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 **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 sub-microscopic 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. 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: *USGS 2002 Review*) of bentonite was approximately 10.3 Mt, Fuller's earth production was estimated to be 3.89 Mt, and kaolin production was 43.2 Mt. 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 2003 figures indicate a shipment value of $234.8 million (tonnage not available), exports of $6.5 million (15 117 t), and imports of $223.9 million (1.5 Mt). Preliminary consumption for 2002 was 2.2 Mt for "other" clays, 683 982 t for kaolin, 284 123 t for bentonite, 24 764 t for fire clay, and 6290 t for ball clay. Preliminary figures reported on the uses of clays by industry were only available up to 2002. 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 below. 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.

Clays do not appear to have any adverse effect on skin. Nevertheless, during clay's 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 risk. In Canada, the Workplace Hazardous Materials Information System (WHMIS) of Health Canada provides proper supervisory and educational control. Environmentally, clays are a natural material that pose no threat to the environment. Indeed, in many instances, it is the material of choice in protecting the local environment and ground waters.

Many changes have taken place in the various clay industries in recent years. Several of these have arisen due to technological advancements, changing economic conditions, new uses, shifts in demand, and increases in both domestic and export markets. The short-term forecast from expert organizations (e.g., *USGS 2002 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 by the clay products and structural industry, and 40% used by the cement [construction] industry); kaolin at 683 982 t (91.8% used in the pulp, paper and paper products industry); bentonite at 284 123 t (63.3% used in the iron ore pelletizing industry and 12.6% used by the foundries industry); fire clay at 24 764 t, of which the major uses are confidential; and ball clay at 6883 t (76.8% 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 2003.

Canadian clay production (Table 1) provides a preliminary shipments value of $234.8 million. In 2003, Canadian shipments maintained a proportional increase from their 2002 value of 20.0%, which is a similar increase from 2001 to 2002 (19.9%).

In 2003, Canada exported 15 117 t of clay valued at $6.5 million, an increase of 3984 t (35.9%) from 2002, compared to an increase of 1349 t from 2001 to 2002 (13.8%). "Other" clays represent 71.2% of Canada's total exports, while bentonite, kaolin and decolourizing clays represent 23.6%, 3.6% and 1.6% of total exports, respectively. Canada's major export destination has been the United States for kaolin, bentonite and fire clay. As for the "Other" clays category, Germany and the United States are the core markets for export. Except for kaolin exports, which have sustained a decrease from 2001, all other clay types have shown a steady increase, especially bentonite, which was up 136.8% from 2002 to 2003 and up 143% from 2001 to 2002.

Canada's overall 2003 imports of clays totaled 1.54 Mt valued at $223.9 million. The slight decrease in value from 2002 ($224.3 million), and also a smaller value than 2001 for more tonnage (1.54 Mt for 2003, 1.45 Mt for 2002, and 1.51 Mt for 2001), can be explained by variations in the Canadian currency vs. the U.S. currency combined with global average clay prices in recent years ($159.34/t for 2001, $154.35/t for 2002, and $145.07/t for 2003). The value of kaolin imports dominated in 2003 (62.8% of total imports valued at $223.9 million), followed by bentonite (15.5%), "Other" clays (15.1%), activated clays (5.1%), decolourizing earths and Fuller's earth (0.8%), and fire clay (0.7%). Imports by tonnage provide a similar standing with kaolin leading (65% of total imports of 1.54 Mt), followed by bentonite (17.7%), "Other" clays (12.5%), activated clay (3.8%), decolourizing earths and Fuller's earth (0.5%), and fire clay (0.5%). The United States maintained its position in being the major supplier of all clays imported into Canada with the exception of activated clay, which was mainly imported from Greece.

A possible explanation for the major increase in imports of kaolin from Brazil since 2001 (125 t in 2001, 68 541 t in 2002, and 92 134 t in 2003) could be the result of the following: Imerys SA of France reports that wholly owned Rio Capim Caulim (RCC) was operating its newly expanded Brazilian kaolin operation in Para at full capacity at the end of 2003, and RCC improved its penetration in the North American paper-coating markets. The company ships kaolin slurry to terminals in Trois-Rivières, Quebec; Nanaimo, British Columbia; and Portland, Maine. By using Brazilian kaolin instead of standard hydrous clays, paper manufacturers have found that they can significantly reduce their consumption of the more expensive titanium dioxide.

CANADIAN CLAY DEPOSITS AND USES

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 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; as 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.

Mining, Processing and Beneficiation

Mining of Canadian bentonite and Fuller's earth is carried out by the stripping method and, although relatively inexpensive, requires controlled conditions to ensure quality. Bentonite deposits, as a rule, cannot be worked efficiently in wet conditions because of their very slippery nature and the resulting insufficient traction for conventional equipment. Well-drained Canadian bentonite deposits are worked during periods of dry warm weather and poorly drained deposits are mined in cold weather.

The variable physical properties of most bentonite and some Fuller's earth deposits require that they be selectively mined. Bentonite from a single pit or bed may be separated into as many as three stockpiles at the plant, each with different physical properties. Various grades of bentonite suitable for different uses are then prepared from the separate piles and by blending bentonite from more than one pile.

Bentonite and Fuller's earth are processed by simple milling techniques that involve removal of water and, in some instances, other volatile matter and grinding to suitable sizes. In most plants, the raw bentonite is passed through a clay "slicer" to break up the large chunks before drying. The dried bentonite is ground and sized in several ways. In some plants, rods in rotary dryers do much of the grinding, but most of the powdered product is ground with roll and hammer mills or other pulverizers, and screened. Most bentonite and much of the Fuller's earth used is ground to approximately 90% finer than 75 micrometres. Fuller's earth for special markets is ground to 95% finer than 10 micrometres.

The mining of kaolin is a highly sophisticated mechanized operation. Following the mining operation, kaolin is either loaded into trucks or dropped into a blunger that disperses it in water with the aid of a dispersant chemical to form a clay-water slip or slurry. This slurry is pumped from the blunger to a degritting station where, by the use of settling boxes, screens and hydrocyclones, the coarse foreign particles called grit are removed. Grit is defined as that material coarser than about 44 micrometres. After degritting, the kaolin slurry is collected in large storage tanks and then pumped through pipelines to the beneficiation plant.

Kaolin is beneficiated by two methods: a dry and a wet process. The dry process is simple and yields a lower-cost and lower-quality product than the wet process. In the dry process, the properties of the finished kaolin generally reflect the properties originally found in the crude kaolin. The kaolin is crushed to approximately 50 mm, dried in rotary dryers, pulverized and air-floated. The air-floating process removes most of the grit.

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. Estevan 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 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 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 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. will be 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 2002 Review*).

Ball Clay

The average value for ball clay reported by U.S. producers was $41.96/t. The average values for imported and exported ball clay were $48.89 and $55.51/t, 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, 2002*).

Bentonite

The average value reported by U.S. producers for non-swelling bentonite was $39.55/ton. The average value for swelling bentonite was $45.85/ton. The average value for all bentonite was $45.34/ton. The average value of imported bentonite by the United States was $115.12/ton while the average value of exported bentonite by the United States was $121.33/ton.

The price for ex-work, Wyoming and crude, bulk, rail cars, was $26/ton; for foundry grade, bagged, rail cars was $50-$76/ton; and for API-grade, bagged, rail cars, $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, 2002*).

Common Clay and Shale

The average value of all common clay and shale produced in the United States and Puerto Rico was $6.43/ton. The average value of clay and shale used in lightweight aggregate was $13.69/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 $23.54/ton. The average value of imported fire clay into the United States was $532.11/ton. The average value of exported fire clay out of the United States was $90.84/ton.

Fuller's Earth

The average value of attapulgite-type Fuller's earth was $122.94/ton. The average value of montmorrilonite-type Fuller's earth was $87.25/ton. The average value of all Fuller's earth was estimated to be $90.11/ton. The average value of imported Fuller's earth was $234.15/ton and the average value of exported Fuller's earth was $144.50/ton.

The price, ex-plant, Georgia, 40-100% less than 325 mesh, truck load, was $220-$551/ton; for granular processed, 40-100% less than 4/8 mesh, truck load, $193-$551/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, 2002*).

The price of filler-grade attapulgite from Asia ranged from $158 to $315/ton (Geo.net Commodities GmbH, 2003).

Kaolin

The average value of kaolin was $118.73/ton for all kaolin grades. The average value for airfloat was $55.64/ton; for refractory-grade (high temperature calcined), $28.57/ton; for pigment-grade (low-temperature calcined), $319.61/ton; for all types of calcined, $183.22/ton; for delaminated, $115.89/ton; for water washed, $114.79/ton; and for unprocessed, $9.57/ton. The average value of imported kaolin was $141.77/ton and the average value of exported kaolin was $160.00/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, 2002*).

Many of the clay producers instituted price increases of 3-8% for the past two to three years because of increased energy costs, particularly for natural gas users, and

increased costs of production. Imerys announced that it would raise the price of all grades of paper-grade kaolin and calcium carbonate products by 2% to 7% (*Imerys, 2002*).

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/hecs-sesc/whmis/) is Canada's hazard communication standard. WHMIS is implemented through coordinated federal, provincial and territorial legislations.

Clay mining has an environmental impact because of the disturbance to the land through open-pit or cut-and-fill mining methods. Overburden is moved and clays are removed, leaving a depression or pit. Leveling or contouring of the disturbed area and planting trees or grasses prevent or minimize erosion. Ponds for recreational purposes often are created when ground-water levels permit. For processing, the impoundment of slimes and dust control are required. The rules for disposal of coarse tailings are similar to or included within those regulations governing reclamation of the mining area.

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.

Environmentally, clay is 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.

The Canadian Council of Ministers of the Environment (CCME) comprises environment ministers from the federal, provincial and territorial governments. The CCME works to promote effective intergovernmental cooperation and coordinated approaches to inter-jurisdictional issues such as air pollution and toxic chemicals. CCME members collectively establish nationally consistent environmental standards, strategies and objectives in order to achieve a high level of environmental quality across the country.

A *National Guidelines for the Landfilling of Hazardous Wastes* report was produced in 1991 for the CCME. The document provides a straightforward reference on the basic design, operating and performance standards to be used by the various federal and provincial/territorial regulatory agencies, designers, owners and operators of hazardous waste landfills in Canada. Recently, there has been some discussion about revising the guidelines.

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, but demand for others is likely to fall short of this growth rate. 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 limit their market range.

The kaolin market (Source: *Mineral Price Watch*, April 2004) has stabilized since 2001 after experiencing about 10 years of declining prices. Recently, the market has been described as oversupplied.

For a long time, plants were near population centres because of transportation costs. Suburban growth in many populations centres has forced plants to close or to relocate because of land access, environmental conditions and raw material supply problems. The rise in fuel costs and a shift to rural areas are the major issues being faced by the industry. This trend will continue until virtually all active plants are in rural areas, which in turn tends to favour a substitute material because of increased transportation costs and other factors.

The economy (source: *USGS 2002 Review*) has shown signs of recovery in the past year, brightening the prospects for several segments of the clay industry. Construction-oriented markets for clay-based products such as adhesives, brick, ceramics, fibreglass, lightweight aggregate and paint remain fairly strong. Domestic sales

to these markets probably will maintain their current levels for the near future. However, there is a trend towards a continued increase in the use of imported clay-based products such as tile and whiteware. If the economic recovery continues and industrial manufacturing begins to increase, that bodes well for clays sold for foundry sand bond (bentonite), pelletizing iron ore (bentonite), and oil and grease absorbent (bentonite and Fuller's earth). These markets have declined in the past several years in response to a decline in heavy industrial manufacturing. Based on the rate of the current recovery, growth in these markets probably will be slow in the near future. Prospects for domestic sales of bentonite for drilling mud applications are not favourable owing to a continued decline in drilling activity in Canada and the United States. Foreign drilling mud markets may help offset this decline. Sales for pet litter markets probably will remain at current levels based on recent trends. A continuing decline in the paper industry and competition in the paper-filling and coating markets will hamper sales in the kaolin industry, with sales likely to remain at current levels for the near term.

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 May 31, 2004. (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

The intent of this document is to provide general information and to elicit discussion. It is not intended as a reference, guide or suggestion to be used in trading, investment, or other commercial activities. The author and Natural Resources Canada make no warranty of any kind with respect to the content and accept no liability, either incidental, consequential, financial or otherwise, arising from the use of this document.

TARIFFS

Item No.	Description	Canada			United States
		MFN	GPT	USA	Canada
2507.00	Kaolin and other kaolinic clays, whether or not calcined	Free	Free	Free	Free
2508.10	Bentonite	Free	Free	Free	Free
2508.20	Decolourizing earths and Fuller's earth	Free	Free	Free	Free
2508.30	Fire clay	Free	Free	Free	Free
2508.40	Other clays	Free	Free	Free	Free
3802.90.10	Activated clay	Free	Free	Free	Free

Sources: Canadian *Customs Tariff*, effective January 2004, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States,* 2004.

TABLE 1. CANADA, CLAY PRODUCTION AND TRADE, 2001-03

Item No.		2001		2002		2003	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
PRODUCTION (all forms)							
	Nova Scotia	..	x	..	x	..	x
	Quebec	..	x	..	x	..	x
	Ontario	..	155 061	..	191 139	..	193 377
	Saskatchewan	..	x	..	x	..	x
	Alberta	..	x	..	x	..	x
	British Columbia	..	x	..	x	..	x
	Total	..	194 579	..	233 244	..	234 775
EXPORTS							
2507.00	Kaolin and other kaolinic clays whether or not calcinated						
	United States	726	481	488	231	504	353
	Brazil	–	–	–	–	43	29
	Germany	–	–	–	–	3	3
	Others	2	20	21	36	–	–
	Total	728	501	509	267	550	385
2508.10	Bentonite						
	United States	483	436	1 383	965	3 500	1 384
	Israel	–	–	43	24	34	30
	Germany	–	–	50	23	25	13
	Others	138	67	33	22	15	11
	Total	621	503	1 509	1 034	3 574	1 438
2508.20	Decolourizing earths and Fuller's earth						
	United States	15	7	–	–	–	–
2508.30	Fire clay						
	United States	132	92	210	139	231	103
	Brazil	–	–	–	–	5	4
	Cuba	1	1	–	–	–	–
	Total	133	93	210	139	236	107
2508.40	Other clays (excluding expanded clays or 68.06)						
	Germany	2 181	1 063	3 701	1 443	5 488	2 023
	Belgium	1 005	430	1 044	474	1 003	711
	United States	2 787	1 376	1 291	498	1 439	390
	Netherlands	354	177	464	227	560	271
	Denmark	307	142	559	224	634	224
	Norway	491	229	506	199	312	189
	Sweden	360	169	447	186	409	153
	Switzerland	257	139	152	124	346	152
	France	206	112	233	107	193	110
	Latvia	–	–	6	9	34	52
	China	–	–	82	23	2	46
	Hong Kong	2	4	3	5	20	38
	Israel	57	39	172	113	22	37
	Taiwan	4	6	2	24	9	32
	Portugal	–	–	5	8	57	32
	Saudi Arabia	–	–	3	1	55	31
	Chile	–	–	4	7	19	28
	United Arab Emirates	20	11	–	–	48	27
	Singapore	–	–	–	–	45	15
	Others	256	166	231	322	62	30
	Total	8 287	4 063	8 905	3 994	10 757	4 591
	Total exports	9 784	5 167	11 133	5 434	15 117	6 521
IMPORTS							
2507.00	Kaolin and other kaolinic clays whether or not calcinated						
	United States	864 473	130 761	785 816	112 360	800 447	106 764
	United Kingdom	103 540	13 864	100 411	13 239	109 921	21 212
	Brazil	125	44	68 541	9 099	92 134	12 562
	Others	90	27	215	50	133	36
	Total	968 228	144 696	954 983	134 748	1 002 635	140 574

TABLE 1 (cont'd)

Item No.		2001		2002		2003	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)							
2508.10	Bentonite						
	United States	195 676	21 668	186 440	20 547	218 976	23 343
	Greece	52 155	4 647	46 050	4 064	9 115	7 121
	India	–	–	–	–	42 058	2 623
	United Kingdom	6 294	2 639	5 347	2 395	2 818	1 382
	Others	118	66	577	113	412	206
	Total	254 243	29 020	238 414	27 119	273 379	34 675
2508.20	Decolourizing earths and Fuller's earth						
	United States	27 912	6 413	7 970	2 258	7 082	1 708
	United Kingdom	391	132	4 887	1 061	116	79
	Others	–	–	7	3	8	6
	Total	28 303	6 545	12 864	3 322	7 206	1 793
2508.30	Fire clay						
	United States	6 278	1 695	7 154	1 785	7 554	1 514
	United Kingdom	160	102	168	103	64	37
	Others	30	11	29	9	28	8
	Total	6 468	1 808	7 351	1 897	7 646	1 559
2508.40	Other clays (excluding expanded clays of 68.06)						
	United States	180 552	37 479	189 013	37 634	191 928	33 119
	France	343	186	417	358	406	292
	China	116	71	489	278	371	178
	Germany	301	120	369	102	179	75
	Spain	1	1	12	10	65	59
	Switzerland	20	23	38	36	25	40
	United Kingdom	136	85	347	139	113	39
	Others	374	254	701	247	92	79
	Total	181 843	38 219	191 386	38 804	193 179	33 881
3802.90.00.10	Activated clay						
	United States	16 540	8 633	15 064	8 206	12 945	6 231
	Greece	59 261	12 446	33 434	10 252	46 271	5 169
	Others	22	16	1	1	2	1
	Total	75 823	21 095	48 499	18 459	59 218	11 401
	Total imports	1 514 908	241 383	1 453 497	224 349	1 543 263	223 883

Sources: Natural Resources Canada; Statistics Canada.
– Nil; . . Not available.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, BENTONITE IMPORTS AND USE, (1) 1988-2003

	Imports		Use (2)
	(tonnes)	($000)	(tonnes)
1988	334 942	14 416	264 032
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	254 243	29 020	(r) 267 449
2002	238 414	27 119	284 123
2003	273 379	34 675	..

Sources: Natural Resources Canada; Statistics Canada.
.. Not available; (r) Revised.
(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, 1999-2002

	1999	2000	2001	2002 (p)
		(tonnes)		
China clay (kaolin)				
Pulp, paper and paper products	580 929	651 842	(r) 603 209	628 193
Rubber products	9 138	8 919	(r) 10 735	11 623
Paint and varnish	8 071	7 728	7 104	10 706
Ceramic products	6 346	8 034	6 489	6 624
Other products (2)	30 620	34 605	(r) 30 396	26 836
Total	635 104	711 128	(r) 657 933	683 982
Ball clay				
Clay products, ceramics and structural	10 712	8 981	6 115	5 285
Refractory brick, mixes	1 783	957	1 032	x
Other products (3)	504	594	238	x
Total	12 999	10 532	7 385	6 883
Fire clay				
Refractory brick, mixes	27 250	32 396	x	x
Foundries	796	388	179	434
Other products (4)	2 494	1 460	x	x
Total	30 540	34 244	22 509	24 764
Bentonite, quantity used (available data) (5)				
Iron ore pelletizing	205 038	240 213	180 643	179 784
Foundries	36 772	38 765	38 511	35 727
Paper, pulp and paper products	7 146	8 736	9 003	9 310
Well drilling (6)	x	x	x	x
Refractory brick, mixes	853	766	512	632
Other products (7)	6 748	7 786	38 780	58 670
Total	256 557	296 266	267 449	284 123
Other clays	1 500 794	1 673 096	1 874 296	2 150 352

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.

TABLE 4. MAJOR CANADIAN MANUFACTURERS OF STRUCTURAL CLAY PRODUCTS, BY PROVINCE, 2003

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	(A)
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	Face Brick	Sodium bentonite	. .
ALBERTA				
I-XL Industries LTD				
Medicine Hat	Medicine Hat	Brick, block, flue liners	Common clay	(B)
Redcliff	Redcliff	Facing and fire brick	Common clay	(B)
Plainsman Clay Ltd	Medicine Hat	Processed clay	Common clay	(A)
BRITISH COLUMBIA				
Clayburn Industries Ltd	Abbotsford	Refractory brick, mortar and monolithics	Imported ball clay & Fire clay	(D)
Sumas Clay Products Ltd	Abbotsford	Brick, drain tile and flue lining	Common clay	(A)
Western Industrial Clay Products Ltd Calcium Bentonite & Diatomite Operarions	Kamloops	Absorbents	Bentonite	. .

Sources: Natural Resources Canada; company web sites.
(1) Size keys: (A) up to 25 employees; (B) 25-49 employees; © 50-99 employees; (D) 100-199 employees; (E) 200-499 employees; (F) 500-999 employees; (G) over 1000 employees.
. . Not available.