Clays

Michel Dumont

The author is with the Minerals and Metals Sector, Natural Resources Canada.
Telephone: (613) 995-2917
E-mail: mdumont@nrcan.gc.ca

The clays are a complex group that consists of several mineral commodities, each having different mineralogy, geological occurrence, mining/processing technology and uses. They are fine-grained minerals of secondary origin and are composed of an alumina silicate structure with additional iron, alkalis and alkaline earth elements. Clay minerals are classified into two broad groups: **specialty clays**, which include attapulgite, bentonite, Fuller's earth, hectorite, montmorillonite and sepiolite; and **kaolinitic clays**, which include ball clay, fire clay (refractory clay), stoneware clay and kaolinite. These minerals rarely occur in a pure state and occur with gangue minerals (e.g., quartz, calcite, dolomite, feldspar, gypsum and iron oxide), which may or may not be deleterious for ceramic applications. (Note: Palygorskite is the internationally recognized mineralogical term for attapulgite, the name more commonly used.)

Clay is an abundant raw material with a wide variety of uses and properties. The commercial value of a clay depends primarily on its physical properties such as plasticity, strength, shrinkage, vitrification range, refractoriness, fired colour, porosity and absorption. Many definitions state that a clay is plastic when wet. Most clay materials do have this property, but some clays are not plastic (e.g., halloysite and flint clay).

Also, it is the physical characteristics of clays, more so than the chemical and structural characteristics, that define this group:

- Clay minerals tend to form microscopic to submicroscopic crystals.
- They can absorb or lose water from simple humidity changes.
- When mixed with limited amounts of water, clays become plastic and can be molded and formed in ways that most people are familiar with as children's clay.
- When water is absorbed, clays will often expand as the water fills the spaces between the stacked silicate layers.
- Due to the absorption of water, the specific gravity of clays is highly variable and is lowered with increased water content.
- The hardness of clays is difficult to determine due to the microscopic nature of the crystals, but actual hardness is usually between 2 and 3, and many clays give a hardness of 1 in field tests.
- Clays tend to form from weathering and secondary sedimentary processes with only a few examples of clays forming in primary igneous or metamorphic environments.
- Clays are rarely found separately and are usually mixed not only with other clays, but also with microscopic crystals of carbonates, feldspars, micas and quartz.

Many changes have taken place in the clay industry in recent years as a result of technological advancements, changing economic conditions, new uses, shifts in demand, and increases in both domestic and export markets. The industry relies on various institutions for assistance in specific fields to meet those challenges. The Mission Clay Products of San Antonio, Texas, provides laboratory analysis for fire clays in North America; the Centre Spécialisé en Pates et Papiers (CSPP) of Trois-Rivières, Quebec, provides clay analysis for paper-grade pulp clay minerals; the Clay Minerals Society of Aurora, Colorado, stimulates research and disseminates information relating to all aspects of clay science and technology; and the Industrial Minerals Association – North America is a trade association created to advance the interests of North American companies that mine or process minerals used throughout the manufacturing and agricultural industries (e.g., ball clay, bentonite).

SUMMARY

The clay-based industries are of fundamental importance to all countries. The large-volume clay industries, besides the construction clays, are the kaolin and bentonite industries, although these large tonnages belie the variety of product specifications and special consumer-designed products that are available as a result of research and development in close liaison with customer needs.

Overall world capacity (source: Peter W. Harben's 4th Edition of *The Industrial Minerals HandyBook*) is estimated at 11.25 Mt (year 2000) for bentonite and other smectite clays and at over 50 Mt for kaolin. World production (source: U.S. Geological Survey *2003 Review*) of bentonite was approximately 10.2 Mt, Fuller's earth production was estimated to be 4.75 Mt, and kaolin production was 41 Mt in 2003. The United States continued to be the leading producer of all three varieties of clays, followed by Greece, countries of the Commonwealth of Independent States for bentonite, and Germany for Fuller's earth. Spain led all countries in the production of sepiolite. Canada, not being a world producer, is not represented in the USGS's review; only a brief reference to its imports of bentonite and kaolin from the United States has been made.

Canada's preliminary 2004 figures indicate a shipment value of $239.1 million (tonnage not available), exports of $8.8 million (21 337 t), and imports of $234.4 million (1.8 Mt).

Preliminary consumption for 2003 was 2.2 Mt for "other" clays, 631 224 t for kaolin, 276 630 t for bentonite, 25 296 t for fire clay, and 8390 t for ball clay. Preliminary figures reported on the uses of clays by industry were only available up to 2003. The "Other" clays category was the biggest variety consumed, followed by kaolin, bentonite, fire clay and ball clay. Their specific markets (i.e., industry sectors) are identified in the review.

Although clays are present everywhere in Canada, not all types are evenly distributed. Clays are mined in all provinces with the exception of Prince Edward Island, New Brunswick and Manitoba. No information on findings or exploration projects in the territories and/or Nunavut has yet been reported, although this should not be interpreted as a lack of existence.

The mining and processing of clays depend upon the type of clay. Kaolin production is a highly mechanized operation that requires conversion into clay-water slip or a slurry. The other clay types (e.g., bentonite, Fuller's earth, etc.) are stripped from the ground under controlled conditions to ensure quality control and are processed by simple milling techniques and de-watering to be dried and stockpiled.

U.S. prices on clays are provided in the text under the "Price" section. It should be understood that the prices provided serve only as a reference measure. Prices for actual transactions vary, not only according to the various types of clays, but also according to geographic region and will take into account the quantity purchased, application, quality assurance, exact grade purchased, credit terms, and other parameters.

The short-term forecast from expert organizations (e.g., USGS *2003 Review*; *Mineral Price Watch*, April 2004) seems to project that overall demand for both bentonite and Fuller's earth are destined to increase at a rate approximately equal to the growth in Gross Domestic Product (GDP). Similarly, common clay is expected to keep pace with GDP and the demand for other clays is likely to fall short of this growth rate.

CONSUMPTION, PRODUCTION AND TRADE

The major uses/consumption of clays reported (Table 3) for Canada are: the "Other" clays at 2.2 Mt (with 56.3% used in the clay products and structural industry and 40% used by the cement [construction] industry); kaolin at 631 224 t (91.8% used in the pulp, paper and paper products industry); bentonite at 276 630 t (71.1% used in the iron ore pelletizing industry and 12.5% used by the foundries industry); fire clay at 25 296 t, of which the major uses are confidential; and ball clay at 8390 t (78.1% used by the clay products, ceramics and structural industries). Table 2 provides a representation of bentonite imports (tonnage and value) and consumption (tonnage only) from 1988 to 2004.

Canadian clay production in Table 1 provides a preliminary shipments value of almost $239.1 million. In 2004, Canadian shipments increased by 2.2% compared to 2003, a better performance than the 2002 to 2003 (0.3%) increase.

In 2004, Canada exported 21 337 t of clay valued at almost $8.8 million, an increase of 6152 t (40.5%) from 2003, compared to an increase of 3984 t from 2001 to 2002 (35.9%). "Other" clays represent 68.7% of Canada's total exports while bentonite, kaolin, fire clay and decolourizing clays represent 26.4%, 3.2%, 1.2% and 0.5% of total exports, respectively. Canada's major export destination has been the United States for kaolin, bentonite and fire clay. Decolourizing clays were exported only to Belgium. With respect to the "Other" clays category, Germany and the United States are the core markets for export.

Canada's overall 2004 imports of clays totaled almost 1.8 Mt valued at $234.4 million, an increase of 217 623 t

(14.0%) from 2003. The value of kaolin imports dominated in 2004 (63.4% of total imports valued at $234.4 million), followed by bentonite (15.6%), "Other" clays (13.9%), activated clays (5.6%), decolourizing earths and Fuller's earth (0.8%), and fire clay (0.8%). Imports by tonnage provide a similar standing with kaolin leading (59.1% of total imports of almost 1.8 Mt), followed by bentonite (21.1%), "Other" clays (17.3%), activated clay (1.4%), fire clay (0.6%), and decolourizing earths and Fuller's earth (0.4%). The United States maintained its position in being the major supplier of all clays imported into Canada.

CANADIAN CLAY DEPOSITS AND USES

Environmentally, certain type of clays are the material of choice in protecting the local environment and ground in the construction and rehabilitation of landfill sites. Clay is used for the production of Geosynthetic Clay Liners (GCLs), where it is sandwiched between two geosynthetic liners. In addition to acting as a containing barrier that protects aquifers, clay (especially bentonite) is used to clean contaminated water (the addition of bentonite in waste water results in the removal of suspended solids and adsorption of polluting heavy metals). The main purpose of a clay barrier is to retard the movement of fluids into the surrounding medium.

Common Clay and Shales

Common clay is sufficiently plastic to permit ready molding and vitrifies below 1100^{o}C. Shale is a sedimentary rock composed chiefly of clay minerals that have been laminated and indurated while buried under other sediments. Suitable common clay and shales are used in the manufacture of structural clay products such as common brick, face brick, structural tile, partition tile, conduit tile, drain tile, lightweight aggregate, and portland cement.

Common clay and shales are found in all parts of Canada: in Newfoundland and Labrador, shales occur near Corner Brook; in New Brunswick, shales occur at Havelock in Kings County and from a quarry at Chipman; in Nova Scotia, shales occur at Lantz in Hants County; in Quebec, shales occur near plants located in Laprairie, Beauport and Deschaillons; and in Ontario, glacial clays occur near Woodstock and St. Mary's, and shales occur near numerous plants located throughout the southeastern portion of the province. In western Canada, glacial shales and clays occur in each of the major provinces: in Manitoba, glacial clays and shales occur near Lake Agassiz; in Saskatchewan, glacial clays occur near Regina, Estevan, Rockglen, Flintoff, and Readlyn; and in British Columbia, there are several active deposits with the most important ones occurring at Sumas Mountain near Abbotsford.

Kaolin

Kaolin is a clay consisting of substantially pure kaolinite, or related clay minerals, that is naturally white or that can be beneficiated to be white. Kaolin has many industrial applications and new uses are still being discovered. It is a unique industrial mineral because it is chemically inert over a relatively wide pH range, it is white and has good covering or hiding power when used as a pigment or extender, it is soft and non-abrasive and has a low conductivity of heat and electricity, and it costs less than most materials with which it competes. Kaolin is used primarily as a filler in the pulp and paper, plastic, paint and rubber industries, and also in the manufacture of conventional ceramic products. Kaolin is also used as a batch ingredient in the production of textile-type fibreglass and, to a smaller extent, in the preparation of medicinal products, food additives, bleaching agents, plaster, filter aids, cosmetics, detergents, paste, roofing granules, foundries, linoleum and textiles.

Kaolin occurs in various provinces of eastern and central Canada including Nova Scotia, New Brunswick, Quebec and Ontario. Kaolin deposits are known in various areas of Quebec (in the counties of Papineau, Montmorency and Gatineau), but their small size and the presence of impurities have hindered their development. In Ontario, extensive deposits of a kaolinized sand mixture occur along the Missinaibi and Mattagami rivers southwest of James Bay in northern Ontario over an area of 10 000 km^2. An occurrence of Mesozoic clay also occurs at Limestone Rapids.

Kaolinitic clays occur at various locations in western Canada. In Manitoba, deposits are found on Deer Island, in the Cross Lake area to the north of Grand Rapids, in the Pine River area in the Swan River group, near Arborg, and in the Phanerozoic Sylvan strata; kaolinitic shales also occur in the Kergwenan area south of Ste. Rose du Lac. The most important deposit is the quarry at Ste. Rose du Lac. The kaolinitic clay resources of southern Saskatchewan occur as Whitemud deposits at Wood Mountain, Knollys, Cypress Hills, Moose Jaw, and as far east as Weyburn. The deposits of principal interest are the Wood Mountain area in south-central Saskatchewan and the Eastend-Shaunavon area along the Frenchman River in southwestern Saskatchewan. A low-grade kaolin and fire clay deposit occurs at Wabamun, Alberta, but further development is unlikely since previous mining of the fire clay has contaminated the kaolin. British Columbia hosts various kaolinitic deposits. The most important deposit occurs at Lang Bay in the southwestern portion of the province. Other deposits occur along the Fraser River near Prince George and, at Sumas Mountain, kaolinized basement rocks occur below the basal fire clay seam.

Ball Clay

Ball clay is a fine-grained mixture of 70% disordered kaolinite with illite, quartz, montmorillonite, chlorite and minor amounts of carbonaceous material. In Canada, ball clay is mineralogically similar to high-grade, plastic fire clay and is composed principally of fine-sized kaolinite, quartz and mica. Ball clay is used mostly in the manufacture of pottery or whiteware, including domestic tableware, wall tiles, sanitaryware and electrical porcelain. Miscellaneous non-ceramic applications include uses as an animal feedstuff binder; a fertilizer anti-caking agent; a filler in rubber, plastics and adhesives; and in chemicals, petroleum refining, paint and varnish.

Economic deposits of ball clay occur only in Saskatchewan in the Whitemud and Ravenscrag geological formations.

Fire Clay (Refractory Clay)

Refractory clay, also known as fire clay, is a detrital clay composed mainly of kaolinite with a high content of alumina and silica. These clays may range in plastic varieties such as flint clay. Fire clay is used in the manufacture of products requiring high resistance to heat such as fire brick, insulating brick, and refractory mortar.

A variety of good-quality fire clay grades occur in several provinces of Canada. Fire clay deposits occur in the Musquodoboit Valley and at Shubenacadie in Nova Scotia. Multi-coloured fire clay also occurs in the James Bay lowlands of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Fire clay deposits occur in western Canada in Whitemud formations in southern Saskatchewan and on Sumas Mountain in British Columbia. A number of brown or dark-grey mud-stone and clay-stone beds have also been reported in the Lang Bay area in British Columbia.

Stoneware Clays

Stoneware clays are intermediary between low-grade common clays and the high-grade kaolinitic clays. They are typically a mixture of kaolinitic and micaceous clay minerals. Stoneware clays are used exclusively in the manufacture of sewer pipe, flue liners, and face brick. They are also used widely by amateur and studio potters.

The principal source of stoneware clay in Canada is the Whitemud formation in southern Saskatchewan and southeastern Alberta. Stoneware clays in British Columbia occur near Abbotsford on Sumas Mountain, at Chimney Creek Bridge near Quesnel, and at Williams Lake. Deposits in Manitoba occur near Swan River and Ste. Rose du Lac, and in Nova Scotia at Shubenacadie and Musquodoboit.

Bentonite

Bentonite is a clay consisting essentially of smectite minerals (montmorillonite group) and is formed from volcanic ash, tuff or glass, other igneous rocks, or rocks of sedimentary origin. There are two categories: swelling and non-swelling bentonite. Sodium bentonite has strong swelling properties and possesses a high dry-bonding strength, while calcium bentonite, or the non-swelling type, usually exhibits greater adsorptive characteristics.

The widest application of swelling bentonite is in well-drilling muds followed by pelletizing iron ore concentrates. Other applications include use as a binder, a filler, an extender, an emulsifier, and as a suspending agent, as well as use for its adsorptive properties.

The principal Canadian bentonite deposits are confined to western Canada, particularly Manitoba, Saskatchewan and Alberta. Bentonite deposits have been located in Ontario and Quebec, but they are not considered to be of economic significance. Calcium non-swelling bentonite in Manitoba occurs mainly near the base of the Pembina member of the Vermilion River formation and in the overlying Millwood member of the Riding Mountain formation. Saskatchewan has many bentonite occurrences: in eastern Saskatchewan near Pelly, in the south-central part near St. Victor, and in the southwestern part near Eastend. Bentonite in Alberta is found at Rosalind near the Battle River Valley. Deposits of bentonite in British Columbia occur along the Fraser River in the Lytton to Gang Ranch area, near coal seams in the Quilchena and Guichon valleys of the Merrit Basin, and in shale and coal-rich sections throughout the northern half of the Princeton Basin. Bentonite is also widespread in the Hat Creek beds of the Hat Creek Valley.

Fuller's Earth

Fuller's earth is a term related to bentonite, but it is derived from a particular application for clay. Fuller's earth is defined as a non-plastic clay or clay-like material, usually high in magnesia, that has adequate absorbing properties. It is formed by the alteration of volcanic ash or by direct chemical precipitation of montmorillonite in shallow marine basins. Fuller's earth is used mainly for its adsorptive properties, although it is becoming employed in other applications as a carrier and as a filler-extender. There are now more than 90 different grades of Fuller's earth. The more important of these grades are used for pharmaceuticals designed to absorb toxins, bacteria and alkaloids; for treatment of dysentery; for purifying water and dry-cleaning fluids; for the manufacture of wallpaper; and as an extender or filler for plastic, paint and putty. A special use of Fuller's earth is its use as a carrier of platinum catalysts.

CANADIAN CLAY-PRODUCING MINES

Newfoundland and Labrador

Trinity Brick Products (1972) Ltd. located in St. John's extracts shale for the building of bricks.

Prince Edward Island

There is no production of clays in the province.

Nova Scotia

Shaw Brick (A member of the Shaw Group Limited) extracts clay from pits at Lantz, Milford and Shubenacadie, all in Hants County, and shale from quarries located in Hardwood Lands, Hants County, and New Glascow, Pictou County. These materials are used in the company's plant in Lantz for the manufacture of bricks and other clay products.

Black Bull Resources Inc. received permits to extract quartz from deposits near Yarmouth County, Nova Scotia. The other ores of the deposits (i.e., kaolin, mica) are to be extracted in later phases once permitting is obtained.

Kaoclay Resources Inc. of Halifax, Nova Scotia, is involved in the development of high-quality Georgia kaolin deposits in the United States; operations are controlled by its wholly owned subsidiary, Sparta Kaolin Corp. (SKC). Kaoclay, after conducting a $20 million exploration program in the Musquodoboit and Shubenacadie valleys in central Nova Scotia, has indicated the potential for a significant tonnage of average-quality kaolin.

Hibernia Resources completed a limited drilling program for kaolin in the West Paradise area of the Annapolis Valley.

New Brunswick

There is no production of clays in the province.

Quebec

Briques Hanson Ltd., previously known as Briqueterie St-Laurent (a division of Hanson Building Materials America), is located in the city of La Prairie and mines shale from a quarry to produce bricks.

Ontario

The brick industry currently extracts most of its raw material from the Queenston Formation shale. The two major producers are Brampton Brick Limited and Hanson Brick Ltd. Other producers include Century Brick, George Coultis and Sons Ltd., Norwich Brick and Tile, and Paisley Bricks and Tile Co.

Hanson Brick is the largest brick manufacturer in Canada. Recently, Canada Brick became part of Hanson Building Materials America, one of the largest brick manufacturers in North America.

Manitoba

There is no production of clays in the province at this time.

Saskatchewan

The most important commercial clays mined in Saskatchewan include the kaolinite, montmorillorite (i.e., bentonite) and illite clays.

Clay and clay products are produced by three major companies. Estavan Brick (1995) Ltd. has quarries at Estevan, Rockglen, Flintoft and Readlyn for the manufacture of face brick. Canadian Clay Products Inc. quarries sodium bentonite near Truax, 60 km southwest of Regina, and processes it at its plant located at Wilcox to produce swelling bentonite products. Cindercrete Products Ltd. produces lightweight clay aggregates for its ready-mix concrete plant in Saskatoon.

Current production from these producers is mainly for face brick for Canadian and U.S. markets and stoneware clay for the Canadian market. Saskatchewan bentonite production is sold mainly in western Canada. The bentonite is produced by quarrying and is processed by drying, adding soda ash, grinding and bagging. Much of the Saskatchewan bentonite production is used as fertilizer carrier, animal feed binding, reservoir sealing, and as a foundry sand binder. Future opportunities for swelling bentonite include its use as a pesticide carrier, as an agent in water and effluent purification, and in the production of pet litter.

At present, there is no kaolin production in the province.

Plainsman Clay Limited of Alberta mines its own pottery clay from Saskatchewan for processing at Medicine Hat, Alberta.

Clayburn Industries Ltd. (a subsidiary of I-XL Industries Ltd. of Alberta), of Abbotsford, British Columbia, mines clay seasonally in Saskatchewan and operates a manufacturing plant in Medicine Hat, Alberta.

Alberta

Plainsman Clay Limited mines clay specifically for pottery (i.e., Helmer kaolin) from sites in Manitoba, Saskatchewan, Alberta, Montana and Idaho for plastic

stoneware and processes the mined clay at Medicine Hat, Alberta.

I-XL Industries Ltd. of Medicine Hat is the largest producer of fired clay products in western Canada. Clays are quarried at modern open-pit mining sites (i.e., Cyprus Hills of Alberta and Saskatchewan) and are stockpiled at I-XL plants (e.g., Clayburn Industries Ltd). Two different processes are used to form the clay into bricks.

British Columbia

Clayburn Industries Ltd. of Abbotsford processes fire clay from Sumas Mountain into a variety of refractory bricks and castable products that are exported worldwide. The company imports ball clay for the manufacture of some of its refractory products.

Clayburn, Lafarge Canada Inc. and Tilbury Cement Ltd. produce shale and sandstone from their Sumas shale quarry on a seasonal basis.

Western Industrial Clay Products Ltd. produces domestic and industrial absorbents, principally from its Red Lake Fuller's earth deposit near Kamloops. In the Princeton area, the company is mining bentonite from the Bud property.

Near Abbotsford, Sumas Clay Products Ltd. produces fluetine pipe and ornamental and facing bricks from fire clay.

Ironwood Clay Company Inc. is the largest producer of cosmetic/medical clay in British Columbia. It mines seasonally from the De Cosmos Lagoon on Hunter Island. The market for cosmetic/medical clay is limited. Similar material from Carrie Cove Clay of Comox Valley also reached the market and is sold by Carrie Cove Cosmetics for medicinal and cosmetic applications.

Glacial Marine Clay Inc. is producing a clay for specialized hydroponics applications. The market for specialized hydroponics clays is large.

PRICES

Prices for actual transactions vary according to geographic region and will take into account the quantity purchased, application, quality assurance, exact grade purchased, credit terms, and other parameters. Due to the unavailability of prices for Canada's clay industry, all of the following prices are provided as a comparative example in U.S. currency and reflect the U.S. industry (source: USGS *2003 Review*).

Ball Clay

The average value for ball clay reported by U.S. producers was $42.93/ton. The average values for imported and exported ball clay were $91.19 and $60.66/ton, respectively.

Average prices for ball clay, England, free on board (f.o.b.), air-dried, shredded, bulk, were $40-$105/ton; for refined noodled, bulk, $88-$112/ton; and for pulverized, bagged, $129-$209/ton. Average prices for ball clay, Germany, f.o.b. dried and ground, bulk, were $52-$141/ton and for shredded, bulk, $15-$61/ton (*Industrial Minerals*, 2003).

Bentonite

The average value reported by U.S. producers for non-swelling bentonite was $41.33/ton. The average value for swelling bentonite was $45.26/ton. The average value for all bentonite was $45.02/ton. The average value of imported bentonite by the United States was $236.40/ton while the average value of exported bentonite by the United States was $122.21/ton.

The price for ex-work, Wyoming and crude, bulk, rail cars, was $26-$63/ton; for foundry grade, bagged, rail cars, was $50-$76/ton; and for API-grade, bagged, rail cars, was $43-$53/ton. The price for bentonite, India, crushed, dried, loose in bulk, was $30-$40/ton for API grade, $32-$40/ton for cat litter grade, and $40-$45/ton for foundry grade (*Industrial Minerals*, 2003).

Common Clay and Shale

The average value of all common clay and shale produced in the United States and Puerto Rico was $5.69/ton. The average value of clay and shale used in lightweight aggregate was $14.33/ton. The value for lightweight aggregate is an estimate of the clay clause. Average prices for lightweight aggregate produced from clay and shale range from $30 to $50/ton for most applications. (Note: The so-called structural clays group for making bricks, pipes and tiles for the construction industry creates a conflict since the common clays and shales often used for these products may contain high proportions of non-clay minerals such as quartz and mica.)

Fire Clay

The average value for fire clay reported by U.S. producers was $25.46/ton. The average value of imported fire clay into the United States was $508.30/ton. The average value of exported fire clay out of the United States was $96.03/ton.

Fuller's Earth

The average value of attapulgite-type Fuller's earth was $122.50/ton. The average value of montmorrilonite-type Fuller's earth was $94.00/ton. The average value of all Fuller's earth was estimated to be $95.92/ton. The average value of imported Fuller's earth was $10.81/ton and the average value of exported Fuller's earth was $183.92/ton.

The price, ex-plant, Georgia, 40-100% less than 325 mesh, truck load, was $220-$550/ton; for granular processed, 40-100% less than 4/8 mesh, truck load, $193-$550/ton; for granular, 6/30 mesh, truck load, $132-$220/ton; and for granular, 6/30 mesh, gel grade, bagged, $358-$772/ton (*Industrial Minerals*, 2003).

Kaolin

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

The kaolin price for ex-work, Georgia, filler, bulk, was $80-$100/ton; for coating, bulk, $85-$185/ton; for sanitary ware-grade, bagged, $65-$75/ton; tableware-grade, bagged, $125/ton; and calcined, bulk, $320-$375/ton (*Industrial Minerals*, 2003).

ENVIRONMENT/HEALTH/SAFETY

During clay mining and processing, dust is generated if proper measures are not taken. As is the case with all dusts, the quantity and duration of inhalation determine the level of health and safety risk. Dust occupational exposure limits are legally implemented in many countries.

In Canada, the Workplace Hazardous Materials Information System (WHMIS) (see www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/index_e.html) is Canada's hazard communication standard. WHMIS is implemented through coordinated federal, provincial and territorial legislation.

The U.S. Environmental Protection Agency (EPA) estimates that more than 64% of the garbage produced in the United States is land filled, 18% is recycled, and 18% is incinerated. With population growth, consuming habits and social concerns, sustainable development considerations of methods of disposal will continue to be of concern to people and regulators, especially since data on the exact number of landfills in the United States and Canada are conflicting, partly because of changing definitions of what constitutes a landfill and because of inadequate record-keeping by some states and provinces.

OUTLOOK

Overall demand for both bentonite and Fuller's earth is expected to increase at the same rate of growth as the Gross Domestic Product (GDP). Long-range demand for some products made from common clay can be expected to keep pace with GDP growth. Demand for clay and shale, which are required for portland cement and lightweight aggregates, is increasing and this trend is likely to continue. Growth in demand for structural clay products is also hampered by increasing production costs and by the heavy weight of these products, which limits their market range.

Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 64. (2) Information in this review was current as of April 29, 2005. (3) This and other reviews, including previous editions, are available on the Internet at www.nrcan.gc.ca/mms/cmy/com_e.html.

TARIFFS

Item No.	Description	Canada			United States	EU	Japan
		MFN	GPT	USA	Canada	Conventional Rate (1)	WTO (2)
2507.00	Kaolin and other kaolinic clays, whether or not calcined	Free	Free	Free	Free	Free	Free
2508.10	Bentonite	Free	Free	Free	Free	Free	Free
2508.20	Decolourizing earths and Fuller's earth	Free	Free	Free	Free	Free	Free
2508.30	Fire clay	Free	Free	Free	Free	Free	Free
2508.40	Other clays	Free	Free	Free	Free	Free	Free
3802.90.10	Activated clay	Free	Free	Free	Free	5.7%	2.5%

Sources: Canadian *Customs Tariff*, effective January 2005, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States,* 2005; *Official Journal of the European Union* (October 30, 2004 Edition); *Customs Tariff Schedules of Japan*, 2004.
(1) The customs duties applicable to imported goods originating in countries that are Contracting Parties to the General Agreement on Tariffs and Trade or with which the European Community has concluded agreements containing the most-favoured-nation tariff clause shall be the conventional duties shown in column 3 of the Schedule of Duties. (2) WTO rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, CLAY PRODUCTION AND TRADE, 2002-04

		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION (Shipments) (1)							
	Nova Scotia	x	x	x	x	x	x
	Quebec	x	x	x	x	x	x
	Ontario	x	191 139	x	192 537	x	192 686
	Saskatchewan	x	x	x	x	x	x
	Alberta	x	x	x	x	x	x
	British Columbia	x	x	x	x	x	x
	Total	x	233 244	x	233 999	x	239 088
EXPORTS							
2507.00	Kaolin and other kaolinic clays whether or not calcinated						
	United States	488	231	504	353	658	259
	Brazil	–	–	43	29	22	19
	United Kingdom	–	–	–	–	9	9
	New Caledonia	–	–	–	–	1	...
	China	21	36	–	–	–	–
	Germany	–	–	3	3	–	–
	Total	509	267	550	385	690	287
2508.10	Bentonite						
	United States	1 383	965	3 500	1 384	5 372	2 162
	Ghana	–	–	–	–	68	50
	Israel	43	24	34	30	57	20
	Brazil	1	1	–	–	15	13
	France	–	–	–	–	21	12
	Guatemala	–	–	–	–	16	9
	Belgium	–	–	–	–	14	8
	Eritea	–	–	11	7	10	6
	Cuba	–	–	–	–	28	6
	Finland	–	–	–	–	17	5
	Mexico	–	–	4	4	3	3
	South Korea	–	–	–	–	5	3
	Italy	–	–	–	–	2	2
	Barbados	–	–	–	–	1	1
	Australia	13	10	–	–	...	...
	China	4	3	–	–	–	–
	Germany	50	23	25	13	–	–
	Philippines	3	4	–	–	–	–
	Vietnam	12	4	–	–	–	–
	Total	1 509	1 034	3 574	1 438	5 629	2 300
2508.20	Decolourizing earths and Fuller's earth						
	Belgium	–	–	–	–	106	57

TABLE 1 (cont'd)

		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)							
2508.30	Fire clay						
	United States	210	139	231	103	253	104
	Brazil	–	–	5	4	1	1
	Cuba	...	...	–	–	...	...
	Total	210	139	236	107	254	105
2508.40	Other clays (excluding expanded clays or 68.06)						
	Germany	3 701	1 443	5 489	2 023	7 426	2 643
	Belgium	1 044	474	1 003	711	2 113	1 039
	United States	1 291	498	1 439	390	1 657	433
	Denmark	559	224	635	225	742	348
	Norway	506	199	312	189	336	333
	Netherlands	464	227	560	271	476	259
	Sweden	447	186	409	153	544	237
	France	233	107	193	110	320	132
	Latvia	6	9	34	52	100	131
	Switzerland	152	124	346	152	225	120
	Italy	–	–	–	–	221	72
	Israel	172	113	22	37	61	50
	Chile	4	7	21	31	26	23
	Portugal	5	8	59	33	31	19
	Austria	–	–	–	–	48	17
	Taiwan	2	24	9	32	12	16
	Panama	1	...	3	1	48	16
	South Korea	–	–	1	1	48	15
	Malaysia	2	2	13	5	28	14
	Brazil	13	16	–	–	6	12
	Philippines	3	5	16	4	44	11
	Belize	–	–	–	–	5	10
	China	82	23	2	46	5	8
	Finland	–	–	–	–	25	7
	Greece	–	–	–	–	24	7
	Japan	31	27	9	9	17	7
	Saudi Arabia	3	1	65	36	13	6
	Uruguay	36	7	2	2	25	5
	Venezuela	3	4	21	3	21	3
	Saint Pierre and Miquelon	–	–	4	2	3	3
	Dominica	–	–	–	–	1	2
	United Kingdom	122	64	23	9	...	1
	Jamaica	–	–	1	...	2	1
	Czech Republic	–	–	–	–	...	1
	Bermuda	–	–	–	–	3	1
	South Africa	–	–	...	...	...	1
	Bahrain	–	–	...	...	...	...
	Colombia	–	–	...	...	1	...
	El Salvador	–	–	...	...	1	...
	Costa Rica	–	–	–	–	...	...
	Slovenia	–	–	–	–	...	...
	Barbados	–	–	...	...	–	–
	Hong Kong	3	5	20	38	–	–
	Lebanon	–	–	6	2	–	–
	Malta	–	–	1	...	–	–
	United Arab Emirates	–	–	48	27	–	–
	Ecuador	16	12	–	–	–	–
	Cuba	...	...	1	...	–	–
	Singapore	–	–	46	16	–	–
	Qatar	–	–	...	...	–	–
	Poland	–	–	1	1	–	–
	New Zealand	2	2	11	6	–	–
	Burkina Faso	2	183	–	–	–	–
	Australia	...	...	...	...	–	–
	Benin	...	...	–	–	–	–
	Total	8 905	3 994	10 825	4 617	14 658	6 003
	Total exports	11 133	5 434	15 185	6 547	21 337	8 752
IMPORTS (1)							
2507.00	Kaolin and other kaolinic clays whether or not calcinated						
	United States	785 816	112 360	800 527	106 732	851 947	118 260
	United Kingdom	100 411	13 239	119 170	22 395	83 964	19 036
	Brazil	68 541	9 099	92 134	12 562	110 944	11 175
	Australia	–	–	12	7	90	21

TABLE 1 (cont'd)

		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
2507.00 (cont'd)	Spain	64	15	21	5	43	11
	China	17	2	...	...	45	6
	France	20	5	9	3	5	6
	Netherlands	–	–	2	...	12	5
	South Korea	–	–	–	–	5	2
	Saudi Arabia	–	–	–	–	3	1
	Switzerland	–	–	–	–	...	...
	Greece	–	–	–	–	...	...
	Japan	...	...	...	...	...	...
	Taiwan	1	...	2	1	...	...
	Thailand	–	–	–	–	...	...
	Argentina	–	–	...	...	...	...
	Austria	–	–	–	–	...	...
	Ghana	...	...	–	–	1	...
	Germany	17	2	8	1	...	...
	Mexico	102	23	2	1	–	–
	Czech Republic	–	–	1	...	–	–
	Finland	–	–	4	1	–	–
	Hong Kong	–	–	1	1	–	–
	Latvia	1	1	–	–	–	–
	Poland	–	–	...	...	–	–
	Sweden	–	–	3	1	–	–
	Israel	5	2	–	–	–	–
	Canada	...	...	68	15	–	–
	Italy	4	1	...	...	–	–
	Total	954 999	134 749	1 011 964	141 725	1 047 059	148 523
2508.10	Bentonite						
	United States	186 440	20 548	218 987	23 349	296 739	28 095
	Greece	46 050	4 064	9 115	7 121	44 300	4 694
	India	–	–	42 058	2 623	29 937	2 791
	United Kingdom	5 347	2 395	2 818	1 382	997	500
	Argentina	203	31	203	49	627	199
	Italy	20	14	77	69	156	146
	Germany	39	37	122	82	120	75
	Egypt	–	–	–	–	108	34
	China	176	11	2	2	105	33
	Uruguay	–	–	–	–	50	16
	Switzerland	–	–	–	–	37	12
	France	2	1	7	3	28	8
	Chile	–	–	–	–	4	4
	Japan	–	–	...	...	1	1
	Belgium	–	–	–	–	...	...
	Spain	–	–	–	–	1	...
	Canada	...	...	–	–	–	–
	Guatemala	...	...	–	–	–	–
	Israel	77	6	–	–	–	–
	Mexico	40	9	1	1	–	–
	New Zealand	...	...	–	–	–	–
	South Africa	20	4	–	–	–	–
	Hong Kong	–	–	...	...	–	–
	Netherlands	–	–	...	...	–	–
	Total	238 414	27 120	273 390	34 681	373 210	36 608
2508.20	Decolourizing earths and Fuller's earth						
	United States	7 952	2 247	7 081	1 707	7 042	1 677
	United Kingdom	4 887	1 061	116	79	349	90
	Germany	–	–	1	...	41	12
	Mexico	5	2	7	5	8	6
	Australia	–	–	–	–	...	...
	Indonesia	2	1	–	–	–	–
	China	–	–	...	...	–	–
	India	–	–	1	1	–	–
	Total	12 846	3 311	7 206	1 792	7 440	1 785
2508.30	Fire clay						
	United States	7 154	1 785	7 554	1 527	10 439	1 713
	United Kingdom	168	103	64	37	127	72
	Italy	22	5	23	6	51	15
	Japan	–	–	–	–	12	2
	Germany	2	1	–	–	6	1
	France	–	–	–	–	7	1

TABLE 1 (cont'd)

		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
2508.30 (cont'd)	China	4	2	–	–	3	...
	India	–	–	...	...	...	...
	Taiwan	–	–	–	–	...	...
	Australia	1	1	1	1	–	–
	Canada	...	...	–	–	–	–
	Indonesia	...	...	–	–	–	–
	Mexico	–	–	2	1	–	–
	Netherlands	–	–	2	...	–	–
	Total	7 351	1 897	7 646	1 572	10 645	1 804
2508.40	Other clays (excluding expanded clays of 68.06)						
	United States	189 013	37 634	191 923	33 114	304 979	31 831
	France	417	358	406	292	431	304
	China	489	278	371	178	289	231
	Germany	369	102	179	75	105	71
	Spain	12	10	65	59	42	70
	United Kingdom	347	139	113	39	139	60
	Switzerland	38	36	25	40	121	30
	Japan	9	11	10	10	54	27
	Australia	...	...	...	...	9	16
	Taiwan	32	29	9	9	6	5
	Italy	2	3	14	24	6	5
	Canada	557	186	14	4	7	4
	Mexico	8	9	14	15	2	2
	Egypt	...	...	–	–	2	1
	Jordan	–	–	8	3	1	1
	Thailand	–	–	1	1	...	1
	India	...	...	2	2	...	...
	Israel	89	7	2	2	...	...
	Philippines	...	...	–	–	...	...
	Portugal	1	...	1	...	1	...
	Czech Republic	...	...	7	2	1	...
	Belgium	–	–	–	–	...	...
	Hong Kong	–	–	...	...	...	...
	Malaysia	–	–	2	2	...	...
	Morocco	–	–	1	1	...	...
	Argentina	–	–	–	–	1	...
	Greece	–	–	–	–	..	...
	Indonesia	...	...	–	–	–	–
	South Korea	1	1	5	2	–	–
	Ecuador	...	...	–	–	–	–
	Norway	...	...	–	–	–	–
	Sweden	...	...	–	–	–	–
	Congo	2	1	–	–	–	–
	Brazil	...	...	–	–	–	–
	Bermuda	...	...	–	–	–	–
	Mali	–	–	1	1	–	–
	South Africa	–	–	1	1	–	–
	Ethiopia	...	...	–	–	–	–
	Total	191 386	38 804	193 174	33 876	306 196	32 659
3802.90.00.10	Activated clay						
	United States	15 064	8 206	12 941	6 230	18 322	7 972
	Greece	33 434	10 252	46 271	5 169	7 316	4 814
	United Kingdom	–	–	...	...	13	167
	Germany	1	...	1	...	14	94
	France	...	...	–	–	1	...
	Taiwan	...	...	...	...	1	...
	Japan	–	–	...	...	...	...
	Sweden	–	–	–	–	...	...
	Malaysia	...	...	–	–	–	–
	Mexico	...	1	1	1	–	–
	Switzerland	–	–	...	...	–	–
	Total	48 499	18 459	59 214	11 400	25 667	13 047
	Total imports	1 453 495	224 340	1 552 594	225 046	1 770 217	234 426

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; (p) Preliminary; x Confidential.
(1) Imports from "other countries" may include re-imports from Canada.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, BENTONITE IMPORTS AND USE, (1) 1988-2004

Year	Imports	Imports	Use (2)
	(tonnes)	($000)	(tonnes)
1988	335 012	14 420	264 033
1989	294 280	15 070	274 987
1990	252 395	12 259	252 333
1991	268 609	11 712	248 725
1992	255 810	14 568	238 867
1993	295 356	20 684	230 006
1994	330 221	27 270	255 171
1995	343 826	25 983	263 294
1996	381 043	26 723	255 475
1997	372 103	29 760	279 602
1998	325 620	29 738	286 329
1999	336 909	28 990	256 566
2000	325 574	34 515	296 266
2001	254 242	29 021	267 449
2002	238 413	27 121	284 123
2003	273 389	34 681	276 630
2004	373 209	36 608	. .

Sources: Natural Resources Canada; Statistics Canada.
. . Not available.
(1) As reported by consumers. (2) Does not include activated clays and earths or Fuller's earth.

TABLE 3. CANADA, REPORTED USE (1) OF CLAYS, BY INDUSTRY, 2000-2003

	2000	2001	2002	2003 (p)
		(tonnes)		
China clay (kaolin)				
Pulp, paper and paper products	651 842	(r) 603 209	628 193	580 034
Rubber products	8 919	(r) 10 735	11 623	9 045
Ceramic products	8 034	6 489	6 624	6 412
Paint and varnish	7 728	7 104	10 706	9 107
Other products (2)	34 605	(r) 30 396	26 836	26 626
Total	711 128	(r) 657 933	683 982	631 224
Ball clay				
Clay products, ceramics and structural	8 981	6 115	5 285	6 554
Refractory brick, mixes	957	1 032	879	1 075
Other products (3)	594	238	719	761
Total	10 532	7 385	6 883	8 390
Fire clay				
Refractory brick, mixes	32 396	x	x	x
Foundries	388	179	434	515
Other products (4)	1 460	x	x	x
Total	34 244	22 509	24 764	25 296
Bentonite, quantity used (available data) (5)				
Iron ore pelletizing	240 213	180 643	179 784	196 594
Paper, pulp and paper products	8 736	9 003	9 310	9 090
Well drilling (6)	x	x	x	x
Refractory brick, mixes	x	x	x	x
Foundries	38 765	38 511	35 727	34 624
Other products (7)	4 189	21 549	21 227	12 041
Total	296 266	267 449	284 123	276 630
Other clays	1 673 096	1 874 296	2 150 352	2 245 136

Source: Natural Resources Canada.
(p) Preliminary; (r) Revised; x Confidential.
(1) Reported from NRCan survey on the use of nonmetallic minerals by Canadian manufacturing plants. (2) Includes chemicals, glass fibre wool, asphalt roofing products, gypsum products, packaging and other miscellaneous products. (3) Includes gypsum products, fertilizers and other miscellaneous products. (4) Includes structural clay products, nonferrous smelting and refining, and other miscellaneous products. (5) Does not include activated clays and earths or Fuller's earth. (6) Well drilling is included in "other products" for 1999 to 2002 due to confidentiality. (7) Includes animal feeds, cat litter, structural clay products, fertilizers, paint and varnish, mortar mixes and other miscellaneous minor uses.
Note: Numbers may not add to totals due to rounding.

TABLE 4. MAJOR CANADIAN MANUFACTURERS OF STRUCTURAL CLAY PRODUCTS, BY PROVINCE, 2004

Company	Plant Location	Products	Raw Material	Size (1) and Remarks
NOVA SCOTIA				
The Shaw Group Ltd.	Lantz	Brick, block and tile	Common clay, ball clay	(B)
QUEBEC				
Briques Hanson Ltée (Formerly Canada Brick Co.)	La Prairie	Building and facing brick	Shale	(C)
ONTARIO				
Brampton Brick Ltd.	Brampton	Building brick	Shale	(D)
Hanson Brick Ltd. (formerly Canada Brick Co.)				(E)
Burlington Division	Burlington Division	Building brick	Shale	
Streetsville Division	Streetsville	Building brick	Shale	
Ottawa Division	Ottawa	Building brick	Shale	
Century Brick Limited (formerly Hamilton Brick)	Etobicoke	Building brick	Shale	(B)
Paisley Brick & Tile	Paisley	Building brick	Shale	(A)
SASKATCHEWAN				
Canadian Clay Products Inc.	Wilcox	Bentonite	Sodium bentonite	(A)
ALBERTA				
I-XL Industries Ltd.				
Medicine Hat	Medicine Hat	Brick, block, flue liners	Common clay	(B)
Redcliff	Redcliff	Facing and fire brick	Common clay	(A)
Plainsman Clay Ltd.	Medicine Hat	Processed clay	Common clay	(A)
BRITISH COLUMBIA				
Clayburn Industries Ltd.	Abbotsford	Refractory brick, mortar and monolithics	Imported ball clay	(D)
Sumas Clay Products Ltd.	Abbotsford	Brick, drain tile and flue lining	Common clay	(A)
Western Industrial Clay Products Ltd.				
Calcium bentonite and diatomite operations	Kamloops	Absorbent products	Calcium bentonite and diatomite	(B)

Sources: Natural Resources Canada; company web sites.
(1) Size keys: (A) up to 25 employees; (B) 25-49 employees; (C) 50-99 employees; (D) 100-199 employees; (E) 200-499 employees; (F) 500-999 employees; (G) over 1000 employees.