, animal feed, unknown applications, fertilizers, miscellaneous ceramics, and pesticides. 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. Nonswelling bentonite accounted for 100% of sales (domestic and international) for desiccants and more than one-half of sales for water treatment and filtering and fertilizers, but swelling bentonite dominated all other markets.

Prices.—The average unit value [free on board (f.o.b.) mine or plant] for nonswelling bentonite was \$99 per ton in 2016, down from \$101 per ton in 2015, and that for swelling bentonite increased to \$74 per ton from a revised \$73 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 \$217 per ton in 2016, up from \$212 per

ton in 2015 (table 13), and the average customs value of imported bentonite was \$372 per ton compared with \$584 per ton in 2015 (table 14). Small shipments of high-value bentonite affected the unit values for exports and imports.

Foreign Trade.—Bentonite exports reported by the U.S. Census Bureau decreased by 15% to 801,000 t valued at \$174 million in 2016 from 938,000 t valued at \$199 million in 2015 (table 13), whereas exports reported by producers to the USGS decreased by 42% (table 4). Some discrepancies typically occur between export data reported by producers and U.S. Census Bureau data because producers often include a portion of the exports destined for Canada and Mexico 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 discrepancies. Companies in the United States mainly exported bentonite to Canada (43%), Saudi Arabia and Japan (11% each), and China (7%).

Bentonite imports included untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite in 2016 increased by 39% to 22,000 t valued at \$8.19 million compared with 16,100 t valued at \$9.35 million in 2015. Imports of artificially activated material totaled 26,000 t valued at \$14.4 million in 2016 and 24,000 t valued at \$13.6 million in 2015 (table 14). United States imports of untreated bentonite came mostly from Turkey (36%), Greece (27%), and China (14%), and 92% of shipments of artificially activated clay and earth came from Mexico.

Common Clay and Shale

Production.—Common clay and shale was produced by nearly 100 companies in 38 States during 2016. The quantity of common clay and shale sold or used increased by 4% to 11.7 Mt valued at \$173 million compared with a revised 11.3 Mt valued at \$167 million in 2015 (fig. 2). Common clay and shale represented 49% of the total U.S. clay sales tonnage but only 12% of the total sales value (not including attapulgite) in 2016. The 10 leading producer States were, in descending order of tonnage, Texas, Alabama, North Carolina, Oklahoma, New York, Ohio, California, Arkansas, Pennsylvania, and Indiana (table 5). These 10 States combined accounted for 68% of common clay and shale sales. An undetermined quantity of common clay that was used for construction fill, landfill caps, and landscaping also was produced in most, if not all, States. Responses to the USGS survey and company production data available from public sources accounted for 73% of the common clay and shale tonnage reported in table 5 for 2016.

Consumption.—Brick manufacturing remained the leading end use for U.S. common clay and shale in 2016, accounting for 43% of sales (table 5). The market share of brick manufacturing increased slightly for the third consecutive year, corresponding to growth in the domestic housing market, where housing starts increased by 6% in 2016 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 6 consecutive years of increased 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). The lightweight aggregate industry (including concrete block, highway surfacing, and structural concrete) was the second-ranked consumer of common clay and shale in 2016 (25% of sales), and the third-ranked use was for the manufacture of portland cement (17%). 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 (f.o.b mine or plant) for all common clay and shale sold in the United States by domestic producers varied from less than \$1 to \$121 per ton in 2016, and the average unit value was \$15 per ton, unchanged from the revised unit value in 2015 (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 2016 and 2015 (table 12); lightweight aggregate, \$36 per ton in 2016 compared with \$37 per ton in 2015; 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 2016, five firms were thought to mine fire clay in four States. Additional companies also may have 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) increased to 528,000 t valued at \$7.09 million compared with the revised production of 393,000 t valued at \$5.00 million in 2015 (table 6). Fire clay accounted for 2% of the tonnage and less than 1% of the value of all clays sold in the United States during 2016. Missouri was the leading producer State, followed by, in descending order of tonnage, Texas, Ohio, and Colorado. Responses to the USGS survey accounted for 41% of the fire clay tonnage reported in table 6 for 2016.

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 remained steady at about \$13 per ton in 2016 (table 6). Unit values reported by individual operations ranged from \$4 to \$52 per ton. The average f.a.s. unit value of exported fire clay was \$198 per ton, down from \$187 per ton during the prior year (table 13); exports of fire clay reported by the U.S. Census Bureau may have included significant tonnages of refractory-grade kaolin. The average customs value of imported fire clay in 2016 was \$291 per ton, up from \$173 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

Harmonized Tariff Schedule of the United States (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. Charleston, SC, and Savannah, GA, are located on the southeastern coast of the United States, in close proximity to several kaolin producers. Overland transportation of fire clay from producers in the Midwest was thought to be cost prohibitive. Therefore, any fire clay leaving those two ports was most likely incorrectly labeled refractory-grade kaolin. Exports of fire clay and refractory-grade kaolin decreased by 15% to 184,000 t valued at \$36.4 million from 217,000 t valued at \$40.6 million in 2015 (table 13). The principal destinations for United States exports in 2015 were Mexico (37%), the Netherlands (20%), Japan (13%), France (9%), and Taiwan (5%).

Fire clay imports in 2016 totaled 22,000 t valued at \$6.4 million, down by 45% from 40,000 t valued at \$6.9 million in 2015 (table 14). Nearly all the fire clay imported into the United States originated in Singapore (58%) and China (41%).

Fuller's Earth

Production.—Eleven companies operating mines in 11 States sold varieties of fuller's earth in 2016. Attapulgitite was produced by four companies in three 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. 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 2016, domestic producers sold 1.86 Mt of the montmorillonite variety of fuller's earth, which was valued at \$166 million, slightly less by quantity than revised sales of 1.96 Mt valued at \$169 million during 2015 (table 7). Sales of montmorillonite in 2016 represented 8% of the tonnage and 11% of the value of total domestic clay sales (not including attapulgitite). Montmorillonite-type fuller's earth was produced, in decreasing order of tonnage, in Georgia, Virginia, Missouri, Mississippi, California, Tennessee, Illinois, Texas, and Kansas. The four leading States accounted for 79% of sales. Responses to the USGS survey accounted for 67% of the 2016 tonnage reported in table 7 for montmorillonite and sorbent-grade attapulgitite. Attapulgitite production was withheld to avoid disclosing company proprietary data, but sales increased by an estimated 15% in 2016 compared with those of 2015. Florida and Georgia were thought to be the leading attapulgitite-producing States.

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 with 76% of domestic and international sales, followed by miscellaneous fillers, extenders, and binders (4%) and animal feed (3%) (table 7). The leading domestic market for gellant-grade attapulgitite was thought to be paint, but other uses included adhesives; animal feed; fertilizers;

filtering, clarifying, and decolorizing; medical, pharmaceutical, and cosmetics products; miscellaneous fillers, extenders, and binders; plastics; and pesticides. 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.

Prices.—In 2016, ex-works unit values for U.S. montmorillonite-type fuller's earth operations ranged from \$11 to \$287 per ton, with the bulk of the values varying from \$60 to \$200 per ton. The average unit value was \$89 per ton in 2016 compared with \$86 per ton in 2015 (table 7). The average unit value of attapulgitite-type fuller's earth was withheld to avoid disclosing company proprietary data but was estimated to be slightly lower than that of 2015. The average f.a.s. value of exported fuller's earth was \$400 per ton in 2016 and \$412 per ton in 2015 (table 13), and the average customs value of imported fuller's earth was \$582 per ton in 2016, up significantly from \$46 per ton in 2015 (table 14).

Foreign Trade.—Exports of fuller's earth increased by 12% to 86,000 t valued at \$34.4 million in 2016 from 77,000 t valued at \$31.7 million during the previous year. The Netherlands, Colombia, Japan, Pakistan, and Brazil were the primary destinations for United States exports (in decreasing order by quantity), collectively receiving 40% 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 and China in 2016, and the imported tonnage decreased to 372 t valued at \$217,000 from 2,220 t valued at \$101,000 in 2015 (table 14).

Kaolin

Production.—Kaolin was mined by 15 companies in seven States during 2016. Estimated domestic production (sold or used by producers) decreased by 8% to 5.32 Mt valued at \$833 million from a revised 5.81 Mt valued at \$877 million in 2015 (table 8). In 2016, kaolin production accounted for 22% of all clays produced in the United States by quantity and 56% by value (not including attapulgitite). Sales from Georgia represented an estimated 89% of the U.S. kaolin sales tonnage, and South Carolina accounted for an estimated 7%, followed by, in descending order of tonnage, Alabama, Arkansas, Nevada, California, Florida, and Texas. Estimated output from Georgia declined by 9% to 4.72 Mt valued at \$788 million in 2016 compared with a revised estimate of 5.19 Mt valued at \$827 million in 2015, and sales from South Carolina increased to 347,000 t valued at \$31.2 million from revised sales of 346,000 t valued at \$30.6 million in 2015. Water-washed kaolin represented an estimated 53% of all kaolin sold in 2016, followed by airfloat, 16%; calcined, 15%; delaminated, 10%; and unprocessed, 7%. Responses to the USGS survey accounted for about 46% of the kaolin production reported in table 8 for 2016.

Consumption.—Paper coating was the predominant end use for kaolin, with domestic estimated sales representing 23% of total sales (table 11). Important consuming industries included refractory products (10%); miscellaneous ceramics (13%); paint (7%); rubber (5%); miscellaneous fillers, extenders, and binders (4%); and oil and gas refining catalysts (5%). Smaller markets for kaolin included ceramic proppants used in hydraulic

fracturing, fiberglass and mineral wool, floor and wall tile, heavy clay products, paper filling, plastics, and sanitaryware.

Kaolin sales for paper coating to the domestic paper industry in 2016 increased by 27% compared with those in 2015 (table 11), despite an overall decrease in the amount of paper products being produced in the United States. Export sales to international paper coating markets decreased by 10% to an estimated 1.12 Mt from 1.24 Mt in 2015, 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) in addition to the overall decrease in the amount of paper being produced. Compared with those in 2015, sales of kaolin for miscellaneous ceramics increased by an estimated 77% in 2016. Estimated refractory sales increased slightly to 548,000 t from a revised estimate of 543,000 t in 2015. Sales in other kaolin end use categories were relatively stable compared with those in 2015.

Prices.—The estimated average unit value (f.o.b. mine or plant) of all kaolin types in 2016 increased to \$157 per ton compared with the revised value of \$151 per ton in 2015 (table 8). Unit values for individual operations exhibited a high degree of variability, ranging from \$7 to \$453 per ton depending on the specific types of kaolin produced. The average f.a.s. value of exported kaolin was unchanged at \$230 per ton (table 13), and the average customs value of imported kaolin was \$112 per ton, up from \$103 per ton the previous year (table 14).

Foreign Trade.—Kaolin exports decreased by 5% in 2016 to 2.29 Mt valued at \$527 million from 2.42 Mt valued at \$557 million in 2015 (table 13). Japan received 17% of the United States export tonnage, followed by Mexico (15%), China (15%), Finland (7%), Canada (6%), and Taiwan (5%). 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 (1.46 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 389,000 t valued at \$43.6 million in 2016, a decline of 9% from 426,000 t valued at \$43.7 million in 2015 (table 14). Nearly all (96%) of the kaolin imported into the United States originated in Brazil.

World Review

In 2016, world production of bentonite decreased by 3% to an estimated 19.0 Mt from a revised total of 19.5 Mt in 2015 (table 15). Global fuller's earth output also decreased by 3% to an estimated 3.4 Mt from 3.5 Mt produced during the previous year (table 16), and an estimated 37.5 Mt of kaolin was produced worldwide, down slightly compared with a revised 37.8 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, China was estimated to be the leading supplier of bentonite, followed by the United States, Turkey, Greece, India, Russia, and Mexico. The United States, Spain, Mexico, Senegal,

and Greece were the top producers of fuller's earth, and the United States, Germany, India, Czechia, China, Brazil, Turkey, and Ukraine lead in the production of kaolin.

Outlook

Construction activity in the United States has shown an upward trend in recent years. Housing starts in the United States have increased each year since 2010, and domestic construction spending (private and public residential and nonresidential spending) has increased 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 2017 (Boral Ltd., 2016, p. 15; Wienerberger AG, 2017, p. 92). These trends indicate that sales of ball clay and common clay, which are strongly linked to construction (fig. 2), are likely to increase in 2017.

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, 2017, p. 6). 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 (2016) reported that output of crude oil declined throughout most of 2016; it was expected to increase in 2017. The American Foundry Society predicted that metal casting sales would increase between 1% and 4% through 2019, with sales returning to more than \$31 billion in 2017 (Modern Casting, 2017). The mixed outlooks for the major bentonite markets suggest that sales may decrease slightly or remain relatively unchanged in 2017.

Sales of kaolin to the domestic paper industry have steadily decreased since the late 1990s (fig. 3), a pattern that may 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 (Food and Agriculture Organization of the United Nations, 2016). Lightweight ceramic proppants for use in hydraulic fracturing also have become a significant market for kaolin, and sales to this industry may increase in 2017 as a result of increasing oil and gas drilling activity. Overall U.S. sales of kaolin are expected to rise in 2017 as a result of these trends, with kaolin use in construction products 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)

	2012	2013	2014	2015	2016
Domestic clays sold or used by producers:					
Quantity	25,200 ^r	24,100 ^r	24,500 ^r	24,500 ^r	23,900
Value	1,510,000 ^r	1,490,000 ^r	1,540,000 ^r	1,560,000 ^r	1,490,000
Exports:					
Quantity	4,430 ^r	4,300 ^r	4,360 ^r	4,140 ^r	3,800
Value	969,000 ^r	985,000 ^r	1,040,000 ^r	1,000,000 ^r	934,000
Imports for consumption:					
Quantity	662 ^r	627 ^r	591 ^r	520 ^r	473
Value	115,000 ^r	97,800 ^r	107,000 ^r	79,500 ^r	78,500

^rRevised.

¹Table includes data available through September 17, 2018. Data are rounded to no more than three significant digits.

²Excludes Puerto Rico.

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

(Thousand metric tons and thousand dollars)

State ³	2015		2016	
	Quantity	Value	Quantity	Value
Alabama	1,390 ^r	21,300 ^r	1,490	21,700
Arkansas	464	2,160	450	2,120
California	640 ^r	37,900 ^r	704	50,800
Colorado and Utah	639	17,500	706	22,500
Connecticut, Maine, and Massachusetts	56	814	49	695
Georgia	6,040 ^r	871,000 ^r	5,530	828,000
Indiana	447	8,990	363	6,580
Iowa	191 ^r	707 ^r	156	636
Kansas	333 ^r	2,950 ^r	315	3,110
Kentucky	180 ^r	6,510 ^r	167	6,660
Maryland and West Virginia	117 ^r	148 ^r	162	201
Mississippi	692 ^r	42,800 ^r	728	43,900
Missouri	1,290 ^r	33,400 ^r	1,120	24,800
Nebraska, North Dakota, and South Dakota	273	1,280	274	1,710
New York	525 ^r	25,300 ^r	668	28,400
North Carolina and Virginia	1,290	44,300	1,470	49,700
Ohio	672 ^r	12,500 ^r	679	13,600
Oklahoma	741 ^r	2,310 ^r	862	2,800
Pennsylvania	406 ^r	2,930 ^r	350	2,640
South Carolina	525 ^r	31,600 ^r	512	32,200
Tennessee	801 ^r	48,300 ^r	774	46,900
Texas	2,300 ^r	68,100 ^r	2,330	47,100
Wyoming	3,610 ^r	254,000 ^r	3,220	230,000
Other ⁴	873 ^r	27,500 ^r	875	26,400
Total	24,500 ^r	1,560,000 ^r	23,900	1,490,000

^rRevised.

¹Table includes data available through September 17, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Excludes Puerto Rico and attapulgite production.

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, 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	2015		2016	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	699	30,900	442	20,700
Unprocessed	237	11,700	451	19,000
Water-slurried	93	4,860	82	4,300
Total	1,030	47,500	975	44,000
Use:				
Fillers, extenders, and binders ²	33	NA	36	NA
Floor and wall tile	417	NA	528	NA
Miscellaneous ceramics ³	229	NA	113	NA
Pottery	4	NA	4	NA
Sanitaryware	213	NA	175	NA
Miscellaneous ⁴	134	NA	119	NA
Exports, reported by producers ⁵	W	NA	W	NA
Total	1,030	47,500	975	44,000

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

¹Table includes data available through September 17, 2018. Data 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 domestic uses.

⁵Includes miscellaneous ceramics and unknown export 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	2015		2016	
	Quantity	Value	Quantity	Value
Type:				
Nonswelling	180 ^r	18,100 ^r	183	18,100
Swelling	3,870 ^r	281,000	3,410	252,000
Total	4,050^r	299,000^r	3,600	270,000
Use:				
Domestic:				
Pet waste absorbents	1,490 ^r	NA	1,450	NA
Adhesives	W	NA	W	NA
Animal feed	69	NA	48	NA
Drilling mud	929 ^r	NA	768	NA
Filler and extender applications ²	44	NA	33	NA
Foundry sand	W	NA	W	NA
Pelletizing (iron ore)	W	NA	W	NA
Waterproofing and sealing	117 ^r	NA	114	NA
Miscellaneous civil engineering ³	103 ^r	NA	86	NA
Miscellaneous ⁴	795	NA	802	NA
Total	3,550^r	NA	3,300	NA
Exports, reported by producers:				
Drilling mud	(5)	NA	(5)	NA
Foundry sand	(5)	NA	(5)	NA
Other ⁶	508 ^r	NA	295	NA
Total	508^r	NA	295	NA
Grand total	4,050^r	299,000^r	3,600	270,000

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

¹Table includes data available through September 17, 2018. Data 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 domestic uses.

⁵Withheld to avoid disclosing company proprietary data; included in "Use: Exports, reported by producers: Other."

⁶Includes absorbents, fillers and extenders, iron ore pelletizing, refractories, and unknown export 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	2015		2016	
	Quantity	Value	Quantity	Value
State:				
Alabama	1,180 ^r	4,600 ^r	1,260	4,900
Arizona, Colorado, New Mexico, and Utah	499 ^r	9,130 ^r	585	14,100
Arkansas, Louisiana, and Mississippi	928 ^r	9,190 ^r	984	10,400
California and Oregon	580 ^r	11,200 ^r	616	W
Connecticut, Maine, and Massachusetts	56	814	49	695
Georgia and South Carolina	529	1,990	491	1,850
Illinois, Indiana, Iowa, Kansas, and Missouri	1,360 ^r	13,500 ^r	1,140	10,300
Kentucky and Tennessee	242 ^r	5,000 ^r	228	5,150
Montana and Wyoming	56	507 ^r	60	W
Nebraska, North Dakota, and South Dakota	273	1,280	274	1,710
New York	525 ^r	25,300 ^r	668	28,400
North Carolina	771 ^r	25,800 ^r	936	W
Ohio	662 ^r	12,300 ^r	652	12,200
Oklahoma	741 ^r	2,310 ^r	862	2,800
Pennsylvania	406 ^r	2,930 ^r	350	2,640
Texas	1,910 ^r	39,000 ^r	1,950	24,500
Other ⁴	539 ^r	2,150 ^r	565	53,400
Total	11,300^r	167,000^r	11,700	173,000
Use:				
Floor and wall tile ⁵	431 ^r	NA	182	NA
Heavy-clay products:				
Brick, extruded	4,340 ^r	NA	4,730	NA
Brick, other	373 ^r	NA	259	NA
Other ⁶	9	NA	4	NA
Lightweight aggregate:				
Concrete block	1,220 ^r	NA	1,560	NA
Highway surfacing	490 ^r	NA	469	NA
Structural concrete	998 ^r	NA	858	NA
Miscellaneous	500 ^r	NA	770	NA
Portland and other cements	2,280 ^r	NA	2,010	NA
Refractories ⁷	162	NA	498	NA
Miscellaneous ⁸	450 ^r	NA	324	NA
Total	11,300^r	167,000^r	11,700	173,000

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

¹Table includes data available through September 17, 2018. Data 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, Virginia, Washington, 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; miscellaneous ceramics 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	2015		2016	
	Quantity	Value	Quantity	Value
Heavy-clay products and lightweight aggregates ²	203 ^r	NA	414	NA
Refractories:				
Firebrick, block, and shapes	W	NA	W	NA
Groggs and calcines	W	NA	W	NA
Other refractories ³	W	NA	W	NA
Miscellaneous ⁴	189 ^r	NA	114	NA
Total	393 ^r	5,000 ^r	528	7,090

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

¹Table includes data available through September 17, 2018. Data 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	2015		2016	
	Quantity	Value	Quantity	Value
Type:				
Attapulgitite	(2)	(2)	(2)	(2)
Montmorillonite	1,960 ^r	169,000 ^r	1,860	166,000
Total	1,960 ^r	169,000 ^r	1,860	166,000
Use:				
Absorbents ³	1,510 ^r	NA	1,410	NA
Animal feed	58 ^r	NA	57	NA
Fillers, extenders, and binders ⁴	73	NA	82	NA
Filtering, clarifying, and decolorizing ⁵	W	NA	W	NA
Miscellaneous ⁶	319 ^r	NA	313	NA
Exports, reported by producers ⁷	W	NA	W	NA
Total	1,960 ^r	169,000 ^r	1,860	166,000

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

¹Table includes data available through September 17, 2018. Data 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 domestic uses.

⁷Includes drilling mud, oil and grease absorbents, paint, pet waste absorbents, and unknown export 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	2015		2016	
	Quantity	Value	Quantity	Value
State:				
Georgia	5,190 ^r	827,000 ^r	4,720	788,000
South Carolina	346 ^r	30,600 ^r	347	31,200
Other ²	270 ^r	19,300 ^r	245	14,000
Total	5,810 ^r	877,000 ^r	5,320	833,000
Type:				
Airfloat	938 ^r	71,100 ^r	822	66,800
Calcined ³	835 ^r	134,000 ^r	785	128,000
Delaminated	552	81,400	552	82,400
Unprocessed	364 ^r	16,400 ^r	360	14,100
Water washed	3,120 ^r	575,000 ^r	2,800	542,000
Total	5,810 ^r	877,000 ^r	5,320	833,000

^rRevised.

¹Table includes data available through September 17, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes Alabama (2015), 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	2015		2016	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	604 ^r	39,400 ^r	494	34,900
Calcined ²	772	125,000	730	125,000
Delaminated	552	81,400	552	82,400
Unprocessed	161 ^r	9,840 ^r	169	7,750
Water washed	3,100 ^r	571,000 ^r	2,780	538,000
Total	5,190 ^r	827,000 ^r	4,720	788,000
Use:				
Domestic:				
Ceramics:				
Catalysts (oil-refining)	W	NA	W	NA
Fiberglass, mineral wool	236 ^r	NA	W	NA
Roofing granules	W	NA	W	NA
Other ³	558 ^r	NA	781	NA
Fillers, extenders, and binders:				
Adhesives	26	NA	48	NA
Paint	258	NA	304	NA
Paper coating	937	NA	1,200	NA
Paper filling	W	NA	W	NA
Plastic	50	NA	99	NA
Rubber	71 ^r	NA	62	NA
Other ⁴	197 ^r	NA	193	NA
Heavy-clay products ⁵	(6)	NA	(6)	NA
Refractories ⁷	(6)	NA	(6)	NA
Undistributed ⁸	957 ^r	NA	582	NA
Total	3,290 ^r	NA	3,270	NA
Exports, reported by producers:				
Paint	W	NA	W	NA
Paper coating ⁹	1,240	NA	1,120	NA
Paper filling ⁹	W	NA	W	NA
Rubber	W	NA	W	NA
Undistributed ¹⁰	659 ^r	NA	337	NA
Total	1,900 ^r	NA	1,460	NA
Grand total	5,190 ^r	827,000 ^r	4,720	788,000

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

¹Table includes data available through September 17, 2018. Data 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 "Use: 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 "Use: 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	2015		2016	
	Quantity	Value	Quantity	Value
Ceramics ³	120	NA	114	NA
Rubber (includes exports)	132 ^r	NA	138	NA
Other ⁴	94 ^r	NA	95	NA
Total	346 ^r	30,600 ^r	347	31,200

^rRevised. NA Not available.

¹Table includes data available through September 17, 2018. Data 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	2015	2016
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	234	238
Fiberglass, mineral wool	294 ^r	W
Fine china and dinnerware	8	11
Floor and wall tile	53 ^r	46
Pottery	W	W
Roofing granules	W	W
Sanitaryware	29 ^r	W
Miscellaneous ²	401 ^r	709
Chemical manufacture	(3)	(3)
Fillers, extenders, binders:		
Adhesives	27 ^r	50
Paint	270 ^r	307
Paper coating	943 ^r	1,200
Paper filling	W	W
Pesticide	W	W
Plastics	52	100
Rubber	199 ^r	197
Miscellaneous ⁴	198 ^r	192
Heavy-clay products ⁵	89 ^r	85
Refractories ⁶	543 ^r	548
Miscellaneous applications	552 ^r	165
Total	3,890 ^r	3,850
Exports, reported by producers:		
Ceramics	W	W
Paint	129	80
Paper coating	1,240	1,120
Paper filling	W	W
Rubber	43 ^r	48
Unknown uses ⁷	499 ^r	215
Total	1,910 ^r	1,460
Grand total	5,810 ^r	5,320

^rRevised. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through September 17, 2018. Data 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	2015		2016	
	Quantity	Value ^c	Quantity	Value ^c
Alabama	345 ^r	1,290 ^r	464	W
Arkansas, Louisiana, and Mississippi	447 ^r	2,950 ^r	466	3,050
California and Washington	133	713 ^r	119	617
Colorado, New Mexico, Utah, and Wyoming	175 ^r	1,080 ^r	172	W
Georgia and South Carolina	522	1,950	488	1,830
Illinois, Indiana, Iowa, Kansas, and Missouri	278	1,530 ^r	240	1,270
Kentucky, North Carolina, and Tennessee	432	1,830	406	1,800
Maryland, Virginia, and West Virginia	266 ^r	1,030 ^r	307	936
Nebraska and North Dakota	132	813	130	911
Ohio	310	1,730 ^r	319	1,740
Oklahoma	575 ^r	1,650 ^r	701	2,160
Pennsylvania	361 ^r	1,970 ^r	317	1,820
Texas	644 ^r	3,280 ^r	775	3,990
Other ³	91	990	86	4,170
Total	4,710 ^r	22,800 ^r	4,990	24,300

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

¹Table includes data available through September 17, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes extruded and other brick.

³Includes Connecticut, Maine, Massachusetts, and Michigan.

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

(Thousand metric tons and thousand dollars)

Type of clay	2015		2016		Principal destinations in 2016
	Quantity	Value	Quantity	Value	
Artificially activated clay and earth	173	91,300	143	80,100	Canada, 16%; Germany, 8%; Japan, 6%; Thailand, 6%.
Ball clay	48	10,200	41	9,320	Mexico, 61%; Japan, 7%; China, 5%; India, 5%; Venezuela, 5%.
Bentonite	938	199,000	801	174,000	Canada, 43%; Saudi Arabia, 11%; Japan, 11%; China, 7%.
Fire clay	217	40,600	184	36,400	Mexico, 37%; Netherlands, 20%; Japan, 13%; France, 9%; Taiwan, 5%.
Fuller's earth	77	31,700	86	34,400	Netherlands, 11%; Colombia, 9%; Japan, 9%; Pakistan, 6%; Brazil, 5%.
Kaolin	2,420	557,000	2,290	527,000	Japan, 17%; China, 15%; Mexico, 15%; Finland, 7%; Canada, 6%; Taiwan, 5%.
Clays, not elsewhere classified	268	73,600	256	72,700	Canada, 72%; Mexico, 5%.
Total	4,140 ^r	1,000,000 ^r	3,800	934,000	

^rRevised.

¹Table includes data available through September 17, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

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	2015		2016		Principal sources in 2016
	Quantity	Value	Quantity	Value	
Artificially activated clay and earth	24	13,600	26	14,400	Mexico, 92%; Germany, 6%.
Ball clay	2	457	(2)	103	United Kingdom, 87%; Germany, 12%.
Bentonite	16	9,350	22	8,190	Turkey, 36%; Greece, 27%; China, 14%.
Chamotte or Dinas Earth	(2)	163	1	115	Italy, 72%; Czechia, 20%; United Kingdom, 7%.
Kaolin	426	43,700	389	43,600	Brazil, 96%.
Fire clay	40	6,900	22	6,400	Singapore, 58%; China, 41%.
Fuller's earth	2	101	(2)	217	Spain, 65%; China, 35%.
Clays, not elsewhere classified	9	5,300	11	5,460	Canada, 35%; Spain, 35%; Mexico, 8%; France, 7%.
Total	520 ^r	79,500 ^r	473	78,500	

^rRevised.

¹Table includes data available through September 17, 2018. Data 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 OR LOCALITY^{1,2}

(Metric tons)

Country or locality ³	2012	2013	2014	2015	2016
Algeria	26,278	27,668	31,510	33,500 ^c	34,000 ^c
Argentina	191,795 ^r	262,899	275,000 ^{r,c}	240,000 ^{r,c}	240,000 ^c
Armenia	4,987	15,387	798	1,592	1,600 ^c
Australia ^c	82,000 ^r	110,000 ^r	66,000 ^r	71,000 ^r	71,000
Azerbaijan	36,700 ^r	97,700 ^r	81,900 ^r	56,800 ^r	49,300 ^c
Bolivia	745	182	886	890 ^c	890 ^c
Bosnia and Herzegovina	18,000	18,808	80,952	67,261	67,300 ^c
Brazil	512,975	403,351	405,169	405,000 ^c	405,000 ^c
Bulgaria	110,000	--	411,000	--	-- ^c
Burma	--	1,522 ^r	NA	700	700 ^c
Canada	2,015	3,451	2,083	583 ^{r,c}	583 ^c
Chile	893	3,313	1,083	1,434	1,430 ^c
China ^c	4,000,000	4,500,000	5,000,000	5,600,000	5,600,000
Colombia	8,500 ^c	9,056	9,000 ^c	9,000 ^c	9,000 ^c
Cuba	670	335	700	500	500 ^c
Cyprus	160,000 ^{r,c}	158,386	140,174	127,036	127,000 ^c
Czechia	221,000	226,000	301,000	369,000	369,000 ^c
Denmark	30,330	56,355	66,388	66,000 ^c	66,000 ^c
Egypt	17,709	4,600	3,615	40,244	40,200 ^c
Georgia	120,000 ^{r,c}	120,000 ^{r,c}	126,400 ^r	135,500 ^r	139,000 ^c
Germany	366,220	358,854	395,000	395,000 ^c	395,000 ^c
Greece ^c	730,000	730,000	850,000	808,000 ^r	808,000
Guatemala	16,183	18,377	38,368	718 ^{r,c}	718 ^c
Hungary	476 ^r	4,144 ^r	5,557 ^r	5,667 ^r	6,000 ^c
India ^c	658,000 ^r	663,000 ^r	800,000 ^r	802,000 ^r	802,000
Indonesia ^c	7,000	6,000	6,000	6,000	6,000
Iran	427,000	397,100	419,700	436,000 ^{r,c}	436,000 ^c
Iraq	6,530	6,288	255	--	-- ^c
Italy	144,000	103,000	100,000 ^c	100,000 ^c	100,000 ^c
Japan ^c	420,000	420,000	420,000	420,000	420,000
Kenya ^c	75	80	110	130 ^r	130
Korea, Republic of	88,500 ^c	80,188	71,850	78,400 ^{r,c}	78,500 ^c
Macedonia	2,355 ^r	18,520 ^r	11,691 ^r	9,000 ^{r,c}	1,970 ^c
Mexico	956,224	826,886	474,025	470,000 ^c	470,000 ^c
Morocco	91,200	105,240	98,757	92,290	92,000 ^c
Mozambique:					
Crude	24,000	21,135	27,167	70,917	71,000 ^c
Processed	1,459	968	1,250	3,300 ^{r,c}	3,300 ^c
New Zealand	2,263	762	--	--	-- ^c
Pakistan	16,520 ^r	22,000 ^r	44,000 ^r	33,600 ^{r,c}	33,600 ^c
Peru	22,977	47,743 ^r	37,375	21,300 ^{r,c}	19,200 ^c
Philippines	2,699	3,329	3,369	3,480 ^{r,c}	3,500 ^c
Poland, crude	800	1,018	650	450	450 ^c
Romania	18,127	21,051	19,171	16,511	16,500 ^c
Russia ^c	550,000	550,000	560,000	580,000 ^r	580,000
Slovakia	129,930	129,877	134,131	164,000 ^c	164,000 ^c
Slovenia	98	143	199	232 ^c	230 ^c
South Africa	120,592	177,187	171,119	165,535	149,000 ^c
Spain	96,605	112,887	113,000 ^c	113,000 ^c	113,000 ^c
Thailand	30,000 ^r	150	--	--	-- ^c
Turkey	1,032,325	731,936	1,098,817	3,134,911	3,140,000 ^c
Turkmenistan:					
Powder	305	360	400	400	400 ^c
Other, unspecified	50,000 ^c	50,000 ^c	7,387	8,000 ^c	8,000 ^c
Ukraine ^c	219,000	220,000	210,000	210,000	210,000
United States	5,010,000 ^r	4,440,000 ^r	4,830,000 ^r	4,050,000 ^r	3,600,000
Uruguay	5,530	8,990	7,800	4,250 ^{r,c}	4,250 ^c

See footnotes at end of table.

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

(Metric tons)

Country or locality ³	2012	2013	2014	2015	2016
Uzbekistan ^e	25,000	26,000	26,000	26,000	26,000
Total	16,800,000 ^r	16,300,000 ^r	18,000,000 ^r	19,500,000 ^r	19,000,000

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

¹Table includes data available through November 20, 2017. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Production may include fuller's earth for some countries.

³In addition to the countries and (or) localities listed, France and Vietnam are thought to produce bentonite, but output was not reported, and available information was inadequate to make reliable estimates of output levels.

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

(Metric tons)

Country or locality ³	2012	2013	2014	2015	2016
Angola	35,492	98,084	98,000	98,000	98,000 ^e
Australia, attapulgite	10,000 ^e	10,543	10,176	16,200 ^{r,e}	16,000 ^e
Greece, attapulgite:					
Crude	19,800	32,400	45,000	107,740	108,000 ^e
Treated	9,200	10,300	14,670	22,070	23,000 ^e
India ^e	5,600	5,600	5,600	5,600	5,600
Korea, Republic of	57,787	51,309	54,001	54,000 ^e	54,000 ^e
Mexico	227,496	306,507	245,147	250,000 ^e	260,000 ^e
Morocco, smectite	81,800	59,000	73,500	84,600 ^e	85,000 ^e
Pakistan	6,906 ^r	4,045 ^r	9,914	10,400 ^{r,e}	10,500 ^e
Senegal, attapulgite	180,000 ^e	234,600 ^r	191,000	188,000 ^{r,e}	188,000 ^e
South Africa, attapulgite	15,019	21,233	17,668	17,627	16,400 ^e
Spain:					
Attapulgite	23,537	25,439	25,400 ^e	25,400 ^{r,e}	25,400 ^e
Sepiolite	622,000	622,000 ^e	622,000 ^e	622,000 ^e	622,000 ^e
United States ⁴	1,980,000	2,020,000 ^r	2,040,000 ^r	1,960,000 ^r	1,860,000
Total	3,280,000 ^r	3,500,000 ^r	3,450,000 ^r	3,460,000 ^r	3,370,000

^eEstimated. ^rRevised.

¹Table includes data available through November 22, 2017. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²Does not include centrally planned economy countries and (or) localities and former such countries and (or) localities, some of which presumably produce fuller's earth but for which no information is available.

³In addition to the market economy countries and (or) localities listed, Algeria, France, Italy, and Iran 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 levels.

⁴Does not include attapulgite.

TABLE 17
KAOLIN: WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons)

Country or locality ²	2012	2013	2014	2015	2016
Albania	961,000	768,000	810,000	1,161,000	1,160,000 ^e
Algeria	100,970	42,504	181,068	192,000 ^e	192,000 ^e
Argentina	66,574	77,063 ^r	46,400 ^{r,e}	61,000 ^{r,e}	61,000 ^e
Australia	89,229	204,521	172,000 ^{r,e}	260,000 ^{r,e}	260,000 ^e
Austria	43,174	40,055	36,334	32,126	32,000 ^e
Bhutan	7,353	15,166	10,209	--	-- ^e
Bosnia and Herzegovina	149,495	44,940	21,610	252,268	253,000 ^e
Brazil	2,189,000	2,200,000	2,055,000	2,100,000 ^e	2,100,000 ^e
Bulgaria	252,100	281,600	321,700	--	-- ^e
Cameroon	8,922	12,107	22,042	22,000	22,000 ^e
Chile	60,429	60,000	60,000 ^e	60,000 ^e	60,000 ^e
China ^c	3,300,000	3,300,000	3,200,000	3,200,000	3,200,000
Cuba	4,000	3,600	1,700	1,500	1,500 ^e
Czechia	3,318,000	3,108,000	3,281,000	3,454,000	3,500,000 ^e
Ecuador	42,564	100,195	40,236	63,829	64,000 ^e
Egypt	300,000 ^e	300,000 ^e	300,000 ^e	232,351	232,000 ^e
Eritrea ^e	-- ^r	-- ^r	-- ^r	-- ^r	--
Estonia	98,600	99,000	107,000	58,000	58,000 ^e
Ethiopia ³	4,200 ^e	4,400 ^e	4,530	4,600 ^e	4,600 ^e
France, marketable	315,000 ^e	267,000	317,000	320,000 ^e	320,000 ^e
Germany	4,398,796	4,290,000	4,275,000	4,300,000 ^e	4,300,000 ^e
Greece	6,268	--	--	--	-- ^e
Guatemala	1,866	2,953	1,285	1,100 ^{r,e}	1,100 ^e
Hungary, beneficiated	--	36 ^r	196 ^r	1,119 ^r	1,100 ^e
India: ^c					
Marketable crude	2,350,000 ^r	4,070,000 ^r	4,580,000 ^r	4,040,000 ^r	4,110,000
Processed	99,800 ^r	67,900 ^r	86,400 ^r	73,600 ^r	74,000
Indonesia ^e	180,000	180,000	180,000	180,000	180,000
Iran	800,000	946,388 ^r	820,067 ^r	791,193 ^r	790,000 ^e
Iraq	3,000	--	--	--	-- ^e
Italy ^c	8,000	8,000	8,000	8,000	8,000
Japan ^c	13,000	12,000 ^r	12,000 ^r	12,000 ^r	12,000
Jordan	76,194	80,000 ^e	80,000 ^e	80,000 ^e	80,000 ^e
Kenya ^e	1,000	1,100	1,600	1,800 ^r	1,800
Korea, Republic of	514,841	532,050	429,081	357,000 ^{r,e}	357,000 ^e
Kosovo	55,300	50,100	55,300	61,300	62,000 ^e
Kyrgyzstan	113,900	133,500	1,121,800	1,332,600	1,330,000 ^e
Lithuania	300,075	318,733	294,386	326,276	326,000 ^e
Madagascar	230	200	221 ^r	220 ^{r,e}	220 ^e
Malaysia	424,622	263,339	207,694	255,448	284,000 ^e
Mexico	163,148	379,110	342,917	320,078	330,000 ^e
New Zealand	11,578	13,066	61,382	13,659	14,000 ^e
Nigeria	15,420	17,000	19,200	22,000	24,100 ^e
Norway	225,000	225,000	225,000	225,000	225,000 ^e
Oman	139,500	114,678	67,000	169,500	170,000 ^e
Pakistan	22,000 ^r	16,463 ^r	13,803	23,100 ^{r,e}	23,100 ^e
Peru	34,585	32,249	19,964	43,500 ^{r,e}	19,300 ^e
Philippines	4,631 ^r	6,568	7,050	8,180 ^{r,e}	8,200 ^e
Poland:					
Crude	249,000	268,000	278,000	287,000	290,000 ^e
Beneficiated	138,000	166,000	164,000 ^e	169,000 ^e	170,000 ^e
Portugal, washed and unwashed	321,039	248,008	269,073	260,000 ^e	260,000 ^e
Romania	--	32,722	30,638	31,000 ^e	31,000 ^e
Russia ^e	284,000 ^r	674,000 ^r	787,000 ^r	786,000 ^r	786,000
Saudi Arabia	137,000	101,000	106,000	120,000	120,000 ^e
Serbia	155,000	156,000	214,000	216,210	217,000 ^e

See footnotes at end of table.

TABLE 17—Continued
KAOLIN: WORLD PRODUCTION, BY COUNTRY OR LOCALITY¹

(Metric tons)

Country or locality ²	2012	2013	2014	2015	2016
Slovakia	3,000 ^e	6,000 ^e	6,000 ^e	10,502 ^r	11,000 ^e
South Africa	20,791	22,295	27,258	20,150	21,100 ^e
Spain, marketable, crude and washed	247,000	247,000 ^e	247,000 ^e	247,000 ^e	247,000 ^e
Sri Lanka	11,800 ^{r,e}	13,000 ^{r,e}	13,000 ^e	13,500 ^e	13,500 ^e
Sudan	11,579	26,000	33,770	14,490	15,000 ^e
Taiwan	26,376	15,963	1,808	732	4,040 ^e
Tanzania	1,422 ^r	907 ^r	3,809	1,953	2,000 ^e
Thailand:					
Filler	300	--	--	--	-- ^e
Nonbeneficiated	1,000,975	631,133	755,913	655,196	655,000 ^e
Turkey	988,081	1,168,441	2,032,103	1,887,302	1,900,000 ^e
Uganda	42,886	43,875	46,286	34,700 ^{r,e}	34,000 ^e
Ukraine	1,218,000	1,179,000	1,426,000	1,815,000	1,820,000
United Kingdom ^e	1,150,000	1,110,000	1,090,000	1,010,000	1,010,000
United States	5,720,000 ^r	5,880,000 ^r	6,020,000 ^r	5,810,000 ^r	5,320,000 ^e
Uzbekistan	300,000 ^e	70,286	64,605	304,000 ^{r,e}	304,000 ^e
Venezuela	2,447	2,793	2,500	2,400 ^e	2,400 ^e
Total	33,300,000 ^r	34,700,000 ^r	37,500,000 ^r	37,800,000 ^r	37,500,000

^eEstimated. ^rRevised. -- Zero.

¹Table includes data available through November 23, 2017. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

²In addition to the countries and (or) localities listed, Belgium, Denmark, Nigeria, Paraguay, Vietnam, and Zambia produced kaolin, but available information was inadequate to make reliable estimates of output levels.

³Production is based on fiscal year, with a starting date of July 7.

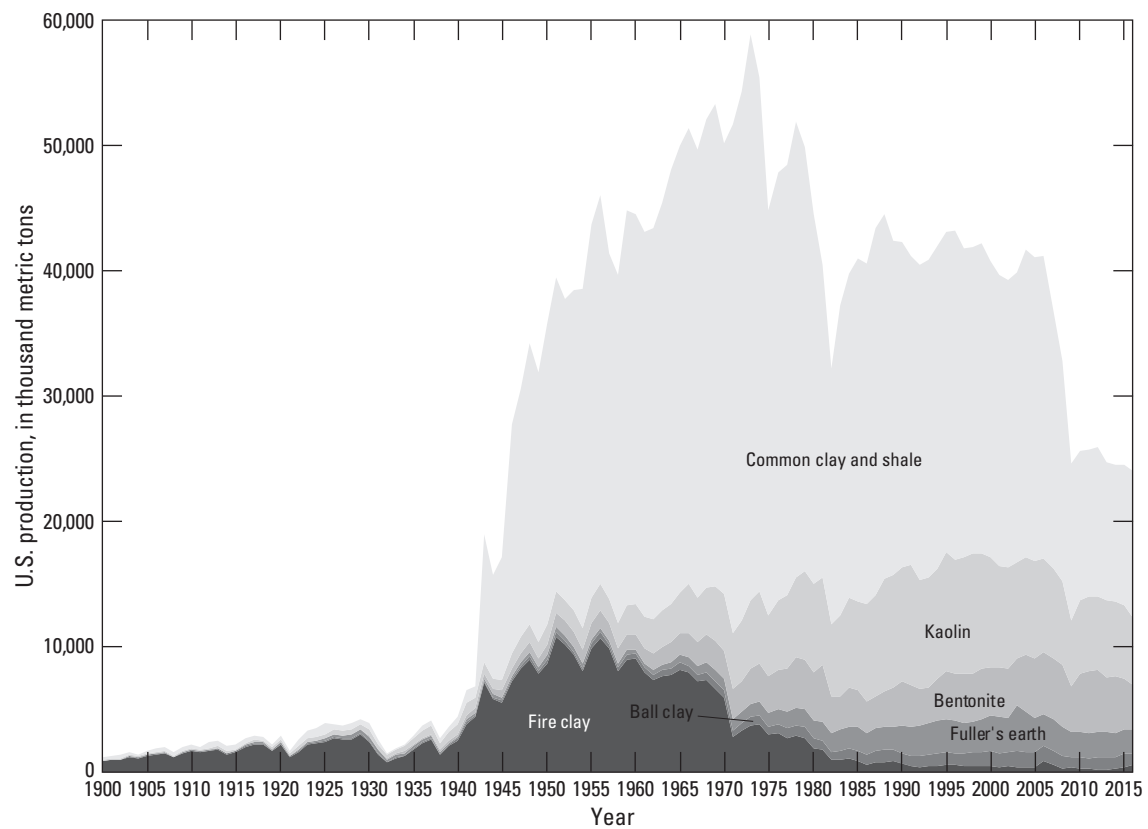


Figure 1. U.S. production (sold or used by producers) of all clay types from 1900 through 2016.

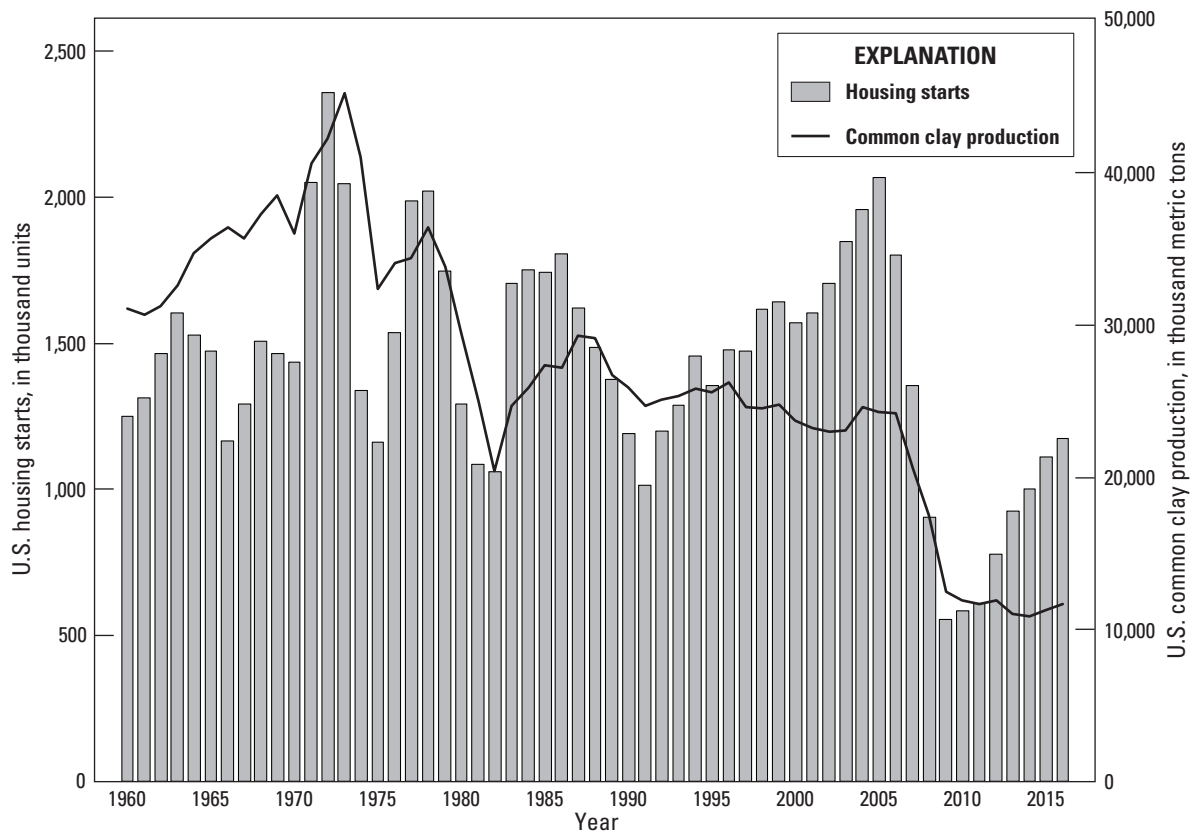


Figure 2. U.S. housing starts and U.S. production (sold or used by producers) of common clay and shale from 1960 through 2016. Sources: U.S. Census Bureau (2017a), U.S. Geological Survey.

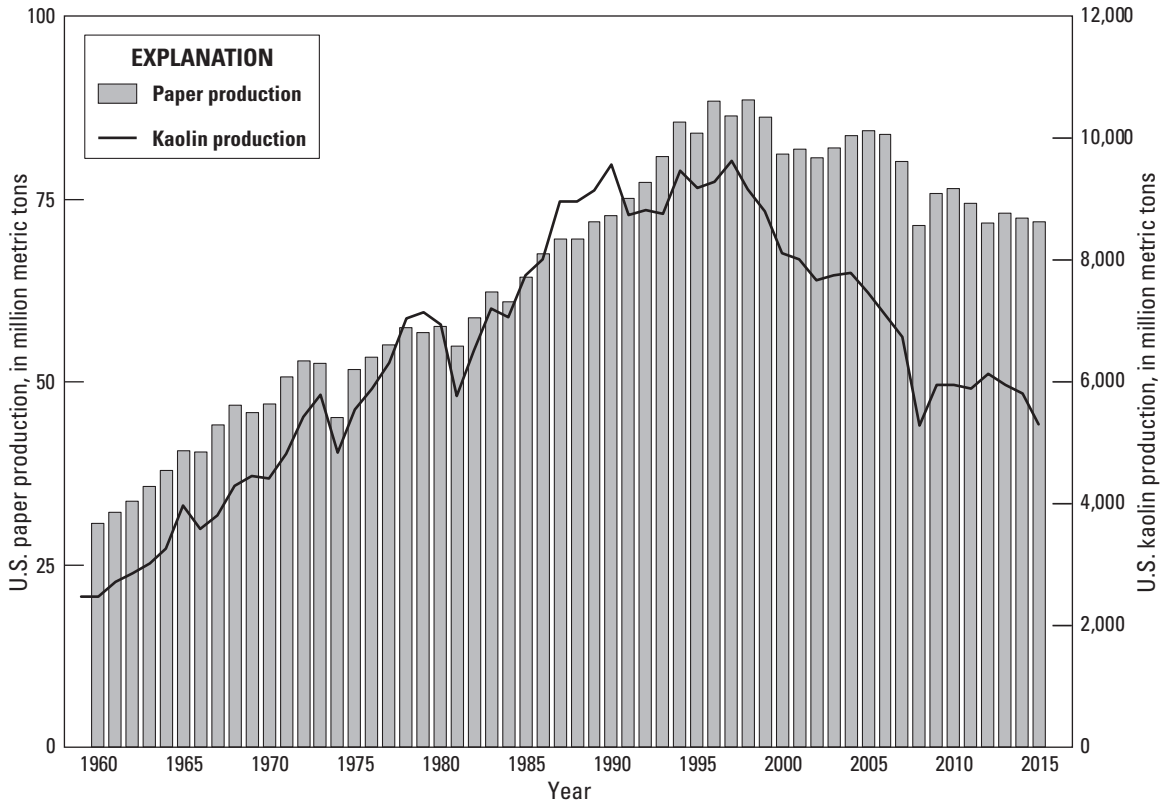


Figure 3. U.S. production of paper and kaolin (sold or used by producers) from 1960 through 2016. Sources: Food and Agriculture Organization of the United Nations (2016), U.S. Geological Survey.