

**Nourishing the Crops of the World:
Saskatchewan's Potash Industry**

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Saskatchewan is famous for its seemingly endless vistas of grain crops and its iconic grain elevators, the “sentinels on the prairies”. But there is something more! Something hidden! Something really ancient! Most of us go about our daily lives on the surface of the planet, oblivious to what’s happening far underground. More than a kilometre below the swaying fields of grain lie the largest and richest proven deposits of potash ore in the world!

Saskatchewan is the world’s largest producer and exporter of potash and will continue to be so for the next century. Our ten active potash mines in the south east and south central areas of the province produce about 90% of the potash mined in Canada and about 30% of the world's supply. About 90% of Saskatchewan’s potash production is used around the world as one of the three major nutrients in fertilizer, plant food which is critical in feeding the people of the planet, particularly in such places as China, India and many Third World countries.

1. What is Potash?

The huge potash deposits hidden more than 1000 metres beneath Saskatchewan’s prairie were left there when the middle Devonian inland sea, which once covered this area, evaporated between 350 and 400 million years ago. This was the time when fish began to crawl out onto the land for the first time. The repeated layering of dissolved minerals over this time left three major flattish layers of economically recoverable potash ore. These layers of “evaporite” salts contain about 4.5 billion tonnes of potassium chloride in a 280 kilometre long band. Called the Prairie Formation, the zone is as wide as 30 km in some places, and runs diagonally with a gentle slope down to the southwest. In the Esterhazy area, the deposits are about 1000 m. below the surface. At Belle Plaine, they are at about 1,600 m. Down in North Dakota and Montana the potash is at a depth of some 3000 metres.

The name “potash” refers to several forms of common salts containing potassium (K), the most important form being potassium chloride (KCl), the mineral sylvite. Sylvite is Saskatchewan’s official provincial mineral. The amount of potassium in a salt varies from mine to mine and may even vary within a single mine. Its greatest use is as a fertilizer, used in combination with nitrogen and phosphate to increase the yields of important crops.

In the ground, potash ore looks like a mixture of red and white crystals with traces of clay and other impurities. It is a soft, crumbly mineral, and it has a silvery look when freshly exposed. After processing, it is white in its pure form. Some impurities give it a pink colour.

2. A Brief History of Potash

An Old Technology

Potassium was used as fertilizer as early as the third century BC, in the form of manure and ashes. Of course, the Romans did not realize that it was potassium: they just knew these materials made their plants flourish: Here in Canada, First Nations people were burying wood ash and dead fish with their corn seed when the first European settlers arrived.

Potash got its name in Europe where there was a long tradition of burning wood or seaweed and leaching the ashes in water. Then the solution was evaporated in large iron pots. What was left was a hard, white residue called “pot ash”.¹ In 1806, the British scientist Sir Humphrey Davy isolated the essential element by sending an electric current through pot ash. It decomposed into little silvery globules which he called “potassium”.

During the 18th and 19th centuries, a great deal of potash was exported from North America to England, derived particularly from kelp harvested along the sea coasts. Then, from the mid-19th century, German potash supplied the world until the export was interrupted by the First World War. The need for new supplies stimulated exploration for potash in North America. The discovery of deposits at Carlsbad, New Mexico, in the 1920s meant that commercial supplies were now available on this continent. Exploration for this important resource grew in Canada as well², particularly in Saskatchewan. A growing world population, the heavy consumption of minerals occurring naturally in soils and advanced farming practices made the demand for potash higher than ever.

Potash Discoveries in Saskatchewan

The spectacular success of potash mining in Saskatchewan is a result of determination in the face of many difficulties. Potash was originally discovered in Saskatchewan in 1943. During war-time oil exploration, a core sample from an exploratory well south of Regina, at Radville, showed potash at a depth of almost two kilometres. This was far too deep to consider mining for commercial production.

The fledgling industry was encouraged three years later when a core sample from an exploratory well near Unity revealed high-grade potash at a depth of about one kilometre. The discovery of ore at a more accessible depth stimulated both government and industry and exploration surged ahead. Soon it was discovered that there were almost unbelievably huge deposits beneath southern Saskatchewan. All that had to be done now was to get the ore out of the ground!

The year 1951 saw the first attempt to mine potash in the province. Flooding made it impossible, and the mine was finally abandoned. In 1957, in the lower Qu’Appelle Valley, a ninety metre deep mine shaft was begun at the Esterhazy K-1 mine by International Minerals & Chemical Corporation (IMC). Problems with flooding were countered by **innovative engineering pioneered in Saskatchewan**, to prevent sand and water from breaking through into the mine.³ There was considerable optimism that the mine would usher in a new era of economic diversity

¹It is interesting to note that the first United States patent, Patent No. 1X, issued in 1790, was for a method of producing potash. (Patent Station 2003)

²In Canada until the 1940s, many fertilizers were manufactured from packing house by-products such as bone and blood. Canada’s first modern fertilizer facility, producing ammonium phosphate, was built in British Columbia by Cominco (now Agrium) in 1931. Then, just after the Second World War, the eastern Canadian chemical company, Cyanamid, and Cominco converted their ammonium nitrate plants from war-time explosives production into fertilizer plants, and began supplying **the world’s first** ammonia-based modern nitrogen fertilizers.

³See Appendix. The Blairmore Ring.

and prosperity to the province, as this newspaper article from the time illustrates.

Welcoming the future industry and its executive officers to Saskatchewan, Premier T. C. Douglas told the gathering that the new \$20,000,000 plant and industry would increase the province's wealth production and employment potential and add a new notch to the diversification of industry which in the past was relegated solely to agriculture. (Leader Post 1957)

Potash production began in the province in 1962 and has not faltered since.

Flooding was a serious problem in many areas and caused several mines to close down. For example, a mine near Saskatoon, opened by the Potash Company of America (now part of Potash Corporation of Saskatchewan or PCS), began production in 1958 but had to close within a year. Frustrated but undaunted, the industry continued to invest. Another mining operation went into production in 1964; a second Esterhazy shaft (K-2) was completed in 1967 and connected underground to K-1; three more operations started up in 1968. By 1974, 10 potash mines were operating in Saskatchewan with a total annual production capacity of nearly 13 million tonnes of potassium chloride.

Today's Potash Industry in Saskatchewan

Unfortunately, this spectacular achievement in the 1970s created its own problems for the industry. There were not enough markets for all the potash produced. Prices and sales volumes plummeted. The new industry was in serious trouble. To try to save it, the Saskatchewan government instituted a series of measures for more orderly potash production and marketing. Canpotex, a potash export association, was created to develop new offshore markets and improve transportation efficiencies and economies of scale in the industry. The crown corporation Potash Corporation of Saskatchewan (PCS) was formed. It was privatized in 1989. By 1971, the 10 potash mines operating at present were all in production.

The relationship between government and business has evolved over the years, while the industry has grown and thrived, and efficiencies and profits have increased. In the 1980s, potash outpaced oil and natural gas as Saskatchewan's most valuable resource. Reduced from the twelve original member companies, Canpotex is now owned by three world class fertilizer companies (Agrium Inc., IMC Kalium Canada Ltd., and PCS) and markets all their offshore sales. PCS and Agrium are among the largest fertilizer producers in the world.

Six of Saskatchewan's ten mines operate near Saskatoon. They mine the upper potash layer, known as the Patience Lake member. In the south, three are operating in the lower potash layer, known as the Esterhazy member. A solution mine just outside of Regina is the only mine operating in the Belle Plaine member, at depths of about 1,600 metres.⁴ Saskatchewan produced about 9 million metric tons of K₂O in 2000, about 33% of world production and 33% of world

⁴Saskatoon area mines: Vanscoy (Agrium), Patience Lake (PCS), Lanigan (PCS), Cory (PCS), Allan (PCS), Colonsay (IMC Kalium). Esterhazy area mines: Rocanville (PCS), Esterhazy (PCS), Esterhazy (IMC Kalium). Regina area mine: Belle Plaine (IMC Kalium).

capacity. Potash mining directly employs over 3,300 people in Saskatchewan. The industry contributes \$6 billion each year to the Canadian economy and has kept Saskatchewan front and centre on the world mining map.

3. What is Potash Used For?

Almost all of the world's potash production is used as agricultural fertilizer. Potash, the workhorse of plant nutrition, is important around the world in helping to feed a rapidly expanding population that must grow its food on diminishing amounts of arable land. Many of the world's major crops are being fed with Saskatchewan potash, including corn, soybeans, coffee, rice and potatoes. Potassium helps plants resist disease, increases tolerance to water stress and crop pests, promotes winter hardiness, and increases efficient use of nutrients as well as yield and quantity, particularly for cereals. Other potash fertilizers are "specialty" fertilizers, such as potassium sulphate used mostly for crops such as tobacco.

About five per cent of the world's potash is used in industrial and commercial products. Caustic potash⁵ is used to manufacture soap, detergent, glass, liquid fertilizers, ceramics, textiles, dyes, alkaline batteries, chemicals and drugs. Salt separated from the potash is used for various products. High grade potash is used as a salt substitute in low-salt diets. As well, potash has several industrial applications in forestry fertilization, as a feed supplement and as a cleaning flux in aluminum recycling.

4. Why Saskatchewan Potash?

Exceptional Quality

Potash ore is graded for marketing purposes according to several criteria⁶, including potassium oxide content. Saskatchewan's potash ore is exceptional for its high grade (25 to 30 % K₂O)⁷, the thickness of its deposits (2.5 to 3.5 m), its uniformity of mineralization, and the absence of structural deformation in the deposits, which makes them relatively safe. An average Saskatchewan ore may have 42% KCl, 53% NaCl and 5% clay, making it by far the world's highest grade potash ore currently being mined. (Potash and Phosphate Institute of Canada 2002)

⁵Potassium hydroxide (KOH), otherwise known as caustic potash, is produced by the electrolysis of potassium chloride and is used in making soaps, detergents, potassium carbonate and other potassium chemicals. Saskatoon's OxyChem is the **world's largest producer of liquid caustic potash** (LKO). During electrolysis, the mineral is melted and an electric current is passed through it to separate into potassium and chlorine gas.

⁶Potash grading comprises five categories: 1. *K₂O content* (potassium oxide). Potash products typically guarantee a minimum K₂O content. Industrial products are usually higher in K₂O content than agricultural products, and lower in other trace elements. 2. *Colour*. Agricultural products range from deep red, to pink, to white. Industrial grades are typically white only. 3. *Sodium chloride (NaCl) and Trace Elements* (sodium chloride, salt, bromine, magnesium). The content of these elements are important depending on the ultimate use of the product. 4. *Sizing*. Sizing is often the most stringent measure for agricultural customers as it is important for bulk blending purposes. The SGN sizing as it is known today was an **initiative of the Canadian industry**. 5. *Use of Reagents* (treated/untreated). (Dechka 1998)

⁷.Potassium chloride: KCl; Sodium chloride (NaCl); Potassium oxide: K₂O

Competitive Advantage

The extent and quality of our potash ore reserves put Saskatchewan at an advantage, making it possible to mine at production cost levels widely considered to be the lowest in the world. The high-grade ore lies in quite flat beds, allowing the use of highly efficient mining techniques. Oversupply is the main difficulty faced by producers. Thus production is trimmed to match potential sales. At the same time, under the right market conditions, Saskatchewan's potash industry is poised to expand quickly to meet sudden demand. For example, IMC Kalium has announced an expansion of its capacity to produce more specialty grades over the next few years. (Potash and Phosphate institute of Canada 2002)

More Than One Hundred Years of Reserves

Proven reserves of potash in Saskatchewan are conservatively estimated to be enough to last over one hundred years at present rates of production, with current technology.

5. How is Potash Mined in Saskatchewan?

Eight of Saskatchewan's ten mines use conventional underground mining methods. Because the potash layers lie in nearly horizontal beds, excavation at a single level is possible. Two mines, however, use solution mining methods which allow extraction of the potash from deeper depths.

Conventional Mining

At conventional underground mines, for depths between 900 and 1100 m, a shaft about 5 m in diameter is constructed from the surface to take men and equipment underground in a cage.

Because potash has little strength under compression, it tends to flow or creep under the weight of the kilometre-plus thick overlying strata, making it potentially unsafe even in stable geological conditions. The size, shape and spacing of mine openings must be dictated by the structure of the beds. About 60% of the ore must be left in place to provide support during the mining operation. The room-and-pillar method of mining is used, in which "rooms" are mined out, leaving unmined "pillars" of a similar size in between. The size of the rooms can be quite large, as much as 20 m wide and 1500 m long, created by the removal of some 150,000 tonnes of ore.

Mines in less stable areas have developed a "stress relief system" to avoid roof collapse. Some mines in the Saskatoon district use a "chevron" pattern of many small rooms about 60 m long, 9 m wide, and 3.4 m high that are excavated on an angle from a single entry as a stress relief technique.

Huge electrically powered machines cut out the ore creating large tunnels. The potash being soft like common salt, the self-propelled mining machines with rotary blades can drive themselves into the orebody at rate of about 1 m every three minutes, cutting a tunnel up to about 8 m wide and 4 m high. At the Allan potash mine near Saskatoon there are approximately 830 km of tunnels. The 180 tonne machines known as "continuous miners" remove up to 900 tonnes of potash per hour. The broken ore is automatically transferred to the rear of the machine. Fans circulate fresh air down the shaft and through the passageways to deal with the pall of dust.

The ore is cut up by the machine blades and broken into smaller pieces. Then a portable conveyor transfers it to a main conveyor belt which takes it to the shaft, where it goes through an initial crushing process. Hoists lift the ore to the surface in 20 to 25 tonne lots, at speeds of over 1,000 m per minute. Once on the surface, the ore goes to a refinery for processing, storage and shipment.

Solution Mining

Saskatchewan has two operating solution mines. An orebody that is between about 1,300 and 2,000 m is too deep for conventional mining, because of the plasticity of the bed. A “solution” to this problem **developed right here in Saskatchewan** in 1964. This pioneering technique has now been adopted in other parts of the world.

In order to get the potash out of the ground at these extreme depths, several wells are drilled. Hot water, or sometimes a solution of sodium chloride (NaCl), is pumped down to the beds. There it dissolves the potassium salts, creating large underground cavities. The brines containing the potassium chloride (KCl) are pumped up to the surface for processing. There is a danger of ground collapse if cavities are not spaced well apart.

Solution mining is effective but expensive. The technique would be less costly than conventional mining, but for the energy needed for the extraction and the natural gas used in the recovery of the potash by evaporation. Overall, the costs are greater.

6. How is Potash Processed in Saskatchewan?

When the potash ore arrives on the surface from a conventional underground mine, it is dry crushed to a size of 3 to 5 mm and a salt brine is added. Next, it is “deslimed” by agitation in tanks, to wash the clay off the ore particles. It then passes through a flotation process.⁸ The finely ground ore is fed into cells containing water and chemical reagents. Air is then forced through the bottom of the cells. As the air bubbles rise, the potash clings to them, while other associated minerals such as common salt and clay fall to the bottom of the cells. These are drawn off. The bubbly froth containing the potassium is skimmed off the cells, any brine remaining removed by centrifuging, and the left-overs are kiln-dried and then sized by screening.

The sizes correspond to the five grades of potassium chloride for the world market: granular, coarse, standard, suspension and chemical. The coarse grade potash is ready for distribution. Fine particles are pressed into sheets which are then crushed and screened to produce sizes for blending with other dry fertilizer components.

Processing at solution mines is very different from the system described above. The brine solution containing dissolved potassium is pumped up into surface ponds. As the hot brine cools in the ponds in the winter environment, from October to April, the potassium precipitates out naturally. Then it is put through heat exchangers/dissolvers, decanters and crystallizers before

⁸The Saskatoon company, Akzo Nobel, produces products which are used by PCS in the flotation process, and as anti-caking devices in fertilizer.

being dried in rotary driers and sized for grade. The result is white high quality potassium.

7. Where Does Saskatchewan's Potash Go?

Saskatchewan's potash is sold in more than 35 countries. About five per cent is consumed in Canada. Approximately 70% of exports (about 9 million tonnes) go to the U.S., where it supplies about 70% of the market demand, mostly in the northern part of the U.S. midwest. The other 25%, about 5 million tonnes, goes beyond North America to the Pacific Rim and other offshore markets, including China⁹, Japan, Malaysia, Korea, Indonesia, Australia and Brazil. Saskatchewan producers make most of their offshore sales through Canpotex, a Saskatoon based marketing company owned by its member companies. Sales within Canada and to the U.S. are made by Canpotex shareholders directly through their individual marketing channels.

The prospects are excellent for the Saskatchewan potash industry.

Potash demand in the future, as in the past, will be driven by agriculture, and at a more basic level by the demand for food. This, in turn, is a function of population. Together, the countries in Canada's offshore markets contain more than 70% of the world's population but (at present) represent only 35% of the world's potash demand. (Dechka 1998)

Canpotex markets Saskatchewan potash to its offshore customers as a scientific tool for use in fertilizing crops on the farm. It is supported in this by the Canadian International Development Agency, the Saskatchewan government, and the Potash and Phosphate Institute of Canada.

8. Transportation

The grades of potash required by a customer are taken from warehouse storage at the mines to the loading facility. The product is treated with oils or animal fats to keep it from caking and to help control dust during shipment. Most mines have truck-loading facilities as well as regular fast loading rail car facilities for unit trains. The potash is then transferred by rail, truck or barge to customers in North America or to port terminals for shipping overseas.

Approximately 10,000 cars are needed for potash shipment. Conventional covered grain hopper cars are used at present. Canpotex is involved in the development of a completely new, more efficient rail car, designed specifically for moving potash. Because transportation costs are a major component of potash price, produced in a province some 2,000 km. from the oceans, the envisaged 30-40% improvement in efficiency will be welcomed over the next few years.

Most of Saskatchewan's overseas exports, about 90%, go through Vancouver or, to a lesser degree, ports in Oregon. Recently, Canpotex opened a new dry bulk fertilizer terminal at

⁹The sales campaign in China centred on the pink colour of Saskatchewan's potash, since pink is a lucky colour in China. The campaign was very successful, until it was badly affected by the Tiananmen Square massacre and subsequent chilled east-west relations. However, by 1994, sales to China set new records. (Martin 1995)

Portland, Oregon, which provides an extra 100,000 tonnes of storage capacity on the west coast of North America. Shipments to South America are routed through Thunder Bay. (Dechka 1998)