Clays

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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 **kaolinic 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, such as pottery.
- 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, fosters 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 *2004 Review*) of bentonite was approximately 10.5 Mt, Fuller's earth production was estimated to be 5.06 Mt, and kaolin production was 44.4 Mt in 2004. 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 appears about its imports of bentonite and kaolin from the United States.

Canada's preliminary 2005 figures indicate a shipment value of $233.1 million (tonnage not available), exports of $10.3 million (27 205 t), and imports of $204.2 million (1.8 Mt).

Preliminary consumption for 2004 was 2.2 Mt for "other" clays, 731 157 t for kaolin, 280 471 t for bentonite, 26 772 t for fire clay, and 7815 t for ball clay. Preliminary figures reported on the uses of clays by industry were only available up to 2004. 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 *2004 Review*; *Mineral Price Watch*, January 2006) 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, demand for 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 an estimated 56.0% used in the clay products and structural industry and 42.0% used by the cement [construction] industry); kaolin at 731 157 t (93.0% used in the pulp, paper and paper products industry); bentonite at 280 471 t (68.8% used in the iron ore pelletizing industry and 12.3% used by the foundry industry); fire clay at 26 772 t, of which the major uses are undisclosed; and ball clay at 7815 t (73.8% 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 2005.

Canadian clay production in Table 1 provides a preliminary shipments value of almost $233.8 million. In 2005, Canadian shipments increased by 1.6% compared to the revised 2004 value of $230.1 million, a better performance than the 2003 to 2004 (1.7%) decrease.

In 2005, Canada exported 27 205 t of clay valued at almost $10.3 million, an increase of 5868 t (27.5%) from 2004. "Other" clays represent 76.4% of Canada's total exports while bentonite, kaolin, fire clay and decolourizing clays represent 19.4%, 1.7%, 1.6% and 0.9% 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, the United States, Belgium and Denmark are the core markets for exports.

Canada's overall 2005 imports of clays totaled almost 1.8 Mt valued at $204.2 million, an increase of 2937 t (0.2%) from 2004. The value of kaolin imports dominated in 2005 (58.2% of total imports valued at $204.2 million), followed by bentonite (16.0%), "other" clays (13.5%), activated clays (10.5%), decolourizing earths and Fuller's

earth (0.9%), and fire clay (0.9%). Imports by tonnage provide a similar standing with kaolin leading (55.9% of total imports of almost 1.8 Mt), followed by bentonite (22.0%), "other" clays (18.1%), activated clay (2.9%), fire clay (0.6%), and decolourizing earths and Fuller's earth (0.4%). The United States maintained its position as the major supplier of all clays imported into Canada.

CANADIAN CLAY DEPOSITS AND USES

Environmentally, certain types of clays are the materials 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°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 developed. 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 kaolinic 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 mudstone 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 kaolinic clays. They are typically a mixture of kaolinic 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 Chimmey 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) that 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 employed mainly for its adsorptive properties for use chiefly in bleaching and clarifying petroleum, and secondarily in refining edible oils. It is also being used in other applications as a carrier and as a filler-extender in fibre, as a filler retention aid in papermaking systems, and as a bonding agent for foundry sands. There are now more than 90 grades of Fuller's earth. The more important of these grades are used for pharmaceuticals designed to absorb toxins, bacteria and alkaloids; for the 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 production of bricks.

Prince Edward Island

There is no production of clay 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. produces quartz from deposits near Yarmouth County, Nova Scotia. Other minerals in the deposits (i.e., kaolin, mica) are to be extracted in later phases as markets dictate an opportunity for exploitation.

Kaoclay Resources Inc. of Halifax, Nova Scotia, has conducted a $20 million exploration program in the Musquodoboit and Shubenacadie valleys in central Nova Scotia. The company is presently evaluating the results of a potential significant tonnage of average-quality kaolin. The company has also agreed to be acquired by Erdene Gold Inc. of Darmouth, Nova Scotia, in exchange for shares and warrants of Ederne.

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 ltée, previously known as St. Lawrence Brick Div. (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 Limited, George Coultis & Son Ltd., Norwich Brick and Tile, and Paisley Bricks and Tile Co.

Canada Brick became, in 2003, part of Hanson Building Materials America, the largest brick manufacturer in Canada and 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 kaolinite, montmorillonite (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 in 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., Cypress 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 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 accordingly 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 *2004 Review*).

Ball Clay

The average value for ball clay reported by U.S. producers was $44.24/t. The average values for imported and exported ball clay were $77.00 and $419.00/t, respectively.

Bentonite

The average value reported by U.S. producers for non-swelling bentonite was $44.23/t. The average value for swelling bentonite was $44.21/t. The average value for all bentonite was $44.23/t. The average value of imported bentonite by the United States was $359.00/t while the average value of exported bentonite by the United States was $114.00/t.

The price for ex-work, Wyoming and crude, bulk, rail cars, was $26-$63/t; for foundry grade, bagged, rail cars, was $50-$76/t; and for API-grade, bagged, rail cars, was $43-$53/t. The price for bentonite, India, crushed, dried, loose in bulk, was $30-$40/t for API grade, $32-$40/t for cat litter grade, and $40-$45/t 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 $7.05/t. The average value of clay and shale used in lightweight aggregate was $20.54/t. 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/t 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 $27.72/t. The average value of imported fire clay into the United States was $284.00/t. The average value of exported fire clay out of the United States was $97.00/t.

Fuller's Earth

The average value of attapulgite-type Fuller's earth was $126.90/t. The average value of montmorillonite-type Fuller's earth was $98.76/t. The average value of all Fuller's earth was estimated to be $100.84/t. The average value of imported Fuller's earth was $211.00/t and the average value of exported Fuller's earth was $210.00/t.

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

Kaolin

The average value of kaolin was $120.64/t for all kaolin grades. The average value for airfloat was $54.49/t; for refractory-grade (high temperature calcined), $30.12/t; for pigment-grade (low-temperature calcined), $293.24/t; for all types of calcined, $190.57/t; for delaminated, $126.19/t; and for water washed, $115.86/t. The average value of imported kaolin was $188.00/t and the average value of exported kaolin was $165.00/t.

The kaolin price for ex-work, Georgia, filler, bulk, was $80-$100/t; for coating, bulk, $85-$185/t; for sanitary ware-grade, bagged, $65-$75/t; for tableware-grade, bagged, $125/t; and for calcined, bulk, $320-$375/t (*Industrial Minerals*, 2004). Prices were $100-$250/t for hydrous pigment-grade kaolin and $320-$375/t for calcined pigment-grade kaolin.

ENVIRONMENT/HEALTH AND SAFETY

Mining and processing can generate dust 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.

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 light-weight 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 65. (2) Information in this review was current as of June 30, 2006. (3) This and other reviews, including previous editions, are available on the Internet at www.nrcan.gc.ca/mms/cmy/com_e.html.

NOTE TO READERS

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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
25.08	Other clays, andalusite, kyanite and sillimanite, whether or not calcined; mullite; chamotte or dinas earths						
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 carbon; activated natural mineral products; animal black, including spent animal black: other: activated clay	Free	Free	Free	2.5%	5.7%	2.5%

Sources: Canadian *Customs Tariff*, effective January 2006, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States,* 2006; *Official Journal of the European Union* (October 27, 2005 Edition); *Customs Tariff Schedules of Japan, 2006.*
(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, 2003-05

		2003		2004		2005 (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	192 537	x	183 807	x	187 258
	Saskatchewan	x	x	x	x	x	x
	Alberta	x	x	x	x	x	x
	British Columbia	x	x	x	x	x	x
	Total	x	233 999	x	230 059	x	233 843
EXPORTS							
2507.00	Kaolin and other kaolinic clays whether or not calcinated						
	United States	504	353	658	259	458	166
	Malaysia	–	–	–	–	...	...
	United Arab Emirates	–	–	–	–	...	...
	Brazil	43	29	22	19	–	–
	Germany	3	3	–	–	–	–
	New Caledonia	–	–	1	...	–	–
	United Kingdom	–	–	9	9	–	–
	Total	550	385	690	287	458	166
2508.10	Bentonite						
	United States	3 500	1 384	5 372	2 162	3 805	1 552
	Sweden	–	–	–	–	350	141
	China	–	–	–	–	155	87
	Finland	–	–	17	5	171	63
	Belgium	–	–	14	8	142	51
	Chile	–	–	–	–	66	38
	Germany	25	13	–	–	84	28
	Israel	34	30	57	20	89	25
	Peru	–	–	–	–	41	24
	Denmark	–	–	–	–	77	23
	Netherlands	–	–	–	–	49	19
	Cuba	–	–	28	6	33	19
	Brazil	–	–	15	13	41	18
	United Kingdom	–	–	–	–	27	12
	Jamaica	–	–	–	–	22	12
	Singapore	–	–	–	–	27	12
	Malaysia	–	–	–	–	25	12
	Norway	–	–	–	–	25	8
	Guatemala	–	–	16	9	10	5
	Mexico	4	4	3	3	7	5
	Turkey	–	–	–	–	19	4
	Ghana	–	–	68	50	...	2
	Iran	–	–	–	–	3	2
	Mali	–	–	–	–	...	1
	Nicaragua	–	–	–	–	1	1
	New Zealand	–	–	–	–	...	...
	South Korea	–	–	5	3	–	–
	France	–	–	21	12	–	–
	Eritrea	11	7	10	6	–	–
	Barbados	–	–	1	1	–	–
	Italy	–	–	2	2	–	–
	Australia	–	–	...	...	–	–
	Total	3 574	1 438	5 629	2 300	5 269	2 164
2508.20	Decolourizing earths and Fuller's earth						
	Belgium	–	–	106	57	201	80
	Sweden	–	–	–	–	38	15
	Total	–	–	106	57	239	95
2508.30	Fire clay						
	United States	231	103	253	104	393	178
	Brazil	5	4	1	1	35	18
	United Kingdom	–	–	–	–	6	3
	Lebanon	–	–	–	–	3	2
	Cuba	–	–	...	...	–	–
	Total	236	107	254	105	437	201

TABLE 1 (cont'd)

		2003		2004		2005 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)							
2508.40	Other clays (excluding expanded clays of no. 68.06)						
	Germany	5 489	2 023	7 426	2 643	12 348	4 613
	Belgium	1 003	711	2 113	1 039	1 585	533
	Denmark	635	225	742	348	1 135	448
	United States	1 439	390	1 657	433	1 901	394
	Sweden	409	153	544	237	809	289
	Netherlands	560	271	476	259	490	233
	Switzerland	346	152	225	120	549	226
	France	193	110	320	132	504	192
	Norway	312	189	336	333	186	169
	Latvia	34	52	100	131	265	101
	Israel	22	37	61	50	144	94
	Finland	–	–	25	7	219	71
	Austria	–	–	48	17	196	60
	Chile	21	31	26	23	46	31
	South Korea	1	1	48	15	74	25
	Portugal	59	33	31	19	60	23
	Belize	–	–	5	10	45	17
	United Kingdom	23	9	...	1	24	13
	Brazil	–	–	6	12	29	12
	New Zealand	11	6	–	–	11	12
	Malaysia	13	5	28	14	18	11
	Taiwan	9	32	12	16	25	11
	Trinidad and Tobago	–	–	–	–	10	10
	Greece	–	–	24	7	4	10
	Lithuania	–	–	–	–	24	9
	United Arab Emirates	48	27	–	–	4	9
	Qatar	...	...	–	–	4	7
	Saint Vincent and the Grenadines	–	–	–	–	5	6
	Barbados	...	...	–	–	12	6
	Vietnam	–	-	–	–	3	5
	Philippines	16	4	44	11	2	4
	Venezuela	21	3	21	3	8	4
	Dominica	–	–	1	2	9	4
	Jamaica	1	...	2	1	5	3
	Cayman Islands	–	–	–	–	2	3
	Panama	3	1	48	16	7	2
	Saint Pierre and Miquelon	4	2	3	3	5	2
	Antigua and Barbuda	–	–	–	–	2	2
	Hong Kong	20	38	–	–	1	2
	Uruguay	2	2	25	5	13	2
	Bermuda	–	–	3	1	4	2
	Saudi Arabia	65	36	13	6	3	2
	Lebanon	6	2	–	–	2	1
	Costa Rica	–	–	...	...	5	1
	Dominican Republic	–	–	–	–	3	1
	Malta	1	...	–	–	2	...
	Grenada	–	–	–	–	...	...
	Saint Kitts and Nevis	–	–	–	–	...	...
	Italy	–	–	221	72	...	...
	Slovenia	–	–	...	...	...	...
	South Africa	...	...	...	1	...	...
	Tanzania	–	–	–	–	...	...
	Guatemala	–	–	–	–	...	...
	Colombia	...	...	1	...	...	...
	Czech Republic	–	–	...	1	–	–
	Japan	9	9	17	7	–	–
	Singapore	46	16	–	–	–	–
	Poland	1	1	–	–	–	–
	El Salvador	...	...	1	...	–	–
	Cuba	1	...	–	–	–	–
	Australia	...	...	–	–	–	–
	China	2	46	5	8	–	–
	Bahrain	...	...	...	...	–	–
	Total	10 825	4 617	14 658	6 003	20 802	7 675
	Total exports	15 185	6 547	21 337	8 752	27 205	10 301

TABLE 1 (cont'd)

		2003		2004		2005 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (2)							
2507.00	Kaolin and other kaolinic clays whether or not calcinated						
	United States	800 520	106 730	851 947	118 260	715 448	81 317
	United Kingdom	119 170	22 395	83 964	19 036	130 668	20 888
	Brazil	92 134	12 562	110 944	11 175	145 573	16 468
	Germany	8	1	...	...	122	49
	Australia	12	7	90	21	149	20
	France	9	3	5	6	8	12
	Spain	21	5	43	11	43	11
	China	...	...	45	6	2	5
	Austria	–	–	...	...	1	3
	Finland	4	1	–	–	3	1
	Indonesia	–	–	–	–	2	1
	Japan	...	...	...	...	1	1
	Canada	68	15	–	–	...	...
	India	–	–	–	–	...	...
	Thailand	–	–	...	...	...	...
	Ghana	–	–	1	...	1	...
	Taiwan	2	1	...	...	...	...
	Macedonia (FYROM)	–	–	–	–	...	...
	Sweden	3	1	–	–	–	–
	Netherlands	2	...	12	5	–	–
	Mexico	2	1	–	–	–	–
	Italy	...	...	–	–	–	–
	Argentina	...	...	...	...	–	–
	Greece	–	–	...	...	–	–
	South Korea	–	–	5	2	–	–
	Saudi Arabia	–	–	3	1	–	–
	Switzerland	–	–	...	...	–	–
	Hong Kong	1	1	–	–	–	–
	Czech Republic	1	...	–	–	–	–
	Poland	...	...	–	–	–	–
	Total	1 011 957	141 723	1 047 059	148 523	992 021	118 776
2508.10	Bentonite						
	United States	218 987	23 349	296 739	28 094	342 840	28 587
	Greece	9 115	7 121	44 300	4 694	46 215	3 508
	Germany	122	82	120	75	479	238
	United Kingdom	2 818	1 382	997	500	357	163
	Italy	77	69	156	146	58	90
	Egypt	–	–	108	34	234	70
	Canada	–	–	–	–	182	18
	Uruguay	–	–	50	16	52	15
	China	2	2	105	33	30	3
	France	7	3	28	8	5	2
	Japan	...	...	1	1	...	1
	Mexico	1	1	–	–	1	1
	Netherlands	...	...	–	–	...	...
	Austria	–	–	–	–	...	...
	Cuba	–	–	–	–	...	...
	Philippines	–	–	–	–	...	...
	Argentina	203	49	627	199	–	–
	Hong Kong	...	...	–	–	–	–
	India	42 058	2 623	29 937	2 791	–	–
	Belgium	–	–	...	...	–	–
	Chile	–	–	4	4	–	–
	Spain	–	–	1	...	–	–
	Switzerland	–	–	37	12	–	–
	Total	273 390	34 681	373 210	36 607	390 453	32 696
2508.20	Decolourizing earths and Fuller's earth						
	United States	7 078	1 705	7 042	1 677	7 158	1 690
	United Kingdom	116	79	349	90	198	122
	Mexico	7	5	8	6	235	102
	Germany	1	...	41	12	30	12
	Iran	–	–	–	–	4	1
	Sri Lanka	–	–	–	–	1	1
	China	...	...	–	–	–	–
	India	1	1	–	–	–	–
	Australia	–	–	...	...	–	–
	Total	7 203	1 790	7 440	1 785	7 626	1 928

TABLE 1 (cont'd)

		2003		2004		2005 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
2508.30	Fire clay						
	United States	7 554	1 527	10 439	1 713	10 823	1 637
	United Kingdom	64	37	127	72	202	99
	Canada	–	–	–	–	138	22
	Italy	23	6	51	15	80	15
	China	–	–	3	...	27	8
	Japan	–	–	12	2	18	3
	Mexico	2	1	–	–	...	...
	Australia	1	1	–	–	–	–
	India	...	...	...	...	–	–
	Netherlands	2	...	–	–	–	–
	France	–	–	7	1	–	–
	Germany	–	–	6	1	–	–
	Taiwan	–	–	...	...	–	–
	Total	7 646	1 572	10 645	1 804	11 288	1 784
2508.40	Other clays (excluding expanded clays of no. 68.06)						
	United States	191 923	33 114	304 979	31 831	319 642	26 752
	France	406	292	431	304	476	373
	China	371	178	289	231	147	112
	Germany	179	75	105	71	48	73
	Spain	65	59	42	70	27	72
	Mexico	14	15	2	2	24	37
	United Kingdom	113	39	139	60	163	35
	Japan	10	10	54	27	175	34
	Italy	14	24	6	5	7	24
	Canada	14	4	7	4	1	17
	Brazil	–	–	–	–	7	11
	South Africa	1	1	–	–	1	11
	Switzerland	25	40	121	30	23	8
	Hong Kong	...	...	...	...	19	4
	Taiwan	9	9	6	5	4	3
	Guyana	–	–	–	–	26	1
	Madagascar	–	–	–	–	...	1
	South Korea	5	2	–	–	...	1
	India	2	2	...	...	...	1
	Portugal	1	...	1	...	...	...
	Greece	–	–	..	...	...	...
	Philippines	–	–	...	...	1	...
	Chile	–	–	–	–	...	...
	Cuba	–	–	–	–	...	...
	Finland	–	–	–	–	...	...
	Iran	–	–	–	–	1	...
	Netherlands	–	–	–	–	...	...
	Peru	–	–	–	–	...	...
	Sweden	–	–	–	–	2	...
	Morocco	1	1	...	...	–	–
	Mali	1	1	–	–	–	–
	Malaysia	2	2	...	...	–	–
	Thailand	1	1	...	1	–	–
	Jordan	8	3	1	1	–	–
	Israel	2	2	...	...	–	–
	Argentina	–	–	1	...	–	–
	Belgium	–	–	...	...	–	–
	Egypt	–	–	2	1	–	–
	Czech Republic	7	2	1	...	–	–
	Australia	...	...	9	16	–	–
	Total	193 174	33 876	306 196	32 659	320 794	27 570
3802.90.00.10	Activated clay						
	Greece	46 271	5 169	7 316	4 814	30 006	11 237
	United States	12 945	6 232	18 260	7 964	20 329	9 684
	Germany	1	...	14	94	511	512
	Mexico	1	1	–	–	58	30
	Spain	–	–	–	–	4	6
	China	–	–	–	–	2	5
	Japan	...	...	...	...	...	...
	Taiwan	...	...	1	...	...	...

TABLE 1 (cont'd)

	2003		2004		2005 (p)	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)						
France	–	–	1	. . .	. . .	. . .
Sweden	–	–	. . .	. . .	. . .	. . .
Austria	–	–	–	–	. . .	. . .
Switzerland	. . .	. . .	–	–	–	–
United Kingdom	. . .	. . .	13	167	–	–
Total	59 218	11 402	25 605	13 039	50 910	21 474
Total imports	1 552 588	225 044	1 770 155	234 417	1 773 092	204 228

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . Not available; . . . Amount too small to be expressed; (p) Preliminary; x Confidential.
(1) Production values for bentonite and diatomite have been included. (2) 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) 1988-2005

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	36 607	280 471
2005	390 453	32 697	. .

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.
Note: Numbers may not add to totals due to rounding.

TABLE 3. CANADA, REPORTED USE (1) OF CLAYS, BY INDUSTRY, 2001-04

	2001	2002	2003	2004
		(tonnes)		
China clay (kaolin)				
Pulp and paper, and paper products	603 209	628 193	580 034	679 997
Rubber products	10 735	11 623	9 045	7 441
Ceramic products	6 489	6 624	6 412	6 158
Paint and varnish	7 104	10 706	9 107	8 430
Other products (2)	30 396	26 836	26 626	29 131
Total	657 933	683 982	631 224	731 157
Ball clay				
Clay products, ceramics and structural	6 115	5 285	6 554	5 767
Refractory brick, mixes	1 032	879	1 075	1 191
Other products (3)	238	719	761	857
Total	7 385	6 883	8 390	7 815
Fire clay				
Refractory brick, mixes	x	x	x	x
Foundries	179	434	515	477
Other products (4)	x	x	x	x
Total	22 509	24 764	25 296	26 772
Bentonite, quantity used (available data) (5)				
Iron ore pelletizing	180 643	179 784	196 594	192 916
Paper, pulp and paper products	9 003	9 310	9 090	7 674
Well drilling (6)	x	x	x	x
Refractory brick, mixes	x	x	x	x
Foundries	38 511	35 727	34 624	34 636
Other products (7)	21 549	21 227	12 041	17 956
Total	267 449	284 123	276 630	280 471
Other clays	1 874 296	2 150 352	2 245 136	2 247 811

Source: Natural Resources Canada.
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 2004 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

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 St. Lawrence Brick Div.)	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	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 Bricks and Tile Co.	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. (Absorbent 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.