Salt

Michel Dumont

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

BRIEF HISTORICAL FACTS

Human history was shaped by the need for salt. Wars were fought over the possession of salt deposits. Salt bought slaves and at times was traded at twice the value of gold. Armies and civilians required salt to maintain health, preserve meat and tan leather. Salt became one of the world's first commodities.

Salt (i.e., sodium chloride) is such a common part of our everyday lives that we rarely think of it as a natural resource that must be discovered, boiled/evaporated or mined, processed, marketed and consumed. Each human being contains about 113 grams (i.e., four ounces) of salt. Unless we get enough of it, our muscles won't contract, our blood won't circulate, our food won't digest and our hearts won't beat. The same is true for livestock; therefore, salt is important in diets.

The salt markets in developed regions such as North America and Western Europe are mature and expanding at a rate a little below the average growth of the world economy. The main consuming regions are North America, Asia and the Middle East, and Western Europe. World salt consumption is on the rise, mainly in response to increasing demand in the countries of Southeast Asia and other developing nations.

In 2004, total estimated world production (source: U.S. Geological Survey [USGS]) increased to 215 Mt from the 210 Mt of the previous year. Salt consumption for chemical uses, particularly chlor-alkali manufacture, can fluctuate depending on the demand for chlorine and co-product sodium hydroxide. Demand for chlorinated bleaching agents has declined while demand for oxygenated bleaching compounds has increased. Most of the other uses of salt (e.g., food processing, water treatment and industrial uses) tend to follow population trends. Although de-icing salt is not significantly affected by economic events, the quantity of salt consumed for road de-icing each year is directly related to winter weather conditions.

CANADIAN SUMMARY

Canada, like many countries, extracts, processes, consumes, exports and imports salt. Canada has a vast territory with many known deposits and some that are yet to be discovered. Only a few areas are exploited by a small group of companies that are large players in the industry. Most of the salt use is for de-icing, chemical production and domestic (e.g., table, food-grade, livestock feed) consumption.

Major Canadian salt deposits are found in Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba, Saskatchewan and Alberta. Since similar geological conditions are necessary for these types of deposits to exist, many salt deposits have been discovered while exploring for oil and gas and potash. In Prince Edward Island, a rock salt deposit of undetermined size was encountered at a depth of over 4200 m under Hillsborough Bay on the southern side of the island. Brine springs, usually indicative of salt deposits, have been found in Newfoundland and Labrador and in British Columbia. Production in most of these provinces is by two main methods of extraction (i.e., underground room-and-pillar mining and brining). Recovery as a co-product of potash mining is also practiced.

Canada's high level of consumption, which at one time was estimated at over 360 kg of salt per person per year (consumption statistics were available until 1987), is due to severe winter conditions in many parts of the country and to the use of road salt to improve winter driving conditions.

Canada is the fifth largest producer of salt (Table 3). Preliminary data indicate that Canadian salt shipments for 2004 were valued at $431.5 million (for 14.1 Mt shipped), a $10.9 million increase from 2003 (for 13.7 Mt shipped). This 2004 value reflects the cyclical production level from

year to year in response to winter conditions. Exports were valued at $83.5 million (for 4.2 Mt exported), a $41.8 million decrease from 2003 (for 4.2 Mt exported), while imports were valued at $50.8 million (for almost 2.1 Mt imported), nearly a $7.50 million increase from 2003 (for almost 1.0 Mt imported).

Although salt prices in Canada are not made available, other sources cited further below under "Prices" provide an indication of prices by type and by packaging.

Environmentally, the use of road salt in Canada has been an issue. In April 2004, Environment Canada issued a *Code of Practice for the Environmental Management of Road Salts*. The Code applies to any organization that uses more than 500 t/y of road salts.

TRADE

Salt is a widespread, low-value, bulk commodity. It is relatively easy to extract and transportation represents a significant proportion of the total delivered price. Many global markets are served by neighbouring countries producing salt; therefore, long-distance trade is limited (Table 1). Nevertheless, even if both Canada and the United States produce salt for their own consumption, some regions on both side of the border still rely, for economic reasons and convenience of supply, on large quantities of imports and exports with each other.

Preliminary data (Table 1) for 2004 show that Canada exported a total of 4.2 Mt (valued at $83.5 million), of which 99.9% was exported to the United States (valued at $83.1 million). This represented a 50 600-t increase from 2003, but was still less than the achieved 2001 export level of 4.6 Mt. The export of 4.2 Mt to the United States in 2004 was that country's largest source of salt imports, accounting for about 44% of its total imports (source: USGS).

Canada also imports salt. Preliminary data show that Canada imported 2.1 Mt in 2004 (valued at $50.8 million) broken down as follows: 75.6% from the United States, 18.9% from Mexico, and 1.3% from France (Table 1).

CONSUMPTION

Of the millions of tonnes of dry salt produced annually in North America, a very small percentage finds its way to family dining tables either in commercially processed foods, in home preparations, or in the salt shaker. Globally, the biggest part of salt produced as brine and dry salt is used in the chemical industry. Directly or indirectly, salt plays a part in the manufacture of a seemingly endless list of chemicals and chemical products. Chemical raw materials represent 60% of world salt consumption, followed by table salt (20%) and road de-icing salt (10%); the remaining 10% is used in animal feed and water treatment.

Consumption patterns differ in North America. On a per-capita basis, Canada is the largest consumer of salt in the world, and this is due mainly to its winter conditions. Most of the salt used as a de-icing agent is consumed in Ontario, Quebec and Atlantic Canada. The apparent domestic consumption (source: Canadian Salt Institute) is reflected as follows: chemical and de-icing uses account for between 90% and 95% while the remainder is used for water conditioning, food processing, fisheries, and other industrial uses.

The United States provides consumption details and these could be used to reflect, to a certain degree, the North American consumption of Canadian salt. In 2003, the U.S. distribution of salt (source: USGS) by major end use was for chemicals (40%), ice control (37%), distributors (grocery and other wholesalers and retailers) (8%), general industrial (6%), agricultural (4%), food processing (3%), primary water treatment (2%), and other uses (less than 1%).

The U.S. Salt Institute's web site provides an explanation of the many uses of salt. It can be found at www.saltinstitute.org/16.html.

The industrial chemicals industry (source: Natural Resources Canada) consumes salt for the manufacture of chlor-alkali such as caustic soda (sodium hydroxide), chlorine, and sodium chlorate. Salt for caustic soda and chlorine plants (i.e., facilities) in Canada is obtained from on-site brining and natural brines; other plants use mined rock salt or imported solar or evaporated salt. Other industrial chemicals that require significant quantities of salt include sodium bicarbonate, sodium chlorite, sodium hypochlorite, sodium carbonate (soda ash), and calcium chloride. For example, salt goes into the production of chlorine and into the manufacture of soda ash; in turn, these two products are used in the processing or manufacture of a wide variety of end products ranging from rayon, polyester and other synthetics to plastics for explosives, fertilizers, glass and cosmetics.

Most pulp and paper mills in Canada have carried out extensive process modifications and improvements in effluent treatment. Several have opted to reduce chlorine usage by installing other bleaching processes such as extended lignification, oxygen delignification, sodium chlorate bleaching, integrated chlorine dioxide with hydrochloric acid recycling, and ozone and hydrogen peroxide bleaching processes. Although seen as a step in the right direction by environmentalists, they would prefer that the industry adopt dioxin-free bleaches such as oxygen and hydrogen peroxide.

Sodium chloride, or salt, remains the primary de-icing agent. Different de-icers are used in accordance with site requirements. Calcium chloride is the second most used de-icer, being effective at temperatures ranging between -10 and -20°C; this chemical is usually mixed with salt at a 2-4% rate. Growing concerns over the environment and the corrosion of infrastructure, such as bridge decks and parking lots, have led to numerous experiments with de-icing salt substitutes.

PRODUCTION

Canada has an abundant resource of salt. The vast Canadian territory has three known major salt formations, all of great area and thickness in economically strategic locations. The largest deposits are in western Canada, followed by Ontario and the Atlantic provinces.

In western Canada, the salt beds extend from the Northwest Territories down through Alberta, Saskatchewan and into Manitoba. This immense deposit, averaging 122 m (400 feet) in thickness and covering an area of approximately 390 000 km^2 (150 000 square miles), contains more than one million billion tonnes of salt.

In Ontario, salt is found along the shores of Lake Huron and Lake Erie. This deposit is part of the known Michigan Basin and is a saucer-shaped formation underlying part of Michigan, part of Ohio, and lakes Huron and Erie.

In the Atlantic provinces, large, thick deposits have been found underlying New Brunswick, Nova Scotia, part of Newfoundland and Labrador, and even the Gulf of St. Lawrence. These deposits occurred in various geologic eras and all of them are the remains of ancient inland seas. The shorelines of these ancient seas, which outline the edges of the salt beds, mark the occurrences of the oil, gas and coal deposits that have been found in such abundance in Canada.

Major salt deposits and dry salt production in North America can be viewed on the Internet at www.saltinstitute.org/images/map.pdf.

In 2003 (sources: USGS and Table 3), the top eight salt-producing nations that collectively accounted for 48.2% of total world output of 210 Mt, in descending order of quantity (Mt) produced, were the United States (43.7), China (32.4), Germany (15.7), India (15.0), Canada (13.4), Australia (9.8), Mexico (8.0), and France (7.0). In North America, some 65.0 Mt of salt were produced in 2003: 67.2% by the United States and 32.8% by Canada. The United States was the largest salt-producing nation, representing about 21% of total world output. Canada's share was 6.3% of world production, compared to its 5.9% share in 2002. Canada still has the largest underground mine in North America located in Goderich, Ontario.

Preliminary data for Canada for 2004 (Table 2) show shipments increasing to 14.1 Mt (85.3% being mined rock, 6.5% being fine vacuum, and 8.2% being brine and salt recovered in chemical operations).

Preliminary data for 2004 estimate that the Canadian salt industry produced 14.1 Mt of salt from major rock salt mines in Ontario, Quebec and New Brunswick and from vacuum pan refineries in Alberta, Saskatchewan, Ontario, New Brunswick and Nova Scotia. More than three-quarters of this production was rock salt, used primarily for highway de-icing.

Preliminary data also indicate that Canadian salt shipments for 2004 were valued at $431.5 million (for 14.1 Mt shipped), almost an $11 million increase from 2003 (for the 13.7 Mt shipped). This 2004 value reflects the cyclical production level from year to year in response to winter conditions.

Two major methods are used to obtain salt from Canada's age-old deposits: underground room-and-pillar mining and brining. Recovery as a co-product of potash mining is also practiced. The most important Canadian producers are described below (refer also to Table 4).

In Nova Scotia, The Canadian Salt Company Limited operates an underground rock salt mine at Pugwash in Cumberland County. Most of the salt from this mine is used for snow and ice control. It also operates an evaporated salt plant where saturated brine is fed to a quadruple-effect vacuum pan; the brine solution is evaporated to produce high-quality salt crystals for use in the chemical and food industries.

Sifto Canada Inc.'s (a subsidiary of Compass Minerals Group Inc.) production process in eastern Canada is a brining operation at Amherst, Nova Scotia. Its vapour re-compression process produces an unequalled salt purity in North America and its evaporated salt products are sold for table salt, fisheries, and water conditioning. This particular operation is one of the newest, most modern evaporation plants on the continent.

In New Brunswick, Potash Corporation of Saskatchewan Inc. (New Brunswick Division) produces potash and salt at its underground mine near Sussex. It extracts salt and sells it mainly to the United States and eastern Canada. It also pumps brine back to the surface for re-use. This brine is produced from the clay slimes, and excess brine slurries from the processing plant are piped underground as backfill where rock salt has been extracted.

In Quebec, Seleine Mines Division (a subsidiary of The Canadian Salt Company Limited) is the only operating salt producer. Located on the Magdalen Islands in the Gulf of St. Lawrence, it produces de-icing salt for markets in Quebec and the eastern United States.

Junex, an oil and gas exploration company, discovered a natural brine zone while drilling for gas in Bécancour. In 2001, Junex created Junex Solnat, which operates two natural brine well operations. Its natural brine is sold as a dust control agent (i.e., suppressor) and for ice removal products.

In Ontario, Sifto Canada Inc. operates an underground rock salt mine in Goderich Harbour on the shores of Lake Huron. It also operates an evaporating plant for brine production on the escarpment of the Maitland River. The products serve the home water softeners, packaged icemelts, agricultural salts, food processing, table salts, and industrial salts markets.

More commonly recognized under the leading consumer brand of Windsor, The Canadian Salt Company Limited is headquartered in Pointe-Claire, Quebec. It produces both rock salt from the Ojibway underground mine and vacuum salt from brine wells near Windsor. Salt products include de-icing road salt and water softening, agricultural and chemical fine salt.

In Saskatchewan, Sifto Canada Inc. operates a brining operation near Unity for the production of fine vacuum pan salt, which is used for water softening, for agriculture, and in food processing, and for the production of some de-icing salt for local use.

The Canadian Salt Company Limited at Belle-Plaine produces evaporated salt from by-product brines sourced from an adjacent potash solution mine operated by The Mosaic Company (an amalgamation of IMC Global Inc. and Cargill Crop Nutrition). Most of the production goes towards water softening; other uses are for agriculture, food processing, and ice control.

NSC Minerals Inc. is a leading supplier of industrial mineral products specializing in salt mineral crystals. It produces coarse and fine salt products from potash tailings. The head office for NSC Minerals Inc. is located in Saskatoon. It has two modern operating plants with a total daily production capacity in excess of 6000 t located at Rocanville and Vanscoy, Saskatchewan. The Rocanville plant is located in southeastern Saskatchewan near the Manitoba border and the Vanscoy plant is located in central Saskatchewan approximately 20 miles southwest of Saskatoon. Products are used for a variety of applications such as highway de-icing, livestock feed supplements, hide curing, drilling muds, water softening, road stabilization, and industrial applications.

In Alberta, The Canadian Salt Company Limited, at Lindberg, produces fine vacuum pan salt, which is also used for water softening, agriculture and food processing; the company also produces some de-icing salt for local use.

Other companies known to produce salt (mainly brine) are as follows:

- In Saskatchewan, Mosaic Potash Esterhazy Limited Partnership (formerly IMC Esterhazy Canada Limited Partnership) supplies by-product rock salt from its potash operation at Esterhazy to Kayway Salt, who is distributing it locally for road de-icing. Saskatoon Chemicals ("SaskChem," a division of Sterling Chemicals Holdings, Inc.) produces brines from wells near Saskatoon for the manufacture of caustic soda, chlorine and sodium chlorate to be used internally for its pulp chemicals operations.

- In Alberta, Dow Chemical Canada Inc. at Fort Saskatchewan near Edmonton extracts salt brines for the manufacture of chlor-alkali. Nexen Inc. (formerly Canadian Occidental Petroleum Ltd. [Canadian OXY Ltd.]) and Albchem Industries Ltd. (where the plant site is located on the large and very pure Upper Lotsberg salt deposit), near Bruderheim, operate solution mines to produce sodium chlorate used mostly for pulp bleaching in the Prairie provinces and western Canada.

METHODS OF RECOVERY

The type of salt produced is a function of geology, geography and climate. Important rock salt deposits occur in central and eastern North America and Europe, as well as in large areas in the Middle East. Solar salt accounts for the bulk of production in Australia, Mexico, Chile, the western United States, China, India and Brazil where the climate is suitable.

Rock Salt Mining

Rock salt is mined by the room-and-pillar method, which is similar to that used in coal and trona mining. The pillar widths are controlled by the percentage of extraction permissible at the various depths and room widths. Most room-and-pillar operations recover about 45-65% of the resource, with the remainder left behind as pillar supports for the structural integrity of the mine. The salt is drilled, cut, blasted, mucked, crushed and transported to the surface for processing, which usually involves removing the impurities and screening the material to finer-size fractions. The mining of bedded deposits usually involves roof bolting haulageways and permanent work areas.

Underground mining practices for bedded halite (commonly referred to as "rock salt") and domal salt formations are similar except for the height differences within the mines of the two types of operations. For example, bedded formations usually are laterally extensive, but are vertically restricted. Salt domes are laterally restrictive, but are vertically extensive. Many salt domes have depths in excess of 6100 m (20 000 feet), yet many outcrop at the surface. Most Gulf Coast salt mining operations are generally less than 300 m (1000 feet) below the surface. Working at increasing depths is difficult because of higher temperatures and denser rocks.

Salt domes are large cylindrical bodies that have been thrust up from buried deposits of rock salt through underlying layers of sediments by static pressure. Salt domes have been penetrated during exploration drilling for oil in Germany, Russia, Romania, the Persian Gulf region, and in the Gulf Coast district of the United States where several hundred salt domes are known to exist. In Canada, salt domes are believed to exist on a few of the Arctic Islands.

The advantages of rock salt mining, when compared to solution or evaporation methods, are that rock salt can generally be produced at a lower cost, a wider range of sizes is possible, and the production rate is higher. The production size ranges from -16 mm to -3 mm. The chief disadvantage is the purity of salt produced, which varies from 95 to 98% NaCl.

Solution Mining

In solution mining, holes are drilled into deep salt deposits, an injection well is sunk, and pressurized freshwater is introduced to hydraulically fracture the bedded salt. Once communication with the production well is established, the brine is pumped to the surface for treatment. Solution mining can also use annulus injection, which introduces the solvent at the bottom of the tube. Every two years, a sonar log is performed to verify the cavity size and to correct any discrepancies with the simulated model. By controlling the quality of the water being injected into the well and the area being brined, the resultant brine is of the highest purity possible.

Solution mining is used to obtain a sodium chloride feedstock for vacuum pan salt production and for chlorine, caustic soda, and synthetic soda ash manufacture. The quantity of underground salt dissolved and recovered as brine to make vacuum pan salt usually is not reported. Only the quantity of vacuum pan salt manufactured is reported as primary salt production. The quantity of brine used to make chlor-alkali chemicals is reported as either the amount of captive brine used or brine sold. The chemical industry is the largest consumer of salt brine in the world.

Processing Rock Salt

Crushing and screening to the proper physical size is usually the only processing that road salt undergoes. In many operations, these steps are done underground in the mine to minimize haulage and storage costs. In addition, the extremely fine fraction, which often is unusable and would represent a waste product if brought to the surface, remains underground.

An exception to this procedure is the use of colour sorting and the thermo-adhesive process to upgrade bedded rock salt products from an average sodium chloride content of 97% to a product with a content higher than 99.0%. The colour sorter measures the translucence of salt and uses a jet of compressed air to separate salt from waste. The thermo-adhesive process depends on the absorption of light by dark-heated particles of anhydrite, shale and dolomite.

The purest grades of commercial salt are produced by the treatment of fine crystal, 1.7-mm rock salt in a recrystallizer. The fine granular rock salt is dissolved in high-temperature brine in the production of a very pure hot brine. The salt produced by the recrystallizer may be as pure as 99.99% NaCl. Salt is produced in the evaporator by flash evaporation and by cooling.

Standard means for producing granulated salt for human consumption is by either the enclosed vacuum pan or open-pan methods.

Solar Salt

Salt can be obtained from seawater along coastal margins and from landlocked bodies of natural saline water and artificial brines. Salt production uses the wind and the sun to evaporate the water, leaving behind relatively pure crystals of salt. Solar salt production is restricted to areas of the world that have high evaporation rates and low precipitation.

Mechanical Evaporation

Vacuum pan salt is not mined; it is a type of salt produced using mechanical evaporation technology. Although rock salt and salt brine may be used to make vacuum pan salt, virtually all domestic vacuum pan salt is obtained from solution mining underground salt formations. Vacuum pan salt is obtained by dehydrating brine using heat alone or in combination with a vacuum. The vacuum pan process conserves energy by utilizing multiple-effect evaporators connected to vacuum pumps. A saturated salt solution will boil at a higher temperature than pure water. When a vacuum is applied, the brine boils at a lower temperature, enabling the superheated vapour that is generated to act as the heating medium for the next evaporator.

The grainer or open-pan process uses open rectangular pans with steam-heated immersion coils to evaporate the water in the brine. Rotating rakes scrape the salt precipitate into a sump or up a ramp, depending on the method, and onto conveyors for debrining and drying treatment. The final product is usually flake-shaped rather than the typical cubic form. Flake salt is preferred for the production of cheese, butter and baked goods.

The Alberger process is a modified grainer operation that produces cubic salt with some flake salt. The pans are shallow, circular units with external heating units, rather than heating coils. The open-pan process cannot be oper-

ated successfully in regions with high humidity because the evaporation rate is too slow and more energy is required to evaporate the brine.

APPLICATIONS

The direct and indirect uses of salt number about 14 000, according to industry sources.

Aside from the different types of salt, there are various distinctions in the packaging and applications of salt. Salt for human consumption is packaged in different-sized containers for several specialized purposes. Table salt may contain 0.01% potassium iodide as an additive, which provides a source of iodine that is essential to the oxidation processes in the body. Kosher salt, sea salt, condiment salt and salt tablets are special varieties of salt.

Water conditioning salt and animal feed salt are made into 22.7-kg (50-lb) pressed blocks, among other sizes. Sulphur, iodine, trace elements and vitamins are occasionally added to salt blocks to provide nutrients not found naturally in the diet of certain livestock. Salt is also compressed into pellets that are used for water conditioning.

Chemical Uses

Within the chemical industry, which is a heavy consumer, if not the largest consumer, of salt brine, the chlor-alkali sector remains the major consumer of salt for manufacturing chlorine, co-product sodium hydroxide, and synthetic soda ash. Salt is used as the primary raw material in chlorine manufacture because it is an inexpensive and widely available source of chlorine ions. Salt is also used as feedstock in chemical establishments that make sodium chlorate and metallic sodium, and in other downstream chemical operations. For example, in powdered soaps and detergents, salt is used as a bulking agent and as a coagulant for colloidal dispersion after saponification; in pharmaceuticals, salt is a chemical reagent and is used as the electrolyte in saline solutions.

Ice Control and Road Stabilization

The second largest or largest end use of salt (in the United States and Canada, respectively) is for highway de-icing. Applied to snow or ice, once melted, brine forms below the surface and prevents the water from freezing into ice and bonding with the road surface, thus causing the snow and ice to melt. Salt is an inexpensive, widely available and effective ice control agent. It does, however, become less effective as the temperature decreases below about -9.5 to -6.5^{o}C (15 to 20^{o}F). At lower temperatures, more salt would have to be applied to maintain a higher brine concentration in order to provide the same degree of melting.

Salt is also added to stabilize the soil and to provide firmness to the foundation on which highways are built, particularly for stabilizing clay and sand and gravel aggregate used in the base of primary roads and the surface of secondary roads. The finer grades of salt generally are used in most road-stabilizing programs. The salt acts to minimize the effects of shifting caused in the subsurface by changes in humidity and traffic load.

Distributors

A tremendous amount of salt is marketed through various distributors, some of which specialize in markets such as agricultural and water treatment services, two sectors where the salt companies also have direct sales.

General Industrial Uses

The industrial uses of salt are diverse. They include, in descending order, oil and gas exploration, other industrial applications, textiles and dyeing, metal processing, pulp and paper, tanning and leather treatment, and rubber manufacture.

In oil and gas exploration, salt is an important component of drilling fluids in well drilling. It is used to flocculate and increase the density of the drilling fluid to overcome high down-well gas pressures. Wherever a drill hits a salt formation, salt is added to the drilling fluid to saturate the solution and to minimize the dissolution within the salt stratum. Salt is also used to increase the set rate of concrete.

In textiles and dyeing, salt is used as a brine rinse to separate organic contaminants, to promote “salting out” of dyestuff precipitates, and to blend with concentrated dyes to standardize them. One of its main roles is to provide the positive ion charge to promote the absorption of negatively charged ions of dyes.

In metal processing, salt is used in concentrating uranium ore into uranium oxide (yellow cake). It is also used in processing aluminum, beryllium, copper, steel and vanadium.

In the pulp and paper industry, salt is used to bleach wood pulp. It is also used to make sodium chlorate, which is added along with sulphuric acid and water to manufacture chlorine dioxide, an excellent oxygen-based bleaching chemical.

In tanning and leather treatment, salt is added to animal hides to inhibit microbial activity on the underside of the hides and to replace some of the moisture in the hides.

In rubber manufacture, salt is used to make styrene-butadiene rubber, neoprene, and white types. Salt brine and sulphuric acid are used to coagulate and emulsify latex made from chlorinated butadienne.

Agricultural Industry

Wild animals satisfy their salt hunger by locating salt springs, salt licks, or playa lake salt crusts. Barnyard and grazing livestock need supplementary salt rations to maintain proper nutrition. Veterinarians advocate adding loose salt in commercially mixed feed or in block forms sold to farmers and ranchers because salt acts as an excellent carrier for trace elements not found in the vegetation consumed by grazing livestock; selenium, sulphur and other essential elements are commonly added to salt licks or salt blocks for free-choice feeding.

Food Processing

Every person uses some quantity of salt in their food. The salt is added to the food by the food processor or by the consumer through free choice as a flavour enhancer, preservative, binder, fermentation-control additive, texture-control agent, and colour developer. This major category is subdivided, in descending order of salt consumption, into other food-processing categories such as meat packing, canning, baking, dairy, and grain mill products.

In meat packing, salt is added to processed meats to promote colour development in bacon, ham and other processed meat products. As a preservative, salt inhibits the growth of bacteria that would lead to spoilage of the product. Salt acts as a binder in sausage to form a binding gel composed of meat, fat and moisture. Salt also acts as a flavour enhancer and a tenderizer.

In the dairy industry, salt is added to cheese as a fermentation-control agent and as a colour- and texture-control agent. The dairy sub-sector includes companies that manufacture creamery butter, natural and processed cheese, condensed and evaporated milk, ice cream, frozen desserts, and specialty dairy products.

In canning, salt is primarily added as a flavour enhancer and preservative. It is also used as a dehydrating agent, tenderizer, enzyme inhibitor, and carrier for other ingredients.

In baking, salt is added to control the rate of fermentation in bread dough. It is also used to strengthen the gluten (the ergastic protein-water complex in certain doughs) and as a flavour enhancer, such as a topping on baked goods.

The food-processing category also contains grain mill products, which consist of milling flour and rice, and manufacturing cereal breakfast food and blended or prepared flour.

In the "other food processing" category, salt is used mainly as a seasoning agent. Other food processing includes miscellaneous establishments that make food for human consumption (such as potato chips and pretzels) and for domestic pet consumption (such as cat and dog food).

Water Treatment

Many areas have hard water, which contains excessive calcium and magnesium ions that contribute to the build-up of a scale or film of alkaline mineral deposits in household and industrial equipment. Commercial and residential water-softening units use salt to remove the ions that cause the hardness. The sodium ions captured on a resin bed are exchanged for the calcium and magnesium ions. Periodically, the water-softening units must be recharged because the sodium ions become depleted. Salt is added and dissolved, and the brine replenishes the lost sodium ions.

PRICES

Salt has unique production, processing and packaging factors that determine its selling price. The price of salt depends on the type of salt, location, product form, and type of sale. Generally, salt sold in bulk is less expensive than salt that has been packaged, pelletized or pressed into blocks. Salt in brine is the least expensive salt sold because mining and processing costs are less. Vacuum pan salt is the most expensive because of the higher energy costs involved in processing it and the purity of the product.

Due to the unavailability of prices from Canada's salt industry, the following price examples from other sources are provided. The July 2005 edition of *Industrial Minerals* (IM) magazine reported that salt prices (ground rock salt, 15-20 short ton lots, average price delivered U.K.) were in the range of £20-£30 (converted: C$50.09-$75.14). As a basis of comparison (source: USGS) for the North American market, 2002 average prices (net selling value, free on board plant, excluding container costs, U.S. dollars per tonne) are as follows: bulk (vacuum pan and open pans, $58.12; rock, $20.10; brine, $5.89); compressed pellets (vacuum pan and open pans, $134.61; rock, n.a.; brine, n.a.); packaged (vacuum pan and open pans, $135.39; rock, $70.62; brine, n.a.); and pressed blocks (vacuum pan and open pans, $107.18; rock, $101.81; brine, n.a.).

Canadian producers and others are well aware of the globalization factor affecting prices. A slight difference in price can result in usual orders made in previous years being lost to a foreign competitor.

HEALTH/ENVIRONMENTAL ISSUES

Health Concerns

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 legislation for working environments.

Each human being contains about 113 grams of salt and, unless we get enough of it in our diet, our muscles won't contract, our blood won't circulate, our food won't digest and our hearts won't beat. Therefore, reasonable consumption of salt is good for human health. Although dietary intake can vary for people from various countries, on average, an adult's total salt intake should be no more than six grams per day and a child's no more than four grams. But the average person's diet incorporates at least nine grams per day. Dietary sodium is measured in milligrams (mg). The most common form of sodium used is table salt, which is 40% sodium. One teaspoon of table salt contains 2300 mg of sodium.

As mentioned above in the section on food processing, salt is added for many applications. Food packaging labels only state part of the amount of sodium in food. This only makes up part of the total salt content as salt contains both sodium and chloride. Sodium is shown in fractions per 100 g of food. You need to multiply the amount of sodium per 100 g by two and a half in order to get the total salt content. In other words, one gram of sodium is the same as two and a half grams of salt. Health and heart organizations recommend that people should aim to get their salt intake to less than five grams per day, which is two grams of sodium. This is the same as about a teaspoonful. As a simple guide, people should avoid consuming on a regular basis foods with a packaging content that contains more than 0.2 g of sodium per 100 g, and choose ones that contain less than 0.1 g of sodium per 100 g.

Environmental Concerns

The effects of salt-spreading on the environment depend on a variety of factors such as weather conditions, road characteristics, traffic loads, winter maintenance methods, and local topography. Environmental effects may include adverse impacts on plant growth and crop productivity in the immediate vicinity of highways, as well as higher salinity levels in streams and groundwater systems. Because of its low price, de-icing salt is the favoured de-icing agent. The optimization of spreading rates, in combination with the search for adequate abrasive mixtures, will continue to be evaluated. For many years, provincial/territorial and regional agencies in charge of road maintenance have pursued the objective of optimizing the use and selection of ice and snow control methods. Cost, operational reliability, public safety, and environmental issues must be considered, and these agencies will continue to evaluate improvements to existing methods and better road safety and rideability.

Although the benefits of de-icing agents were recognized by the Environment Minister's Expert Advisory Panel on the Second Priority Substances List, the Panel recommended that they be assessed for potential impact on the environment but that "any measures developed as a result of the assessment must never compromise human safety." The overall conclusion of Environment Canada's *Canadian Environmental Protection Act, 1999* (CEPA 1999) report entitled *Priority Substances List Assessment Report – Road Salts* is as follows: "Based on the available data . . . road salts that contain inorganic chloride salts with or without ferrocyanide salts be considered 'CEPA toxic' . . . as defined under paragraphs 64(a) and (b) of CEPA 1999."

A working group that includes representatives of governments, industry and environmental groups met three times in 2002 to discuss best practices for the application and storage and disposal of road salt, and to develop a guideline under CEPA 1999. In April 2004, Environment Canada issued a *Code of Practice for the Environmental Management of Road Salts*. The Code applies to any organization that uses more than 500 t of road salts per year. These organizations have to prepare and implement a salt management plan that contains best management practices to protect the environment from the negative impacts of road salts. Environment Canada will review the effectiveness of the Code after five years and decide whether further steps are needed to protect the environment. The salt industry hopes that the Code is effective and that Environment Canada does not act on a recommendation that road salts be added to Canada's list of toxic substances.

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

TARIFFS

Item No.	Description	Canada MFN	Canada GPT	Canada USA	United States Canada
2501.00	Salt (including table salt and denatured salt) and pure sodium chloride, whether or not in aqueous solution or containing added anti-caking or free-flowing agents; sea water				
2501.00.10	Table salt made by an admixture of other ingredients when containing 90% or more of pure sodium chloride	2.5%	Free	Free	Free
2501.00.90	Other	Free	Free	Free	Free

Sources: Canadian *Customs Tariff*, effective January 2005, Canada Border Services Agency; *Harmonized Tariff Schedule of the United States*, 2005.

TABLE 1. CANADA, SALT SHIPMENTS AND TRADE, 2002-04

Item No.		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
SHIPMENTS							
	By type						
	Fine vacuum salt	870 370	89 229	905 096	93 790	912 056	92 491
	Mined rock salt	10 581 246	319 078	11 739 364	317 302	12 049 387	328 829
	Salt content of brines used or shipped	1 284 861	10 947	1 073 362	9 465	1 163 242	10 197
	Total	12 736 477	419 254	13 717 822	420 557	14 124 685	431 517
	By province						
	Nova Scotia	x	x	x	x	x	x
	New Brunswick	x	x	x	x	x	x
	Quebec	x	x	x	x	x	x
	Ontario	7 630 364	262 429	8 697 031	253 479	8 646 411	258 401
	Manitoba	x	x	x	x	x	x
	Saskatchewan	914 558	39 642	1 159 976	48 180	1 283 242	47 559
	Alberta	1 323 683	20 207	1 088 959	19 063	1 196 581	22 064
	Total	12 736 477	419 254	13 717 822	420 557	14 124 685	431 517
EXPORTS (1)							
2501.00	Salt and pure sodium chloride whether or not in aqueous solution or containing added anti-caking or free-flowing agents; sea water						
	United States	3 663 957	96 197	4 186 836	124 649	4 242 994	83 101
	Barbados	23 036	46	1 497	112	1 037	131
	France	583	59	229	30	989	127
	Saint Pierre and Miquelon	365	30	813	100	524	71
	Saint Kitts and Nevis	250	20	1 027	16	253	27
	South Korea	200	5	970	20	892	22
	Senegal	–	–	282	6	202	13
	Costa Rica	233	91	306	108	37	6
	Jamaica	60	17	–	–	41	6
	Spain	24	4	1 183	23	22	3
	Antigua and Barbuda	–	–	22	2	21	3
	Taiwan	–	–	–	–	200	3
	Trinidad and Tobago	21	2	69	10	21	2
	Greenland	–	–	–	–	80	2
	Bermuda	–	–	–	–	2	1
	United Kingdom	1	...	21	3	9	1
	Tanzania, United Republic of	–	–	–	–	1	...
	Suriname	–	–	–	–	1	...
	Malta	–	–	–	–	1	...
	Brazil	–	–	–	–	..	...
	Germany	14	2	126	11	1	...
	French Southern Territories	–	–	–	–	1	...
	Panama	–	–	4	...	1	...
	Israel	1	...	2	...	1	...
	Colombia	–	–	2	...	2	...
	Greece	–	–	43	7	1	...
	Guatemala	–	–	2	...	2	...
	Uruguay	–	–	–	–	..	...
	Netherlands Antilles	2	...	–	–	..	...
	Anguilla	–	–	–	–	..	...
	Argentina	–	–	–	–	..	...
	Haiti	–	–	–	–	1	...

TABLE 1 (cont'd)

Item No.		2002		2003		2004 (p)	
		(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
EXPORTS (cont'd)							
	New Zealand	–	–	–	–	2	...
	Kuwait	–	–	..	...	–	–
	Macau	–	–	5	1	–	–
	Malaysia	–	–	542	37	–	–
	Ireland	–	–	35	5	–	–
	Poland	–	–	12	...	–	–
	Portugal	–	–	1	...	–	–
	Saudi Arabia	–	–	3	...	–	–
	Honduras	–	–	2 476	137	–	–
	Vietnam	–	–	3	4	–	–
	Chile	–	–	6	...	–	–
	South Africa	17	3	69	11	–	–
	Saint Lucia	200	4	99	10	–	–
	Japan	6	...	12	...	–	–
	Hong Kong	364	90	10	7	–	–
	Dominican Republic	213	42	1	...	–	–
	Switzerland	–	–	24	4	–	–
	Cuba	60	1	6	2	–	–
	China	192	4	–	–	–	–
	Total	3 689 799	96 617	4 196 738	125 315	4 247 339	83 519
	Total exports	3 689 799	96 617	4 196 738	125 315	4 247 339	83 519
IMPORTS (1)							
2501.00	Salt						
	United States	641 655	32 380	615 985	32 160	1 622 230	40 228
	Mexico	436 173	8 294	235 498	4 969	405 913	6 321
	France	8 286	899	12 219	1 204	27 634	1 327
	Bahamas	25 432	664	5 250	165	22 467	584
	Ireland	4 829	349	3 939	437	4 299	394
	Israel	700	91	1 208	146	1 636	208
	Greece	1 233	156	2 031	218	1 382	201
	China	2 754	242	482	46	16 198	199
	South Korea	1 248	124	1 031	131	1 403	174
	Germany	927	67	2 832	179	5 925	163
	Belgium	191	27	1 338	175	12 503	132
	Italy	610	54	567	70	2 218	112
	Portugal	746	74	583	75	2 130	98
	United Kingdom	617	57	731	79	2 245	95
	Austria	758	97	912	57	10 639	91
	Pakistan	176	11	425	31	1 064	84
	India	661	25	472	46	772	63
	South Africa	204	25	842	90	293	45
	Australia	10	1	30	3	232	41
	New Zealand	212	13	87	13	246	40
	Brazil	254	29	1 006	104	300	31
	Canada	324	19	3	...	368	22
	Spain	124	26	321	31	16	21
	Japan	1 364	118	622	69	171	17
	Niger	–	–	–	–	7	15
	Netherlands	232	41	284	44	77	13
	Slovenia	19	9	23	11	26	10
	Madagascar	–	–	–	–	168	8
	Greenland	–	–	–	–	292	8
	Hong Kong	39	5	58	5	485	7
	Taiwan	54	7	23	4	388	7
	Jordan	1	...	40	3	12	5
	Singapore	–	–	–	–	60	4
	Thailand	8	1	30	4	3	3
	Switzerland	254	20	363	46	2 878	3
	Nepal	–	–	181	2	119	3
	Poland	105	9	96	7	71	2
	Turkey	1	...	27	2	2	1
	Iceland	–	–	–	–	..	1
	Croatia	–	–	6	1	3	1
	Papua New Guinea	–	–	–	–	1	1
	Indonesia	11	1	–	–	150	1
	Serbia and Montenegro	3	1	–	–	1	1
	Argentina	–	–	...	...	1	1
	Trinidad and Tobago	–	–	–	–	...	...
	El Salvador	–	–	–	–	1	...
	Ghana	–	–	–	–	..	...
	Jamaica	–	–	–	–	1	...
	Vietnam	2	...	2	...	3	1
	Chile	246 152	7 333	76 267	2 514	1	...

TABLE 1 (cont'd)

Item No.	2002		2003		2004 (p)	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
IMPORTS (cont'd)						
Czech Republic	4	. . .	3	. . .	. .	. . .
Macau	–	–	–	–	. . .	. . .
Guatemala	–	–	. . .	. . .	3	. . .
Sri Lanka	6	1	55	3	2	. . .
Cuba	–	–	–	–	3	. . .
Finland	3	. . .	7	1	. .	. . .
Paraguay	–	–	–	–	1	. . .
Philippines	–	–	–	–	. . .	. . .
Bahrain	–	–	1	. . .	–	–
Bosnia-Herzegovina	–	–	2	. . .	–	–
British Virgin Islands	–	–	5 500	150	–	–
Bulgaria	–	–	89	16	–	–
Iran	19	2	–	–	–	–
Sweden	57	2	4	. . .	–	–
Haiti	–	–	1	. . .	–	–
Lebanon	–	–	7	2	–	–
Malaysia	–	–	2	. . .	–	–
Romania	4	1	–	–	–	–
Panama	3	1	–	–	–	–
Norway	16	2	53	6	–	–
Nigeria	1	. . .	–	–	–	–
Morocco	2	. . .	–	–	–	–
Kenya	1	. . .	–	–	–	–
Egypt	3	. . .	1	. . .	–	–
Denmark	54	6	46	5	–	–
Barbados	2	. . .	-	–	–	–
Russia	4	. . .	5	1	–	–
Total	1 376 548	51 284	971 590	43 325	2 147 043	50 787
Total imports	1 376 548	51 284	971 590	43 325	2 147 043	50 787
By province or territory of clearance						
Newfoundland and Labrador	92 336	1 877	25 624	662	15 467	485
Prince Edward Island	–	–	–	–	–	–
Nova Scotia	7 041	124	5 603	161	7 002	103
New Brunswick	3 016	290	904	95	323	14
Quebec	269 084	9 051	90 785	5 129	88 179	3 489
Ontario	465 421	25 108	546 478	27 939	1 482 498	34 637
Manitoba	10 052	803	5 523	638	5 688	628
Saskatchewan	1 987	444	2 527	327	4 634	310
Alberta	7 905	748	12 439	923	11 489	1 193
British Columbia	519 709	12 842	281 705	7 450	531 763	9 923
Yukon	–	–	–	–	–	–
Northwest Territories	–	–	–	–	–	–
Nunavut	–	–	–	–	–	–
Total	1 376 550	51 287	971 589	43 324	2 147 043	50 783

Sources: Natural Resources Canada; Statistics Canada.

– Nil; . . Not available; . . . Amount too small to be expressed; (p) Preliminary; x Confidential.
(1) Includes table salt, pure sodium chloride and seawater salt.
Note: Numbers may not add to totals due to rounding.

TABLE 2. CANADA, SALT SHIPMENTS AND TRADE, 1988-2004

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
	(tonnes)					
1988	7 126 762	783 368	2 777 050	10 687 180	1 202 220	3 030 124
1989	7 548 732	821 284	2 788 395	11 158 411	2 360 433	2 137 321
1990	7 704 499	778 428	2 708 458	11 191 385	2 095 324	1 897 816
1991	8 615 755	799 563	2 455 541	11 870 859	1 202 879	2 783 021
1992	7 912 989	770 370	2 404 667	11 088 026	1 041 424	2 650 921
1993	8 073 435	817 859	2 101 711	10 993 005	1 051 029	3 079 298
1994	9 446 002	822 181	1 975 704	12 243 887	940 130	3 638 674
1995	8 077 661	850 676	2 029 047	10 957 384	1 294 994	2 986 802
1996	9 499 189	853 858	1 895 430	12 248 477	1 137 603	3 816 788
1997	10 923 966	863 112	1 709 778	13 496 856	1 262 836	3 634 009
1998	10 517 641	834 944	1 681 710	13 034 295	977 943	4 177 880
1999	10 004 167	823 983	1 857 745	12 685 895	1 375 143	3 808 093
2000	9 458 260	827 630	1 878 179	12 164 069	1 141 063	3 475 755
2001	11 528 499	844 719	1 351 761	13 724 979	1 644 424	4 616 739
2002	10 581 246	870 370	1 284 861	12 736 477	1 376 550	3 689 799
2003	11 739 364	905 096	1 073 362	13 717 822	971 589	4 196 738
2004 (p)	12 049 387	912 056	1 163 242	14 124 685	2 147 043	4 247 339

Sources: Natural Resources Canada; Statistics Canada.
(p) Preliminary.

TABLE 3. WORLD SALT PRODUCTION, 1996-2003

	1996	1997	1998	1999	2000 (r)	2001 (r)	2002	2003 (e)
	(000 tonnes)							
United States (1)	42 300	41 500	41 300	45 000	45 600	44 800	40 300	43 655
China	29 035	30 830	22 420	28 124	31 280	34 105	32 835	32 424
Germany	15 907	15 787	15 700	15 700	15 700	15 700	15 700	15 700
India	14 466	14 251	11 964	14 453	14 453	14 503	14 503	15 003
Canada (2)	12 248	13 264	13 296	12 686	12 164	13 725	12 736	13 350
Australia	7 905	8 801	(r) 9 033	(r) 9 888	8 778	9 536	9 887	9 800
Mexico	8 508	7 933	8 412	8 236	8 884	8 501	8 500	8 000
France	7 860	7 085	7 000	7 000	7 000	7 000	7 000	7 000
Brazil	5 384	6 516	6 837	5 958	6 074	5 578	5 600	6 100
United Kingdom	6 610	6 600	6 600	5 800	5 800	5 800	5 800	5 800
Poland	4 163	3 859	4 005	4 212	4 307	4 200	4 200	1 500
Italy	3 541	3 510	3 600	3 600	3 600	3 600	3 600	3 600
Spain	4 000	4 000	3 500	3 200	3 200	3 200	3 200	3 200
Russia	2 100	2 100	2 200	3 200	3 200	2 800	2 800	2 800
Ukraine	2 800	2 500	2 500	2 185	2 287	2 300	2 300	2 300
Other countries	37 173	38 464	41 787	(r) 40753	39 673	41 652	41 039	39 768
Total	204 000	207 000	200 000	(r) 207 000	209 000	214 000	208 000	210 000

Sources: Natural Resources Canada; U.S. Geological Survey.
(e) Estimated; (r) Revised.
(1) Excludes Puerto Rico. (2) The U.S. Geological Survey is the source for all data, excluding data for Canada, for which the source is Natural Resources Canada.
Note: Numbers may not add to totals due to rounding.

TABLE 4. CANADIAN SALT PRODUCERS, 2004

Company	Location/ Initial Production	Mill/Plant Capacity	Remarks
		(t/y)	
ERCO Worldwide	Haegrave Facility, Man./2002	65	Brining to produce sodium chlorate
	Bruderheim, Alta./1991	129	Brining to produce sodium chlorate (salt brine)
Nexen Chemicals Canada Limited Partnership	Bruderheim, Alta./1991	100	Brining to produce sodium chlorate (salt brine)
Canadian Salt Company Limited, The	Pugwash, N.S./1959		Rock salt
	Pugwash, N.S./1963	7 800	Brine made from mined rock salt used to produce fine evaporated salt (rock salt)
	Mine Seleine, Iles-de-la-Madeleine, Que./1982	4 800	Rock salt
	Ojibway, Ont./1955	10 300	Salt graded and prepared for markets (rock salt)
	Windsor, Ont./1892	710	Evaporated salt
	Belle-Plaine, Sask./1969	650	Plant uses sodium chloride brines produced at the nearby potash solution mine of IMC Potash Belle Plaine (evaporated salt)
	Lindbergh, Alta./1968	400	Produces coarse and fine salt (evaporated salt)
Dow Chemical Canada Inc.	Fort Saskatchewan, Alta/1967	3 500	Brining to produce caustic soda and chlorine (salt brine)
The Mosaic Company (an amalgamation of IMC Global Inc. and Cargill Crop Nutrition)	K1 & K2 mines, Esterhazy, Sask./1962	180	By-product rock salt from potash mine (standard, coarse and granular grades)
NSC Minerals Inc.	Rocanville, Sask./1990	200	Produces coarse and fine products (rock salt)
	Vanscoy, Sask./1988	300	Produces coarse and fine products (rock salt)
Potash Corporation of Saskatchewan Inc., New Brunswick Division	Sussex, N.B./1983	700	Three grades of potassium muriate (KCl) are produced from a flotation circuit and a crystallizer circuit (salt)
Sterling Pulp Chemicals (Sask) Ltd.	Saskatoon, Sask./1979	130	Primarily a manufacturer of pulp and water treatment chemicals; brining to produce caustic soda, chlorine and sodium chlorate
Sifto Canada Inc.	Amherst, N.S./1947	310	Brining for vacuum pan evaporation (evaporated salt)
	Goderich, Ont./1959	26 000	Rock salt mining
	Goderich, Ont./1872	500	Brining for vacuum pan evaporation (evaporated salt)
	Unity, Sask./1949	408	Brining for vacuum pan evaporation (evaporated salt)
Esterhazy Salt Operations	Kayway Salt, Sask.	1 320	Rock salt

Sources: Natural Resources Canada; company surveys.