Saskatchewan’s Uranium Bonanza

By Janet MacKenzie

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1.8 billion years ago, the huge continents crashed together, one driving up and over the other, ripping apart the earth's crust, the hot magmatic blood spurting red and fresh, hurling rocks and horrible gases into the atmosphere. They were succeeded by a huge range of mountains which pushed and ground its way through the surface of the continent, rising up and up, as high as our Himalayas. Gradually tropical seas crept up the jagged slopes, eventually flooding the entire area. Over the next one hundred million years, the restless waters eroded even these titans to a sludge which drifted down and filled what would some day be known as the Athabaska Basin.

By about 65 million years ago the continent, carrying the Athabaska Basin sediments, had drifted into the position we are familiar with today. These sediments are the primary source of uranium mined in Saskatchewan today.

1. Introduction

Uranium was named after the newly discovered planet, Uranus, in 1789. It was not until 1841, however, that the element was truly separated from its oxide. For another one hundred years uranium was used as a reddish colouring agent in ceramic glazes and photographic tints. Its radioactivity was discovered in 1896, but it was only in 1939 that the amazing energy potential of uranium was glimpsed. Saskatchewan has the world's largest high-grade uranium deposits and is the largest uranium-producing area in the world. More than one third of the world's uranium is produced here, with most of it being exported to make electricity in nuclear reactors around the world.

2. What is Uranium?

Uranium is one of the more common elements in the earth's crust[1], found naturally in the rocks, soil, rivers and oceans of the planet. Uranium is the heaviest metal that occurs in nature. It is so heavy that it is unstable, falling apart under its own weight. Its atoms slowly break down or "decay" over time, a quality possessed by radioactive materials. As it decays, invisible bursts of penetrating energy called "atomic radiation" are given off.[2]

3. Where is Uranium Found?

Major uranium deposits have been found in only a few places in the world. Today it is mined in Canada, Australia, Kazakhstan, Namibia, and the United States. In Canada, the world's largest and highest-grade uranium deposits lie right here in the province of Saskatchewan.

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[1] More about uranium, chemical symbol U. There are more than 200 minerals which contain uranium. It is more common than tin, about 40 times more common than silver and 500 times more common than gold. Traces can also be found in food and in the human body. Uranium concentrations vary from substance to substance and place to place. Uranium occurs naturally in two forms that are found together. 99.3% of uranium is U-238, the remaining .7% is U-235.

[2] See Appendix. Radiation. The decay process also produces unstable radioactive by-products which have little commercial value. These "uranium decay products" are discarded as waste during the mining process. One of them is a toxic radioactive gas called radon. The others are radioactive solids.

About 1.8 billion years ago, the granite rock of the ancient Hudsonian mountain-forming era were ground down and the sediments were deposited in the present-day Athabaska Basin. It is in these sediments, now near the surface of the planet, that the major deposits of Saskatchewan's uranium exist. Our mines in the northern quarter of the province, around Lake Athabaska and Wollaston Lake, produce about 34% of the world's uranium.

4. What is Uranium Used For?

Canada has signed the International Nuclear Non-Proliferation Treaty. The treaty's rules, policed by the International Atomic Energy Agency, make it illegal to export uranium, nuclear components or nuclear technology for use in weapons. Although Saskatchewan's uranium has been used in the past in nuclear weapons, today most of our production is sold on long term contract to generate electrical power. All contracts must be approved by the Canadian government and must meet Canadian safeguard requirements. More than four hundred nuclear reactors around the world use our uranium to provide about 17% of all the electricity used in the world.

In the power plant, a process called nuclear fission[3] releases energy in the form of heat which is then used to produce steam to power electrical generators. One kilogram of uranium produces as much energy as 35 tonnes of coal or 150 barrels of oil, or about 175 million calories.

Uranium is also used to make artificial radioisotopes[4] for medical diagnosis and research and radiotherapy treatment. Each year, millions of medical procedures and laboratory tests are performed using nuclear techniques. At least 80% of new drugs are tested with radioactive materials to help prove that they are safe and effective. Radiation is used to sterilize medical supplies such as syringes, sutures, and clothing for health care workers.

Radiation is used effectively to kill parasites and pests and to sterilize food and cosmetics. In agriculture, radioactive materials are used to develop disease- resistant and hardier crop and livestock varieties with higher yields and to study the absorption of fertilizer by plants to help prevent the over-use of fertilizers.

Radioactive materials are also used to detect flaws in steel used in vehicles and jet engines, to toughen rubber in radial tires, to test pipe welds, to eliminate static in photocopiers, to scan baggage at airports for metal objects, to treat computer disks to improve the retrieval of data, as part of a system used in oil exploration. They are used in household smoke detectors, in the

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[3] Heat energy is released during nuclear fission, a process in which the nucleus of a U-235 atom is split in two by a neutron and additional neutrons are thrown off. When this becomes a continuous process, enough heat is released to produce sufficient steam to generate electricity. U-238 cannot be used in nuclear bombs in its natural form. It is however the starting point for other weapons material, such as the uranium isotope, U-235, which occurs naturally along with U-238 but in very small quantities. U-235 can be separated from U-238 only with an "enrichment" process. U-235 is used in nuclear bombs. U-238 can be bombarded by neutrons to form plutonium-239. Pu-239 is also used in nuclear bombs.

[4] Many of these radioisotopes can also be produced in nuclear accelerators, such as the one at the University of Saskatchewan, which do not require the use of uranium.

manufacture of coated paper, in highway construction to test the density of road surfaces, and in museums to authenticate paintings and art objects. (Cameco 2001- Uranium 101; Canadian Broadcasting Corporation 2003)

5. A Brief History of Uranium Mining in Saskatchewan

The uranium mineral, pitchblende, was discovered in Saskatchewan in 1936. At this time there was little commercial use for uranium. It had long been used to create a reddish pottery glaze, and its radioactive properties had been studied by scientists. It was known to be a by-product of radium mining operations.

During the Second World War, when the United States established the highly secret Manhattan Project[5] to create the world's first atomic bombs, the Canadian government re-opened a disused radium mine at Port Radium in the Northwest Territories as a uranium mine, secretly bought up its shares, and turned it into a crown corporation called Eldorado Nuclear Ltd. Its product was refined in Ontario for the U.S. Army and was used in the two bombs, "Fat Man" and "Little Boy", which were used to destroy the Japanese cities of Hiroshima and Nagasaki in 1945.

The Effects of the Bomb

After the first use of the atomic bomb, interest in Canada's uranium deposits grew. In 1945, the government established the Atomic Energy Control Board. The next year, a ban on private prospecting was lifted and incentives offered which resulted in a "uranium rush" which produced over 10,000 radioactive ore discoveries, especially in the Athabaska Basin.

However, the government was reluctant to be seen to be participating in such a destructive and frightening venture as nuclear weaponry. In 1946, Saskatchewan published a pamphlet entitled "Atomic Future" in which the peaceful uses of nuclear fission, such as radiation cancer treatment, were lauded.

Nevertheless, Saskatchewan and other Canadian uranium was used during the Cold War arms race. Exploration methods used at this time included direct sighting of mineralized boulders by aerial survey and ground exploration using the recently invented Geiger counter. These techniques detected uranium deposits near the surface and uranium which had been spread by recent glaciers..

Saskatchewan's First Uranium Mine

In 1952 Uranium City was established as a base for uranium mining in the Beaverlodge area. Operations at Saskatchewan's first uranium mine began in May of 1953 and continued until June of 1982, by which time rising costs and failing ore grade made it unprofitable. It had been producing more than 1600 tonnes annually from its three main mine shafts, two satellite underground mines and several open pit mines. When Eldorado decided in 1981 to shut the mine down, decommissioning plans were designed. At that time, no Canadian uranium mine had ever

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[5] The Manhattan Project involved the United States military, government, industry and academia, produced four crude atomic bombs. The first was tested in New Mexico on July 16, 1945. The second was dropped from a B-29 called the Enola Gay onto Hiroshima on August 8 and, three days later, the third destroyed Nagasaki.

been officially decommissioned and there were no standards for this procedure. After a lengthy process of monitoring and adjustments, decommissioning was completed in June of 1985.

The Athabaska Basin "Unconformity" Discoveries

In the mid 1960s "unconformity" uranium deposits were discovered in Saskatchewan's Athabasca Proterozoic Basin. Unconformity deposits contain a much higher concentration of uranium. These extraordinarily rich deposits were located along a line of contact between older "basement" rocks and younger sandstone and quickly became the "ore of choice" in the exploration industry.[6] Because of the higher concentration levels the discovery costs for unconformity uranium deposits in Saskatchewan averages about $1.30 per kilo compared to more than $11 per kilo for other deposit types in Canada.

Exploration began in the Athabaska Basin in 1966. A major uranium discovery at Rabbit Lake in 1968 along the unconformity was an important find. This mine opened in 1975 and was the first Canadian mine with a seven-days-in/seven-days-out commuter system of staffing. Rabbit Lake operations extracted from several deposits, and included open pits as well as an underground mine. It was mined out in 1984 and its pits are now used to store tailings. Today, Rabbit Lake is the largest uranium milling operation in the world, with a capacity of nearly 5.5 million kilograms. It is also Saskatchewan's longest operating production facility.

Electromagnetic Surveys Result in Many New Mines

During the 1970s and into the 1990s, discoveries continued to be made where there was no evidence on the surface, by the use of geological models built on information gathered at earlier mines and by deep penetrating geophysical techniques on the ground and in the air. Up to this time, there was little understanding of these huge hidden deposits.

The Saskatchewan Mining Development Corporation, (SMDC), was formalized as a crown corporation in 1977 to explore for minerals, other than oil, gas, potash and sodium sulphate, in the province. SMDC participated in joint ventures with private companies and also formed its own subsidiary, SMD Mining.

The high-grade Gartner and Deilmann uranium deposits were discovered in 1975 and 1976, and were being mined at Cluff Lake and Key Lake on the west and south sides of the Basin, about the time the Uranium City mines closed in 1982. The Key Lake operation was the largest high-grade uranium mine in the world at that time. The Midwest uranium deposit was discovered in the eastern Athabaska Basin in early 1978 after 10 years of exploration in the area. The McClean uranium deposits, discovered in 1979, lie about 11 km northwest of the Rabbit Lake uranium mine.

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[6] The viability of uranium resources in all other types of deposits was immediately diminished ...witness the closing of the large quartz-pebble conglomerate uranium mines at Elliot Lake in Ontario. Whereas a ton of Elliot Lake ore contained just 2 pounds of uranium, a tonne of ore from the Key Lake Proterozoic, unconformity deposit yields from 60 to 90 pounds of uranium, and the Cigar Lake and McArthur River unconformity deposits contain more than 300 pounds of uranium per ton! (Hornby Bay Exploration Ltd. 2002)

Uranium prices reached their highest levels in 1977. A great deal of money was invested in exploration in the Athabaska Basin, peaking in 1980 with $77 million invested that year, largely by state, crown or utility-owned companies.[7] The result of this was the peak, about four years later, in discoveries. By the mid 1980s, the SMDC had effectively discovered uranium in areas such as Maurice Bay, Michael Lake, an area south of Rabbit Lake, Collins Bay, Midwest Lake and the Lake Athabasca region.

A spectacular discovery at the 450 metre level at Cigar Lake was made in the early 1980s. Cigar Lake is the second largest high-grade uranium deposit in the world. Initial probes showed uranium grades of more than 25%, and conservative estimates of about 48,000 tonnes of uranium. A 500 m shaft was sunk in 1990 by SMDC and its partners and as work continued the main seam alone was estimated to contain around 130,000 tons of uranium at an average grade of 14% U_3O_8 .

Politics Has Its Effects

Since the Three Mile Island accident in 1979 and, especially, the Chernobyl accident of 1986, almost no new Candu nuclear reactors have been sold. During the 1980s, with the growing environmental movement, there was a decline in uranium prices, government funding, and exploration spending. Exploration slowed and companies concentrated on drilling into already known deposits and into deeper deposits (more than 700 m sandstone depth) which require fewer tests. This trend is ongoing.

Mergers and other events have altered the corporate landscape. The French-owned Cogema Resources Ltd., formerly known as Séru Nucléaire, began operations at Cluff Lake in 1980. In1988, the two crown corporations Saskatchewan Mining Development Corporation and Eldorado Nuclear merged to become the Canadian Mining and Energy Corporation (Cameco). About this time, Cogema began operations at McClean Lake. There was a great deal of controversy. In response to pressure from lobbying groups at home and elsewhere, the government of Canada and the Provincial government of Saskatchewan formed a panel to review uranium mining projects in 1991. The panel was to look objectively at the environmental and social impact of proposed mining projects and present its recommendations to the government. Despite the panel's opposition to Cogema's hazy plans for waste disposal, the government supported Cogema. A new source of uranium became available with weapons reduction in the former Soviet Block countries. In 1999 Cameco agreed to purchase uranium from highly enriched uranium (HEU) harvested from dismantled Russian nuclear weapons.

[7]such as the two Canadian crown corporations SMDC and Eldorado Nuclear, French companies Seru/Amok (later Cogema), and German explorer Uranerz. Japanese state- or utility-directed companies such as PNC also became major joint venture players. A contingent of oil companies were also active in the 70s, including some major ones such as Shell and Texaco. However, some of the more important joint venture participants were smaller US and Canadian oil companies, taking advantage of the rapid rise in market interest in uranium. Thus, the majority of the initial exploration funding was sourced from companies who were either nuclear entities with interests in long-term supply security rather than short-term price, or exploration companies who were very aware of the price-driven upside of this growing commodity. (Macdonald 2001)

New Development of Known Deposits
In 1995, it was announced that the capacity of the McClean Lake mill would be expanded from about 2700 tonnes to about 11,000 tonnes in order to process the very high-grade ore of the Cigar Lake project. This would give the McClean Lake mill the largest uranium output capacity in the world.

The huge McArthur River operation, whose deposits were discovered in 1988, is the world's largest and highest grade uranium mine, with average ore grades of 21%. In 1992, in response to the proposal of an extensive underground exploration program for this unique ore body, a detailed report was commissioned by the government under the Joint Federal and Provincial Panel on Uranium Mining. It was approved. In 1999 Cameco and Cogema began mining with remote-controlled equipment and “non-entry” mining methods that enable employees to mine the high-grade ore without increasing their radiation exposure. The mine produces about 8 million kilos of U_3O_8 annually which is blended for processing with low-grade ore in the stockpile at Key Lake.

The Cigar Lake project which was planned for production in 2002 has experienced many delays. There have been technical problems in raising the ore, including its high clay content, and innovative mining techniques such as jet boring may be used because of high ore grade and ground instability. Following the complete flooding of the mine in October of 2006 the immediate future of the Cigar Lake operation is uncertain.

Originally scheduled to close in 2000, mining was extended at Cluff Lake through May 2002 as higher grades of ore were encountered. Final ore stockpiles went to the mill in 2002 and the mine is to be decommissioned beginning in 2003.

Cogema and its partners will mine the Midwest deposit, some 15 km west of McClean Lake. It was discovered in 1978. In early 2002, a Uranium Mine Site Preparation Licence, with no changes from the previous licence to continue the care and maintenance of the site, was issued for an indefinite term under the new Canadian Nuclear Safety and Control Act.

6. Uranium Mining and Milling in Saskatchewan Today

How is Uranium Mined in Saskatchewan?
Northern Saskatchewan contains some of the world's richest deposits of uranium. The ore is mined underground or in open pits, depending on the depth of the deposit.

Open pit mines Open pit mines at Cluff Lake, Key Lake and Rabbit Lake extract ore from very rich, shallow ore deposits. First it must be decided if water in sandstone must be removed by drilling drainage wells, as is often the case in Saskatchewan. Pumping to keep water levels below the ore zone may have to continue throughout the operation. The soil and rock overburden must be removed by mechanical shovels and huge trucks. These same shovels dig out the ore by cutting down in ringed benches, forming a wide funnel-shaped excavation. The ore is removed by truck to the milling plant. Mined-out pits are frequently lined and used to store tailings.

Underground mines Underground mines, such as Cluff Lake and McArthur River, extract the ore from a deeper ore body by a variety of methods. The area above the ore is excavated to within about 35 m. of the uranium deposit. The deposits at McArthur River are so rich that remote-controlled equipment and remote mining methods must be used to protect employees from high levels of radiation underground. These methods include a remotely-operated ore processing circuit 640 metres below the surface, designed to use conventional technologies adapted to the underground environment because of the increased radiation. Problematical groundwater is kept out by freezing the ground. Three remote mining methods are used: raise-boring, box-hole boring and remote box-hole stoping.

Raise-boring In the raise-boring method, used at Eagle Point and McArthur River, a 30 cm pilot hole is drilled down about 125 m from the 530 metre level through the orebody into a lower extraction chamber on the 640 metre level. A 2.4 metre wide reaming head is then attached to the drill and the raise-bore machine is rotated as it is pulled up through the hole, and waste rock removed to the surface. The reamer then enters the ore, cutting it into fine bits which fall down to the lower level to be transported to the underground sizing screen and crusher processing circuit. When the top of the ore zone has been reached, the reaming head is lowered to the extraction chamber and removed. The raise-bore machine then lifts the pilot drill rods and removes them within the upper chamber. Then the empty “raise” is plugged with concrete and a new one begun next to it. The successive plugging of empty bores with concrete provides stability and ground support so that a high percentage of ore is able to be extracted from the ore zone. (Jamieson and Frost 1997)

Box-hole boring The box-hole boring method needs only the lower mining chamber. The box-hole machine pushes the reamer up through the ore, adding stabilisers to the drill rods as mining progresses. The ore falls down the raise to a chute above the box-hole machine, and is then diverted to the sizing screen and crusher. (Jamieson and Frost 1997)

Remote box-hole stoping This method combines the improved productivity of “stoping”, or stepped excavation, with the control and containment of box-hole boring. The raise is reamed as in box-hole boring. Then blast holes are remotely drilled in the sides of the raise above the mining chamber, charged with explosive and detonated as needed, to provide broken ore to the box-hole boring unit. (Jamieson and Frost 1997)

Vertical blast-hole stoping In this method, used at mines such as Eagle Point, ore broken up by blasting in vertical shafts is removed by scoop trams, operated by remote control from 15 to 30 metres away.

In situ leaching At Crow Butte, uranium is leached out of sandstone several hundred feet below the surface, without removing the ore from the ground. A closed-loop recirculation system extracts the uranium without disturbing the ground. The uranium, insoluble in groundwater, is dissolved by small amounts of oxygen and carbon dioxide added to a stream of water injected into the orebody. The solution is then pumped from a production well to a satellite facility where it is extracted and dried to become yellowcake. (Cameco 2001)

How is Uranium Ore Processed?

The processing of uranium comprises several basic steps, but is carried out in a variety of ways, depending on the mine. Each mine has its own mill where uranium ore is processed into a product called uranium oxide concentrate or "yellowcake" containing the oxide U_3O_8. In the mill the rock is crushed and ground into fine sand. At McArthur River, this process is carried out underground, where the ore is crushed and thickened into a muddy slurry in tanks set in concrete, for shielding. From here, high pressure pumps push it to the surface where it is placed in storage tanks ready to be loaded into specially designed containers for transportation to the Key Lake mill by truck.

Then uranium is leached from the ore with acid[8], concentrated and dried into crystal powder. It is packaged into special drums for transportation. Most of the pulverized rock waste is stockpiled as radioactive sands and slimes called "tailings". They will be hazardous for hundreds of thousands of years. The acidity of waste materials is neutralized with lime and pumped to the tailings storage area.

Yellowcake can be further refined and converted to uranium dioxide (UO_2), uranium trioxide (UO_3) and uranium hexafluoride (UF_6).[9] This is done out of province.

7. Where does Saskatchewan's uranium go?

Saskatchewan's annual production capacity is more than 13 million kilos of uranium oxide. Since military sales of Canadian uranium ended in 1965, all uranium mined in Canada has been sold for fuel for the world's more than 400 nuclear power reactors in countries such as the United States, Japan, Germany, Sweden, Spain and Finland. Nuclear power provides 17% of the world's electricity without emitting greenhouse gases.

Many small specialized nuclear reactors around the world make artificial radioisotopes, used for a variety of purposes including medical diagnosis, food preservation, agricultural productivity and manufactured products. UF_6 can be enriched to increase its concentration of fissionable uranium (U-235). Since Canada does not have enrichment facilities, "hex" is exported to nuclear weapons countries such as the United States, Great Britain, France or Russia where it is made into fuel for light water reactors, which are the majority of nuclear power plants and research reactors in the world. Countries buying Canadian uranium must promise not to use it for weapons but this is difficult, if not impossible, to police. Canadian Candu reactors use heavy

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[8] Leaching is a method of extraction in which a solvent is passed through an acid mixture to remove a desired substance from it. Leaching is used to remove metals from their ores.

[9] The refining is done in Ontario at Blind River, the world's largest refinery, and at Port Hope, one of only four commercial suppliers of hex in the western world and the world's only commercial supplier of natural UO_2. At Port Hope, UO_2 is processed into pellets to fuel Canadian-made Candu reactors. The UF_6 can be enriched to increase its concentration of fissionable uranium (U-235). Since Canada does not have enrichment facilities, "hex" is exported to nuclear weapons countries where it is processed.

water and do not require enriched uranium.

8. Reserves

Saskatchewan's uranium reserves are sufficient to last for more than 40 years at the current rate of production. At the end of 1999, total proven reserves, using all mines, all grades of ore and all mining methods, were estimated to be 1,795 thousands tonnes, 636,000 tonnes of that in the Athabaska Basin alone. Total U_3O_8 in those reserves is thought to be 215.6 million kilos. (Cameco 2000)

9. Radiation Safety and Environmental Protection

Extraction of uranium from its ore beds far below the surface is inherently destructive to our environment because of the very nature of the element and because of the high grade of ore mined in Saskatchewan. The dangers of radiation exposure are now well documented and acknowledged by governments, mining companies and mine workers.

Governments, communities and mining companies have invested heavily in protecting workers, their communities and the environment. Mine and plant layout and equipment choices are determined to a large extent by radiation danger. Mining and milling operations manage radiation and escaping radon in mines through various specially designed safety systems such as ventilation, remote control operations and equipment, barren rock and concrete shields, and individual, workplace and environmental monitoring.

Innovative measures, such as the *in situ* leaching process which does not disturb the ground; the processing of mill tailings under water to control the release of radioactive dust and emissions; freezing and grouting of the ground to contain radon gases and provide stability; remote mining techniques; monitoring of air, water, animals and aquatic and terrestrial vegetation at each mine to track and prevent contamination; mining companies work with local communities to develop monitoring strategies; stakeholders involvement, such as the Athabaska Working Group[10] which designed and implemented its own environmental monitoring program; the McClean Lake operation became, in 2000, the first uranium mine in North America and the first mine in Saskatchewan to receive ISO 14001 environmental management certification; new environmental management systems are being adopted. Tailings are being stored in lined pits and heavily monitored; mine sites are being filled and returned to native vegetation, following environmentally responsible procedures based on the premise that *mining in Saskatchewan is a temporary use of the land*; mining companies post financial guarantees to the government to ensure decommissioning is carried out properly; mining companies and Saskatchewan universities conduct ongoing research on environmental and industrial improvements.

The province of Saskatchewan is attempting to clean up many mines abandoned in the 1950s and

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[10]The Athabasca Working Group is helping the Athabascan communities in northern Saskatchewan participate in their own environmental monitoring of uranium developments. Three uranium companies and seven Athabascan communities jointly designed and implemented a community-based environmental monitoring program. Water, air, plants, fish and animal tissues such as caribou and moose were sampled in and around the communities with the help of local hunters and other residents. The program began in 2000. (Cameco 200)

1960s when there was little requirement for reclamation and cleanup. Many mining companies of the past no longer exist, and the government has taken on the responsibility of inspecting mine sites to determine if they constitute a danger to public or environmental health, so far without federal help.

There is Still Much to be Done

The tailings and dumps at Uranium City, Saskatchewan, symbolize the reluctance of governments to deal with the past. The federal government understood at least some of the dangers of uranium mining as early 1932. In 1958, Ottawa declared it safe, and it was not until 1973 that some victims were compensated for the damage done to them in the mines. First Nations communities have long voiced their concerns about uranium mining and the dangers it represents. Buried or ponded mine tailings have led to water pollution, affecting fishing communities. The tailings may remain dangerous long after a mine has been decommissioned, creating environmental and health problems for northern communities. In 1985, a roadblock was set up at Wollaston Lake to publicize these difficulties. The issue has had wide support among the public, churches and scientists. As recently as 1998, a mining company was convicted of contaminating the environment and not reporting it.

Nevertheless, the uranium mining industry is more socially and environmentally responsible today than in the past. It is an important industry in the province, accounting directly and indirectly for some 4,300 jobs and an investment in the province of more than $3.2 billion in capital, exploration, pre-development expenditures, royalties and taxes. Company policies to educate and hire northern residents have meant more and better employment, but when mines shut down, locals are often put out of work. Those in the mining service industries, such as equipment, transportation and construction companies, usually fare better.

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