MINERAL EDUCATION SERIES

Industrial Minerals In Manitoba

Manitoba
Energy and Mines

Welcome to the Mineral Education Series

Manitoba's abundant mineral wealth has been part of its heritage since the earliest human habitation. Over the centuries, our uses for minerals have multiplied, until today we use more minerals to produce more products than ever before in history.

While the stone axe has been replaced by the space shuttle's Canadarm, some vital ingredients remains the same. It takes human ingenuity and hard work to transform the natural wealth of our province into the tools and materials we need.

The staff at Manitoba Energy and Mines is proud of the record Manitobans have established in the minerals industry. The Mineral Education Series is an attempt to pass on some of the history and geology which have combined to make our mining industry what it is today. The series introduces the province's most important minerals, and the people and companies which have translated the potential of our resource heritage into a vibrant and innovative industry.

Mining is as old as civilization, but only over the past century has it become an important part of Manitoba's economy. One hundred years ago, industrial minerals such as salt, building stone, and brick formed the mainstay of mining in Manitoba. In **Industrial Minerals in Manitoba,** we trace the growth of this industry from those early days to modern development of valuable minerals with sophisticated applications. The uses of industrial minerals range from the humble yet vital sand and gravel which plays a role in virtually every part of our lives in the form of concrete, to rare metals like lithium which are used in space-age alloys.

You will be introduced to the challenges faced by explorationists searching out minerals hidden below the earth's surface. You will learn about the ways those active in the mining industry have devised to bring the ore from the ground and transform it into the raw materials that form the basis of industrial society.

Manitoba Energy and Mines has played an important role in fostering Manitoba's minerals industry. The department's goal is to help build a strong and prosperous mining sector in the economy, and to ensure our precious mineral heritage is developed with care and wisdom.

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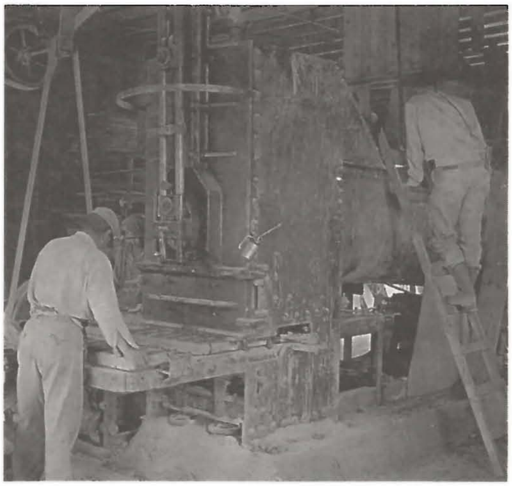
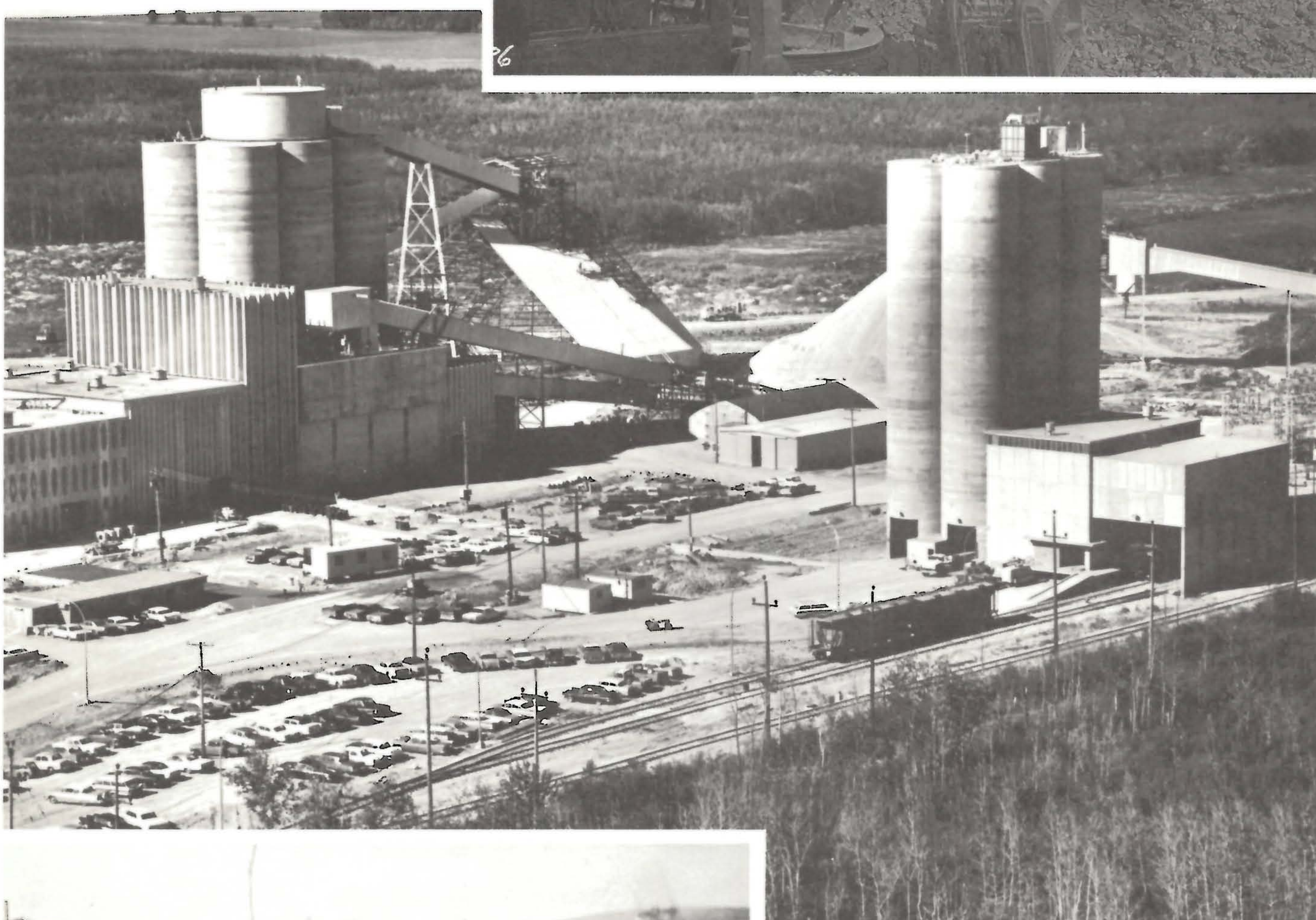
Note: Unless otherwise stated, value of production is in unadjusted dollars, at prices current at the time of production.





History of Industrial Minerals in Manitoba

Industrial minerals can be broadly defined as any mineable products which do not yield base or precious metals as final products. They encompass the oldest forms of mining — providing stone tools, fire-making flint, clay for the earliest pottery and the salt our bodies crave. In Manitoba, all of these were known to the aboriginal population long before the arrival of Europeans. Early European explorers were far more interested in furs than minerals, and it is fitting that the first commercial mineral development in Manitoba was salt for the fur trading posts.

In the early 1800s, former employees of the Hudson's Bay Company and the North West Company supplied the new Red River settlement, and trading posts from Norway House to Fort Qu'Appelle, with salt from brine springs on the west side of Lake Manitoba and Lake Winnipegosis. Evidence indicates that Plains Indians had long made use of these springs for their own domestic needs. By 1874, more than "1,000 bushels" a year were manufactured at Monkman's Springs, near present-day Winnipegosis. The Canadian Salt Company in Neepawa, Manitoba produced salt from brine from two wells drilled between 1910 and 1935. By 1940, production from the wells reached 3,071 tonnes per year.

Quarrying construction materials was the next step in developing Manitoba's mineral resources. The first recorded use of local building stone in the Red River settlements occurred in 1830, when the now-famous Tyndall stone, a mottled dolomitic limestone, provided the raw material for the northwest bastion of Lower Fort Garry. The fort, on the banks of the Red River, is preserved as an historic site, 15 kilometres north of Winnipeg. In 1845, settlers built St. Andrew's Anglican Church of Tyndall stone, a few kilometres upstream from the Lower Fort. It is the oldest church still in use in western Canada.

In 1895, William Garson, an ambitious local farmer, opened Manitoba's first commercial stone quarry, in the Garson district, to serve Canada's booming construction industry. The original rail shipping point for the stone was the nearby town of Tyndall, and the name has stuck to the final product to this day.

Other quarries soon followed Garson's. At the height of Winnipeg's construction boom after the turn of the century, Tyndall stone was in common use in Winnipeg architecture. The quarries were barely 10 years old at the time, and Tyndall stone was all but unknown outside of Manitoba. By the early 1920s, however, Canada's architects and engineers were using it to grace many of the finest new buildings in the country.

Canadian structures built of Manitoba Tyndall stone include: the Saskatchewan and Manitoba Legislatures, the Calgary post office, the Hudson's Bay Memorial in Vancouver, the T. Eaton store in Montreal, and Eaton's College Street store in Toronto. Tyndall stone was also used to trim the main lobby and corridors of the Parliament Buildings in Ottawa, the Banff Springs Hotel, and the St. Roch Cathedral in Quebec City.

Making bricks from Manitoba's clay deposits was another early industry. By 1886, four brick plants were operating in the province. The number of brick plants increased to 16 between 1886 and 1910 as Manitoba went through a lengthy construction boom. However, the declining popularity of brick as a construction material, and the relatively low quality of the brick-making clay deposits known in Manitoba at the time, caused the common brick industry to subside.

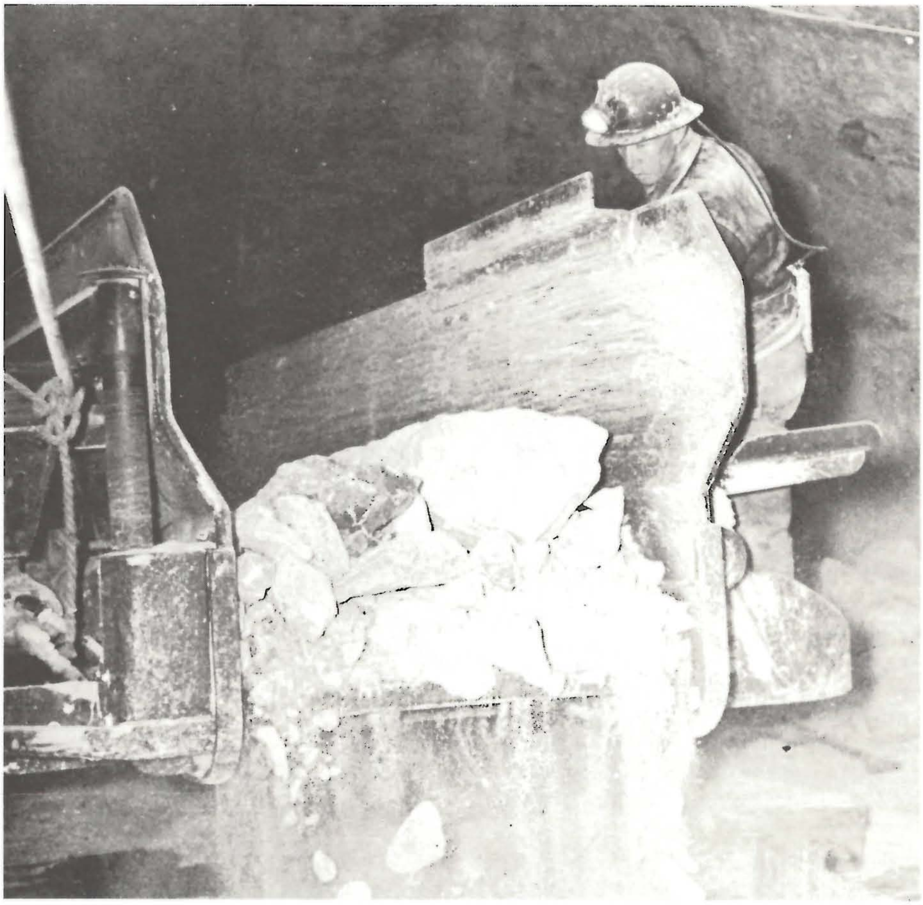
The discovery of gypsum in the Interlake area during the 1850s eventually led to Manitoba's first gypsum quarry. Mining of the gypsum ridges began in 1901, at Gypsumville, near Lake St. Martin in the Interlake region. A railway line reached Gypsumville in 1910, and the Manitoba Gypsum Company, which later became Domtar Construction Materials Ltd., produced gypsum in the area until 1984.

The province's first natural cement plant opened about 1900 at Arnold, 113 kilometres southwest of Winnipeg. A second plant operated at Babcock, west of Carman, from 1907 to 1924. Production involved the reduction, in a charcoal fired kiln, of suitable clay-rich limestone of the Boyne Member near Deerwood and Babcock in southern Manitoba. Portland cement, which has more consistent setting times and composition, was developed in England in the nineteenth century and entered the Manitoba market early in the twentieth century, quickly replacing natural cement. The first portland cement plant opened in 1911 at Fort Whyte, just southwest of Winnipeg. Inland Cement Company Ltd. (formerly Genstar Cement Ltd.) is still producing cement near the Fort Whyte site.

Coal mining is an even older, though much less successful, part of Manitoba's mining industry. Mines in the Turtle Mountain area of southwest Manitoba produced small amounts of lignite coal as early as 1883. The Manitoba Coal Company, incorporated in 1888, mined lignite coal commercially in the area for a short period in the 1890s. Lignite was mined again in this area on a small scale in the 1930s, but was soon abandoned for better deposits in southeastern Saskatchewan.

New industrial minerals potential opened up in eastern Manitoba in the 1920s. In 1920, gold prospectors discovered interesting rock formations, called pegmatites, to the east of Lac du Bonnet. Tin and beryl were recognized in the pegmatites, opening up new mineral potential for the region. Drilling for tin in 1929, Jack Nutt Mines Ltd. encountered the unique Bernic Lake pegmatite. The company sank a shaft and set up a 9-tonne-per-day mill to extract the tin, but without commercial success.

While the tin mine was a failure, work on the Bernic Lake pegmatite uncovered commercial quantities of a number of rare minerals. Large reserves of lithium were outlined during 1955 and 1956. In 1958, massive cesium ore was found in the pegmatite and tantalite was identified in 1960. In 1969, Tantalum Mining Corporation of Canada Ltd. opened North America's first tantalum mine.



General Geology of Manitoba

It is no accident that Manitoba has such a rich history of mineral exploration and development. Its geology has long been recognized as having excellent mineral potential.

The province occupies 652 000 square kilometres and is underlain entirely by rocks of Precambrian age, formed over 510 million years ago. Two-fifths of the Precambrian basement is concealed beneath rocks formed during the more recent Paleozoic, Mesozoic, and Cenozoic eras. The surface geology of Manitoba is divided into four major regions that reflect the nature of the underlying bedrock and the effects of glaciers that covered much of the province in the most recent age, the Pleistocene.

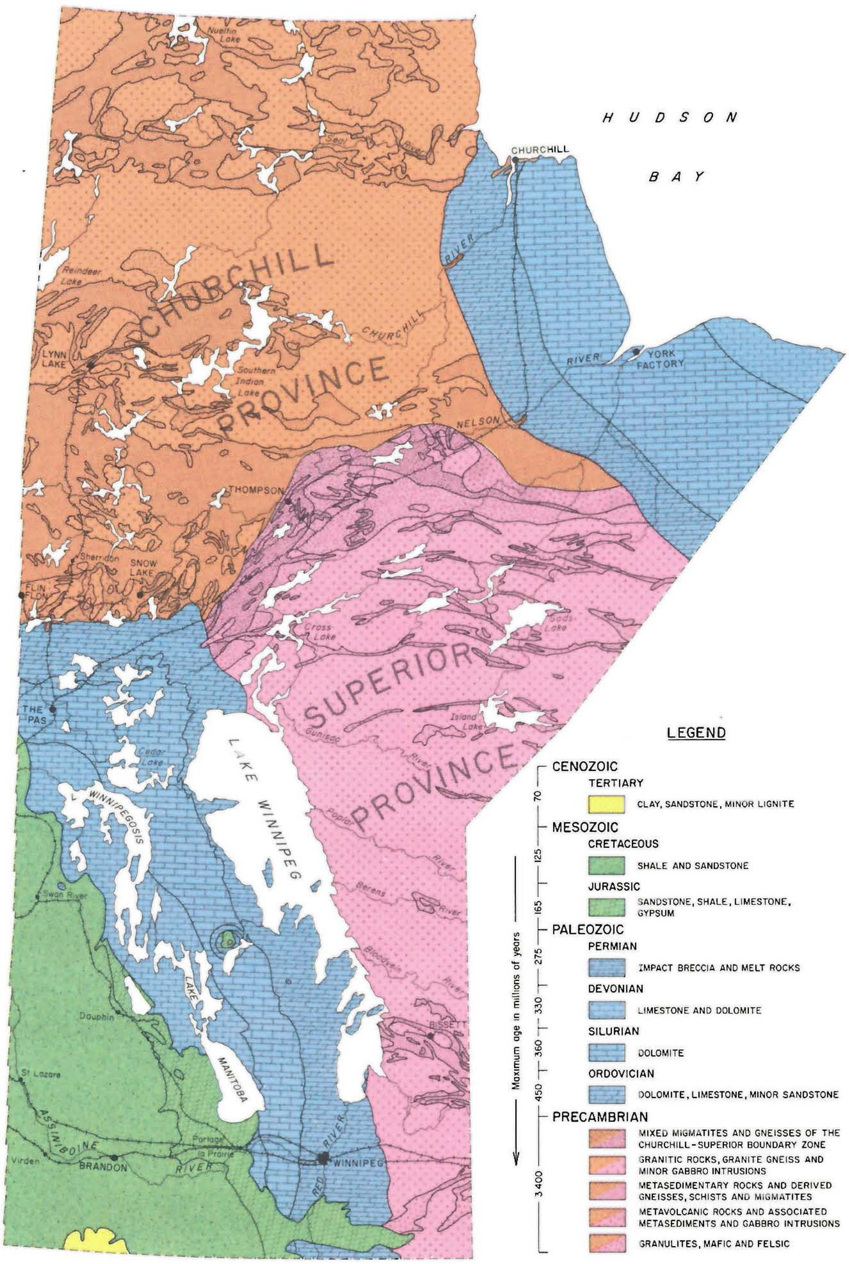


Figure 1 Generalized geological map of Manitoba.

Most of Manitoba's industrial minerals occur in the Paleozoic and Mesozoic regions of the province — the Manitoba Lowlands, the Southwestern Uplands, and the Hudson Bay Lowland (Figure 1). The Precambrian Shield roughly divides the Paleozoic in half with the Hudson Bay Lowland to the northeast and the Manitoba Lowlands and Southwestern Uplands to the south and west.

Manitoba Lowlands

The Manitoba Lowlands are bounded to the west by the Manitoba Escarpment and the Southwestern Upland, and to the north and east by the Precambrian Shield (Fig. 2). Although elevations range between 217 and 300 metres above sea level, the variation, or relief, is generally less than eight metres. The region is drained by the Saskatchewan, Red, and Assiniboine Rivers, and the principal lakes are Winnipeg, Winnipegosis, and Manitoba. In the extreme southeast, south of the Trans-Canada Highway, sandy glacial deposits cause variable drainage and relief, forming large areas of peat bog and swamp.

The Manitoba Lowlands are underlain principally by sedimentary rock of Paleozoic age (Fig. 2) that constitutes the northeastern portion of the Williston Basin, a major sedimentary basin centred in northwestern North Dakota. Below the surface, the Paleozoic strata dip progressively southwest towards the centre of the Williston Basin, to a depth of 2300 metres in the southwest corner of the province. These Paleozoic strata consist almost entirely of dolomite, limestone, and dolomitic limestone with minor clay, limestone, and/or sandy intervals. The Paleozoic formations are overlain with marked angular uncomformity by younger Mesozoic strata that progressively overstep Paleozoic strata to rest directly on the Precambrian basement in the area southeast of Winnipeg (Figure 1).

The primary industrial mineral resource in the Manitoba Lowlands is sand and gravel. Commercial useful deposits are locally abundant — a legacy of our glacial past.

Southwestern Upland

Mesozoic rocks and Pleistocene morainal deposits underlie the Southwestern Upland (Fig. 2). The Porcupine, Duck, and Riding Mountains, whose eastern sides form the steepest parts of the Manitoba Escarpment, are separated in turn by broad gentle valleys. Turtle Mountain, on the border with North Dakota, is an erosional remnant capped by Paleocene sandy, silty shales containing sub-economic deposits of lignite, and by Pleistocene glacial moraines.

Mesozoic formations consist almost entirely of shales and sandstones, with some limestone and gypsum. The Mesozoic beds dip gently to the southwest, towards the Williston Basin. Maximum thickness of Mesozoic beds in the southwestern corner of the province is approximately 1 070 metres. Numerous outliers, or channel-fill deposits, of Mesozoic sediments also occur within the Paleozoic outcrop belt.

The Southwest Upland, in addition to its petroleum resources, produces all of Manitoba's bentonite clays and contains commercially important potash deposits.

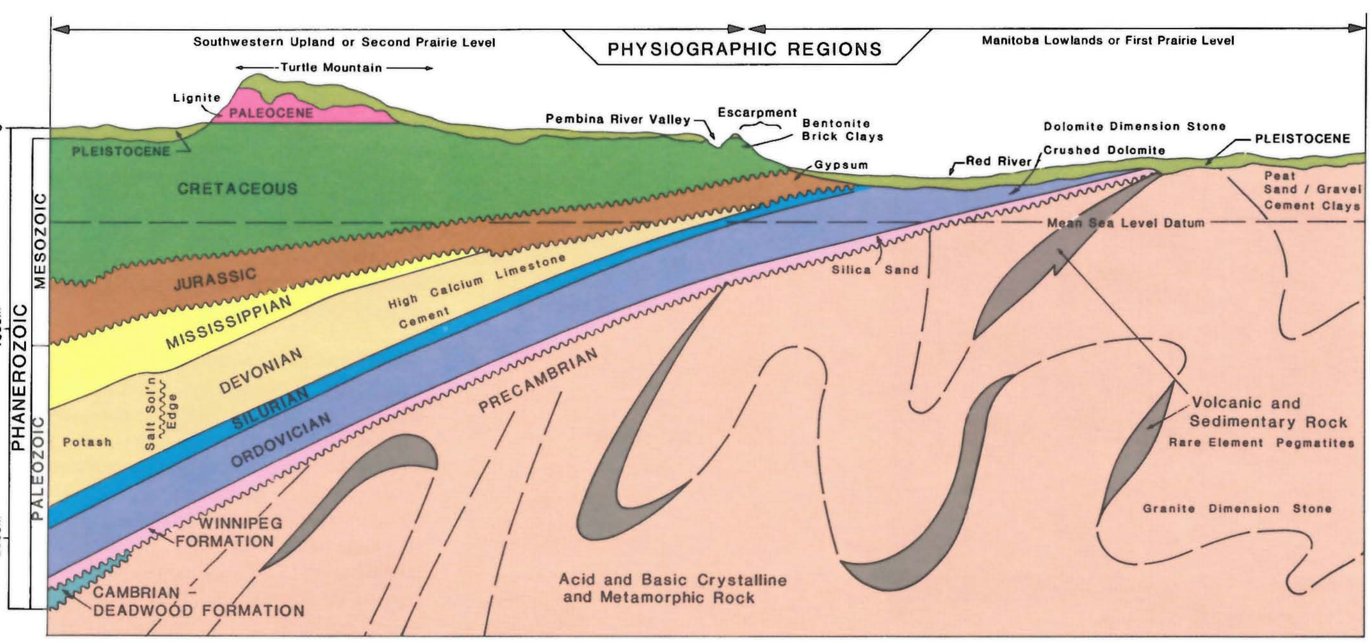
Hudson Bay Lowland

The Hudson Bay Lowland (Fig. 1) is an undulating plain of subdued relief and low elevation. Erosion by the continental ice sheet deranged the drainage, resulting in a maze of swamps, lakes, and streams. The Churchill and Nelson Rivers, which developed upon the new topography, have cut 18 to 50 metres into till and bedrock.

Paleozoic strata of the Hudson Bay Lowland region dip gently to the northeast, towards the bay. The maximum onshore thickness of Paleozoic strata is 884 metres, but in the central part of Hudson Bay, the thickness probably exceeds 1 800 metres. These strata, as in the Manitoba Lowlands, consist mainly of limestone, dolomitic limestone, and dolomite.

Its remote location makes this an unpromising location for the development of industrial minerals. However, substantial deposits aggregate materials exist and are locally valuable for rail, hydro and local community projects.

Figure 2 Structural cross-section, southern Manitoba, along Manitoba-North Dakota/Minnesota border.



Precambrian Shield

The Precambrian Shield is the largest region of Manitoba. It is exposed in a relatively level, though hummocky, terrain flanked to the northeast by the Hudson Bay Lowland and to the southwest by the Manitoba Lowlands. The central part of the Shield, the Nelson depression or trough, slopes northeast towards Hudson Bay, drained by the waters of the Churchill, Nelson, and Hayes Rivers. Much of the Nelson trough is less than 260 metres above sea level, but to the northwest, highlands rise to 506 metres and to the southeast to almost 380 metres.

Local relief on the Shield is marked by numerous rivers and lakes, commonly 15 to 30 metres deep, and by rocky hills or morainal ridges formed by glacial debris. In northwestern Manitoba, the surface is hilly, with rock outcrop, eskers, and drift ridges rising 100 metres above the valley bottoms.

The Precambrian Shield in Manitoba is divided into two geological or structural provinces. To the southeast, the Archean rocks of the Superior Province, the oldest known in the Shield, have an easterly structural grain and were involved in the Kenoran mountain building that ended approximately 2.5 billion years ago. Isotopic studies of these rocks indicate they were formed approximately 2.5 to 3.0 billion years ago.

To the northwest, the Churchill Province contains Proterozoic and Archean rocks that were involved in the Hudsonian mountain building, which ended approximately 1.7 billion years ago, and exhibit both an easterly and northeasterly structural grain. Isotopic ages for these rocks range from approximately 1.7 to 3.3 billion years.

A highly deformed boundary zone, produced by the collision of two pre-existing continents, is characterized by complexly interfolded and faulted Archean gneisses and some supracrustal Proterozoic rocks where the Churchill and Superior Provinces meet. Part of this boundary zone is the Thompson Nickel Belt, which contains some of the world's largest nickel deposits. The Churchill-Superior boundary zone reveals a distinctive signature and trend when its magnetic properties are mapped from the air, using modern instruments. Using these techniques, the boundary zone can be traced underneath overlying Phanerozoic rocks far into Ontario to the east and North Dakota to the south.

Throughout most of Manitoba, the Precambrian Shield was reduced to an almost featureless plain by the time the initial sediments of the Phanerozoic era were deposited.

Commercially important industrial minerals in this geological region include granite, peat and the varied production from the Tanco mine at Bernic Lake.

Top: Manitoba's Precambrian Shield houses a wealth of minerals beneath its lakes and forests.

Bottom: Exposure of Dolomite, Silurian Interlake Group, Grand Rapids, Manitoba.

Evaluation Techniques

In many respects, exploration for industrial minerals resembles the search for base metal deposits. Trenching, sampling, drilling and reserve estimates are common to both parts of the mineral exploration industry. But some unique characteristics shape exploration practices. The low unit values for most industrial minerals dictate the amount of overburden that can be removed economically and the distance from markets that is feasible — factors that are secondary considerations in metal mining operations. Unit value rarely allows economical underground mining.

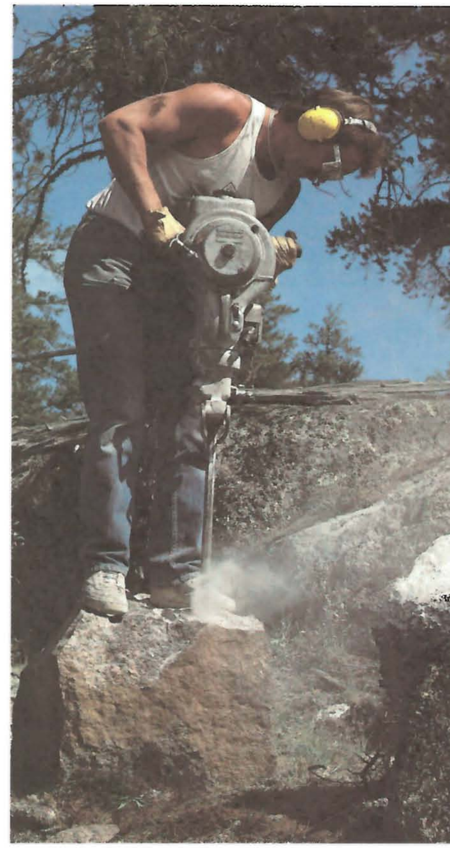
A second consideration for industrial minerals explorationists is the amount of impurities in a deposit and the nature of the impurities. These can be vital factors, as few of the low-value industrial minerals are profitable if they require expensive flotation or leaching processes to meet industry requirements.

Most promising deposits, especially those close to urban areas, have been known for decades, sometimes prior to European settlement in Manitoba. In these cases the challenge was not exploration, but evaluation and development. Early production was often haphazard, conducted by small companies with little or no exploration of the resource. Many of these early producers are now abandoned, as economies of scale pushed the smaller companies out of the market in favour of larger, centrally located producers.

The search for economically viable industrial mineral deposits is also shaped by forces which have little to do with geology. In the world metals markets, a system of commodity exchanges — such as the dominant London Metal Exchange — similar to Winnipeg's Grain Exchange, handles the marketing of the processed metal. As a result Inco can sell its nickel and Hudson Bay Mining and Smelting can sell its copper and zinc, without concerning themselves with the end users. Industrial minerals, for a number of historical and economic reasons, have not developed any similar system.

Industrial mineral producers sell directly to the companies or individuals which use or retail their product. This means that there is no assurance of any market, at any price for any of their product. To adapt to this economic fact of life, producers must evaluate potential or existing deposits in light of the specifications demanded by individual customers. Or, to reverse the equation, if they find a deposit with perhaps unique composition or mix of minerals, they must go out and search the market to see if there are any users who would prefer that product to the one they currently use.

So the market for industrial minerals is constantly in flux, as new technology brings different specifications to be met by raw material suppliers and as buyers and sellers react to new deposits and economics. This demands that the industry constantly reviews its evaluation criteria to make sure they remain in step with market place demands. It also often places exploration in a secondary role to evaluation and marketing when a company tries to expand its operations.



Sampling granite with a plugger and feather/wedge, Nutimik Lake, Energy and Mines summer project.

Evaluating the economic potential of mineral deposits is part science and part art. The first steps in the process are taken by the geologists in the field.

Figure 3 ***Present and past producers, and significant industrial mineral deposits, 1988.***

Mining and Quarrying Methods

Due to differing requirements of purity, unit value and physical properties, each industrial mineral must be mined in a different manner. Some, such as tantalum and spodumene, are mined in underground operations identical to base metal mines. By contrast, limestone and gypsum are drilled and blasted in quarries that resemble open pit mines, but on a smaller scale.

Building stone, either granite or dolomite, must be quarried carefully in order to minimize damage. Quarrying of granite is a specialized art that uses blasting caps to jar blocks loose, after the outline of the block has been drilled. In the softer building stones, large saws are mounted on tracks that run parallel to the working face of the quarry. The saws cut the slabs loose with a minimum of damage.

The clay minerals, brick clay and bentonite, are simply scraped from the clay beds with a bulldozer after the overlaying material has been removed.

Peat offers unique challenges. First the bog must be cleared and drained. Then the exposed peat is disced using a conventional tractor. After the turned up peat has dried in the sun, tractor mounted vacuums harvest the peat. The bulk peat is stockpiled near the plant to await final processing and packaging. Within the plant, the peat is cleaned of debris, put through a tumbler and a series of sieves to produce a saleable product. The peat is then compressed into bales and wrapped in plastic.

Unlike metal mines that normally extract ore at rates of several thousand tonnes per day, industrial minerals operations are small (10 000 to 100 000 tonnes per year), relatively long-lived, extractive sites. Very few metal mines have life expectancies longer than 25 years, yet the majority of industrial minerals sites, in the more heavily populated areas of the eastern U.S., have operated for more than 100 years. In some cases, such as the granite quarries at Barre, Vermont, they are still in production after nearly 300 years.

The small scale and long life expectancy of an industrial mineral operation places different constraints on the layout and techniques used in their quarrying. Most of the quarries are operated by fewer than 10 people, often by only one or two, with mobile equipment that can be easily transported from one site to another. A large number of the quarries, especially in northern and central Canada, are seasonal. A four to five month winter break from quarrying is common, with the processing plant relying on previously stockpiled raw material to keep the processing and/or marketing operations going.

The relatively low value of the majority of bulk industrial minerals makes transportation a major factor in the location of not only the quarry, but also the processing plant. Establishing the processing plant close to the source of raw materials, minimizes problems with transporting unusable material, carrying excess water in the raw material, and environmental concerns with dust and heavy truck traffic.

The ideal situation is a processing plant adjacent to the quarry. This is not a common situation for most industrial minerals producers in Manitoba, with a few exceptions. The result is that, on the whole, Manitoba is a high-cost producer of items such as brick and wallboard. This in turn limits the markets for these products.

Above: Extraction of Tyndall Stone at the Gillis Quarry, using a circular rock saw.

Flame cutting with an oxyacetylene flame, Canadian Shield Quarry.

Overview of Manitoba's Industrial Minerals Industry

Resurgence in Manitoba Mining

Mining, in all its forms, is a key segment of Manitoba's economy. On average, mining accounted for 5.12 per cent of Manitoba's Gross Domestic Product during the last decade (from 1978 to 1987). After hitting a low of 3.93 per cent in 1982, the mineral industry's contribution to the GDP climbed back up to 5.02 per cent in 1987. The resurgence in 1987 signalled dramatic growth in both volume and monetary value of Manitoba's mining industry.

In 1987, Manitoba's mineral production surpassed the billion-dollar mark for the first time, with the value of mineral production reaching its highest level ever, at $1.016 billion, or $941.61 per capita, up from a $732 million average annual production value over the last decade. This figure was a 33.1 per cent increase over 1986.

As of 1987, 5 258 Manitobans worked in mines, quarries, smelters, and refineries. With wage levels traditionally second only to the construction industry, the minerals industry is an important source of income for Manitobans.

The mining industry also brings significant income to the province as a whole. In 1987, the mining and petroleum industries brought a total of $60.5 million in revenue to Manitoba through direct industry taxes and royalties. This is in addition to the indirect benefits the province receives through corporation, sales, and income taxes. As we shall see, the industrial minerals sector contributes a healthy portion of this revenue to Manitoba.

Minerals contributed over 29 per cent of the value of Manitoba's 1987 resource production. Ranking after agriculture, mining exceeds electric power, forestry, fishing, and hunting in importance to Manitoba's economy.

Industrial Minerals*

In the last decade, industrial minerals have accounted for an average 14.9 per cent of the total value of mineral production in Manitoba. This makes industrial mineral production a small but significant part of Manitoba's mining industry, next to metals' 71.2 per cent share over the last 10 years. Petroleum production accounted for 13.9 per cent of all minerals and petroleum production in Manitoba in the last decade. Industrial minerals' 1987 industry share, 14.2 per cent, was very close to its 10-year average.

A buoyant construction industry boosted industrial mineral production in 1987, especially that of cement. In fact, the value of production of construction materials like cement and building stone in Manitoba has grown steadily over the last two decades.

The value of Manitoba industrial minerals production has averaged $107.2 million per year in the last 10 years. In 1987, the industry hit an all-time high of $144.7 million. This was an 8.7 per cent increase over the previous year's production.

Taking inflation into account, the value of 1987 industrial minerals production was still 4.2 per cent higher than the previous year, and beat the 10-year average by 8.6 per cent.

Employment in the industry has increased correspondingly. A low of 709 in 1981 jumped to 1 050 by 1987, beating the 10-year average of 904 Manitobans employed directly in industrial minerals. Including Manitobans employed in "spinoff" services and industries that depend on mining, the number of jobs created indirectly by the industrial minerals industry is two to three times those created directly. In recent years, the industrial minerals industry has been increasing its share of employment in both the mining sector in general and in Manitoba's total labour force.

Industrial minerals are also an important source of revenue to the province. During the 1986-87 fiscal year, Manitoba collected $576 200 in quarry royalties, $82 100 in lease rentals on Crown land, and $4 400 in administrative fees. Overall, industrial minerals constituted about 41.5 per cent of the

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*Statistics Canada does not include materials extracted from Tanco Ltd.'s mine near Bernic Lake in its aggregated production data. These figures are expressed separately in the next section.

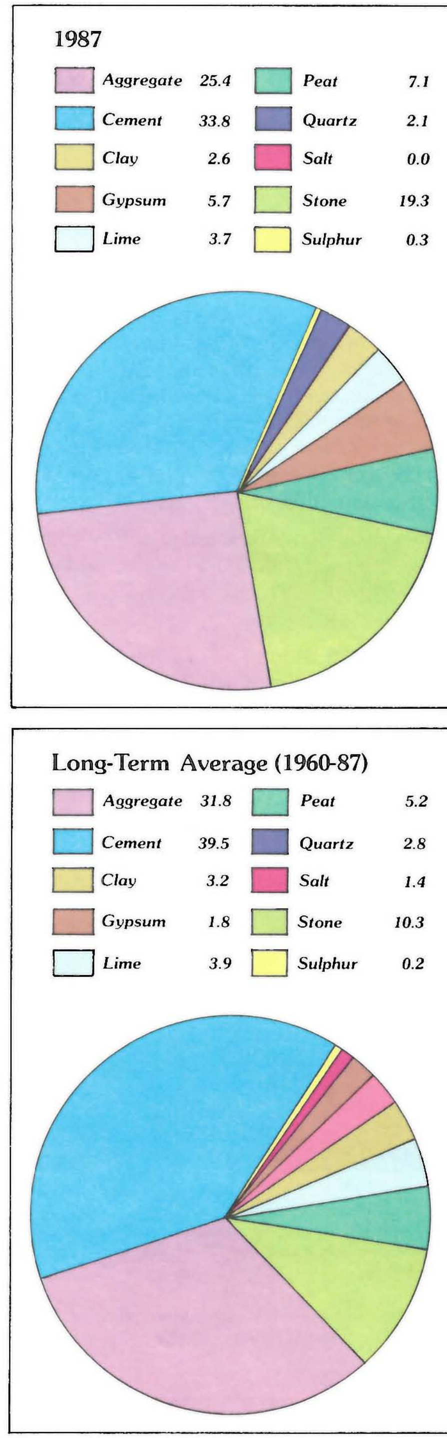


Figure 4 Percentage of Industrial Mineral Production as a Proportion of Total Output Value.

province's total revenue from the minerals industry.

Aggregate resources (sand and gravel) provided 58 per cent of the royalty revenue Manitoba collected from industrial minerals production in 1986-87. Gypsum and building stone production each contributed 12 per cent; lime and peat, six per cent each; quartz, five per cent; and one per cent of royalty revenue came from production of clay products.

Production in 1987

In 1987, cement made the largest contribution to industrial mineral production in Manitoba, at 33.8 per cent. Figure 4 gives each commodity's share of industrial mineral production in 1987, as well as its long-term average share from 1960 to 1987.

Table 2 provides the quantity of each industrial mineral commodity produced in 1987 and 1986, as well as the average in the last decade.

Table 2

Quantity (in Tonnes) of Industrial Mineral Production, By Commodity

Mineral Commodity	1987	1986	Average 1978-87
Aggregate Products	13 000	13 050	12 205
Cement	451	415	483
Clay Products	data not available*		
Gypsum	431	247	201
Lime	data not available*		
Peat	62	61	59
Quartz (Silica Sand)	data not available*		
Stone Products	4 125	4 100	2 652
Sulphur	3.0	2.0	2.33**

*Products in this category have dissimilar forms of measurement and so do not add up.

**This is a three-year average only, as production stopped after 1977 and did not resume until 1985.

Figure 5 provides the real value (in 1987 dollars) of each industrial mineral commodity produced in 1987 and 1986, as well as the average in the last decade.

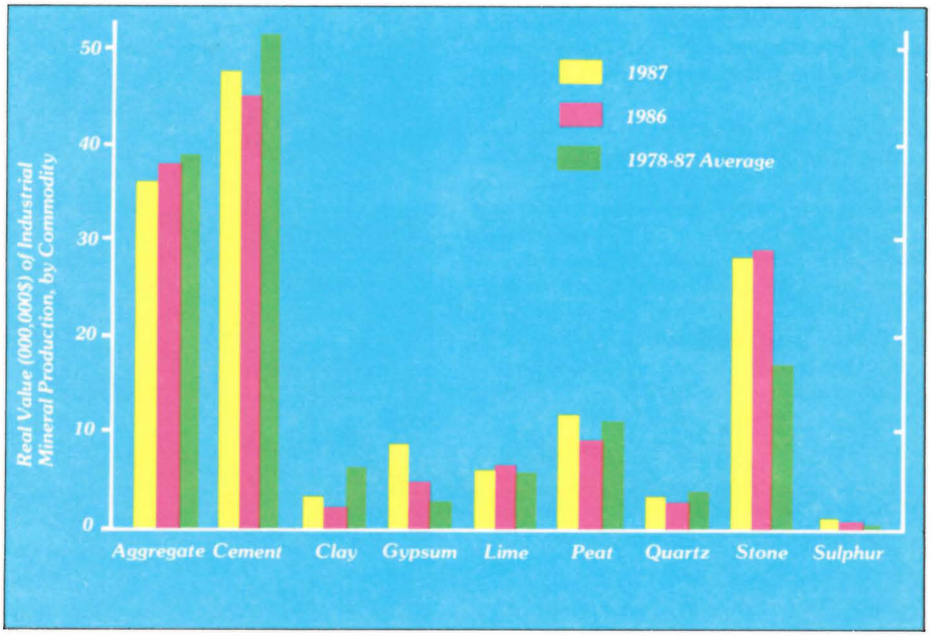


Figure 5 *Real Value (000,000$) of Industrial Mineral Production, by Commodity.*

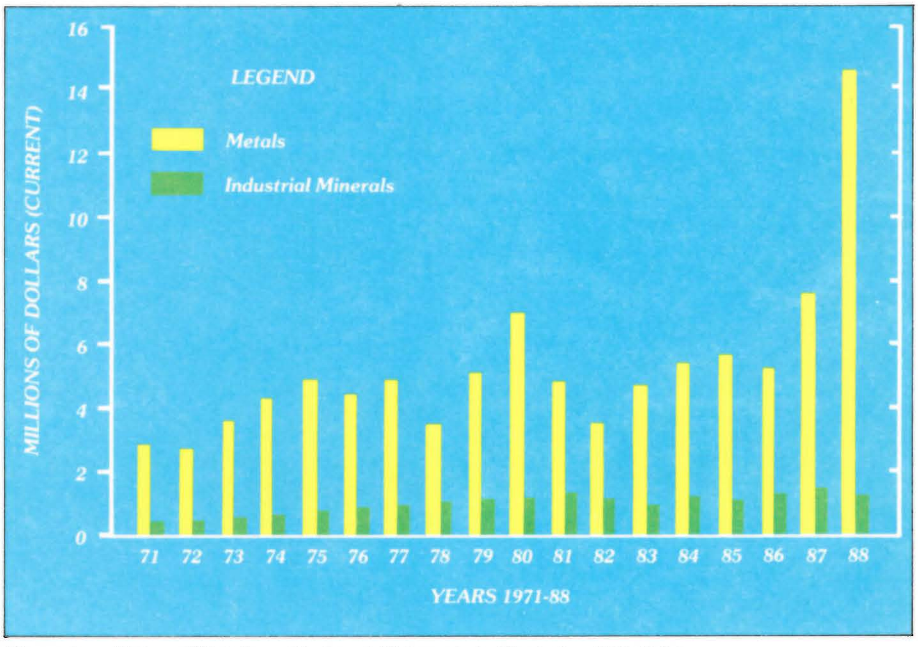
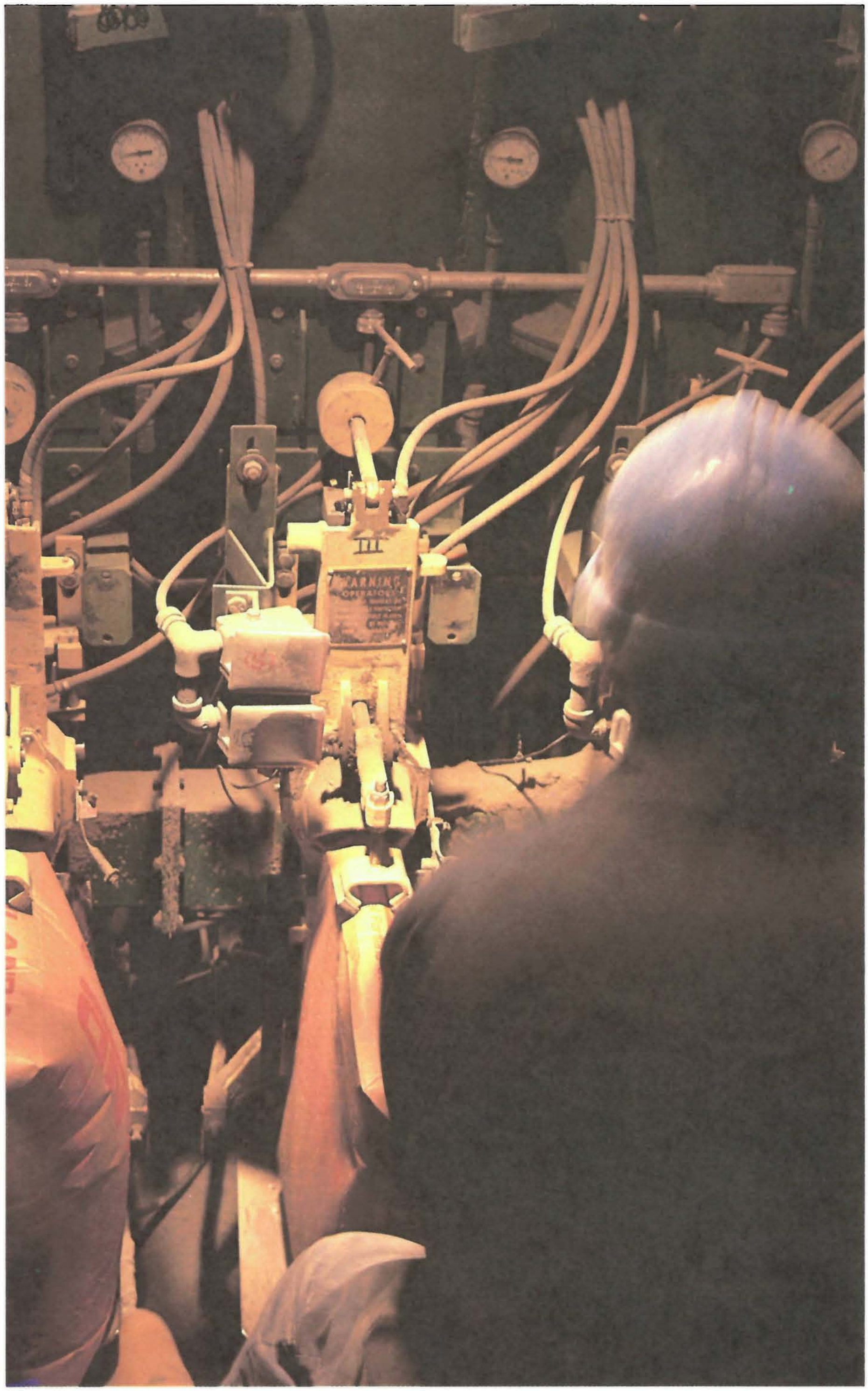


Figure 6 *Value of Metals and Industrial Minerals in Manitoba 1970-1987.*

Figures 5 and 6 indicate a healthy industrial minerals industry, with long-term increases in production in most categories.

Production from Tanco Ltd.'s Bernic Lake mine are not included in tables of industrial mineral production values because Statistics Canada treats them as metallic minerals. In 1987, Tanco sold 36 000 kilograms of tantalum, worth $2.40 million, from its stockpiles (tantalum production stopped in 1982, but re-commenced in 1988). In addition, Tanco produced $3.9 million worth of other industrial minerals, including cesium and lithium, in 1987.



Careful attention to quality has kept Inland Cement's Fort Whyte plant a key supplier to Manitoba's construction industry.

Present Producers in Manitoba

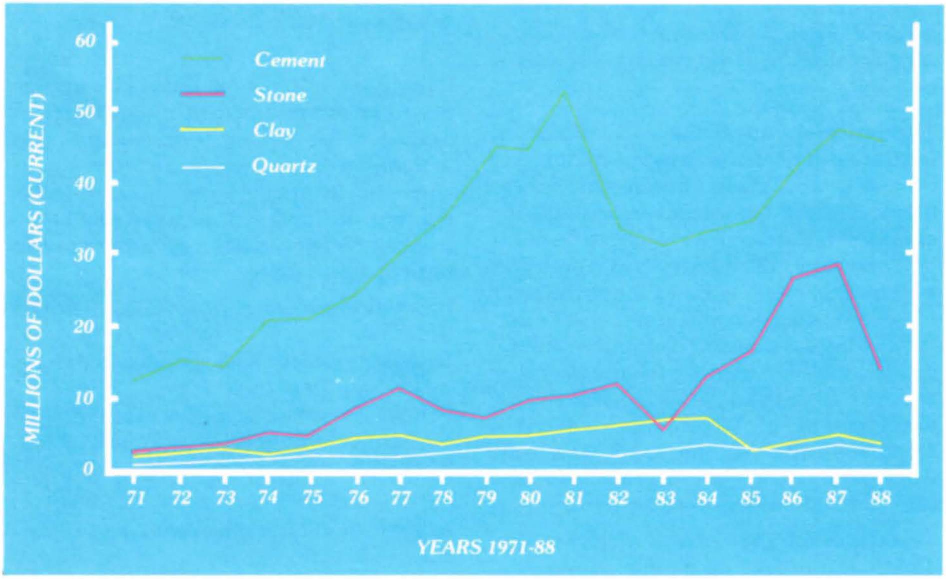


Figure 7A: *Value of selected industrial mineral production, 1971-1988.*

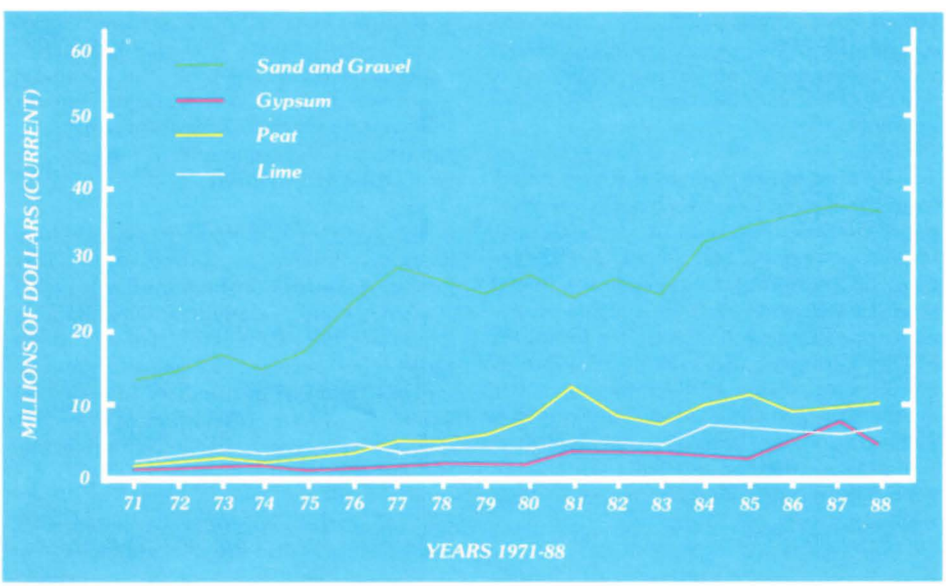


Figure 7B: *Value of selected industrial mineral production, 1971-1988.*

Precambrian

The Precambrian Shield (Fig. 3) is famous for its wealth of metallic minerals. But it is also host to some of Manitoba's most interesting, and profitable, industrial minerals.

Rare Elements

Several rare elements exist in the granitic pegmatites of Manitoba. These include beryllium, cesium, gallium, lithium, molybdenum, rubidium, tantalum, and tin. Rose quartz, topaz, and tourmaline also occur in the pegmatites. The pegmatites range in size from small pods or lenses to the giant zoned Tanco mine at Bernic Lake — one of the world's largest rare-element-bearing pegmatites. Most of the known deposits occur in southeastern Manitoba.

Small amounts of all these rare elements were produced in Manitoba before mining commenced at Bernic Lake, but all current production is from the Bernic Lake pegmatites. Mined by different companies over the years, the Bernic Lake deposit has produced important amounts of spodumene, a lithium ore, and cesium as well as lesser amounts of rubidium, gallium, and beryllium. But its primary significance lies in its large tantalite (tantalum ore) reserves — a resource that is matched in only a few places world-wide.

The steel industry is the primary user of tantalum, using it as an alloy to provide the hardness required for metal cutting tools. It is also used in the production of tantalum/nickel/cobalt alloys that are a major heat resistant component in high temperature turbine engines.

Major lithium consumers include the aluminum, ceramics, glass, grease and synthetic rubber industries. An aluminum-lithium alloy, still in the development stage, has advantages over pure aluminum in aircraft parts and may be an important future consumer of lithium.

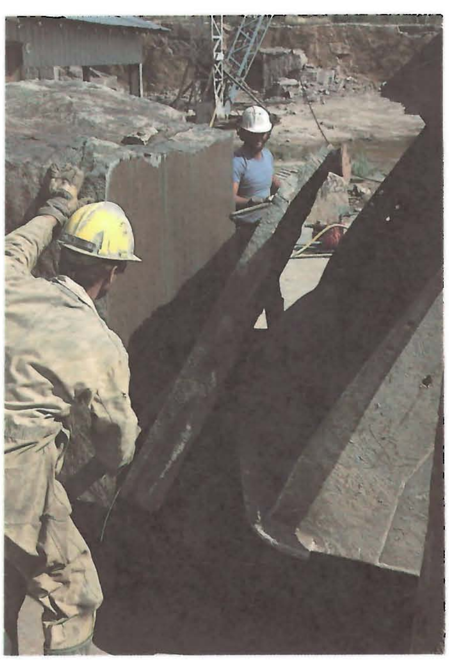
Cesium is a key material for research on energy conversion devices such as solar cells. There are only two sources of cesium ore in the world, Tanco and the Bikita Mine in Zimbabwe. Cesium is currently produced on a contract basis.

The Bernic Lake pegmatite is unusual in the number of minerals found in one deposit. But the history of the mine is a good example of the way industrial minerals producers must respond to market forces and changing end-use technology. In the first period of mining at Bernic Lake the operator produced tantalum, cesium and spodumene in small quantities in order to establish processing procedures and test markets. During this period, 1959-1981, spodumene was tested as a raw material for ceramics. Increased competition and decreased demand reduced the profitability of spodumene during much of the 1960s and 1970s.

Because of this the second, more extensive phase of mining, 1967-81, was conducted largely for tantalum and cesium. Spodumene was investigated seriously again in the late 1970s, largely as a source of lithium carbonate for the chemical industry. The ceramics industry was looked on as a smaller potential market for the highest grade material.

Following a period of volatile prices and constrained world demand, Tanco stopped mining tantalum in 1982, meeting market demand from its stockpile, and leaving spodumene even more crucial to the mine's viability.

After granite blocks are quarried they can be saw cut into slabs for finishing.



The introduction in the early 1980s, of lithium carbonate processed from Atacama Desert brines, made spodumene uneconomic for the traditional market in the chemical industry. Tanco had to look for new markets. Geologists had noted low iron spodumene — white-coloured instead of the more common light green — at Bernic Lake. This spodumene had an advantage in the ceramics market, where iron is a serious contaminant. With Dow Corning's development of VisionWare, which is manufactured using only spodumene and which requires an extremely low iron content, Tanco found an ideal market.

To take advantage of this new market, Tanco and one of its parent companies, Kawecki Berylco, commissioned a pilot ceramic-grade spodumene plant in 1984, using a portion of the idle Bernic Lake tantalum mill. This pilot project was a success, and in the spring of 1986, a new $6.4 million spodumene flotation plant was completed. Spodumene production, currently a seven-day-per-week operation, combined with the renewal of tantalum mining in August 1988, has rejuvenated this once-idle mine.

The volume of ore concentrate produced from the Bernic Lake deposits is modest: approximately 100 tons of tantalite, 600 tons of pollucite (cesium ore), and 15,000 tons of spodumene (lithium ore) every year. However, their high market prices make production attractive. The Tantalum Mining Company of Canada Ltd. (Tanco) employs an average of 30 employees, with production currently valued at about $6.8 million annually. With the reopening of tantalum production in 1988, total output from Tanco could increase to about $8.0 million per year.

Several studies are underway to identify markets for other significant minerals in the Bernic Lake pegmatite, particularly potassium and sodium feldspar, which could broaden the product base of the Tanco mine and reduce the boom or bust cycles of the past.

Dimension Stone

Dimension stone is natural rock that has been quarried and shaped to specifications for use in the building, construction, and monument industries. It includes rough stone, blocks, panels, and polished material, but not crushed or powdered stone used as an aggregate or reconstituted to form artificial stone.

Dimension stone is commercially classified as:

Granite:	crystalline igneous/metamorphic rock
Sandstone:	granular sedimentary rock
Limestone:	non-polished carbonate rock
Marble:	carbonate-bearing polishable rock

In 1986, Manitoba dimension stone quarries produced 1 882 tonnes of granite and 20 875 tonnes of limestone. There is currently no commercial production of sandstone or marble dimension stone in Manitoba.

World production of dimension stone totals about 15 million tonnes per year, with Italy accounting for one-third. Canada produced over 4 million tonnes, valued at $28 million, in 1987. Quebec is by far the dominant producer of dimension stone in Canada, followed by Ontario, with Manitc tant third. Four companies quarr sion stone in Manitoba.

Gillis Quarries Ltd. produces a dolomitic limestone known as Tyndall stone. This famous dimension stone, sometimes called "tapestry stone," is an attractive dolomitic limestone from the Selkirk Member of the Ordovician Red River Formation. Its unique colour comes from a matrix of light buff limestone, with mottled areas of brownish dolomitic limestone distributed uniformly throughout.

Gillis Quarries Ltd., incorporated in 1925, extracts slabs that are cut and finished at its Garson plant. The stone is used primarily as building, monument, and ornamental stone, with small or irregular pieces used as flagstone and crushed rock. It is shipped by rail and truck, mainly to markets in Manitoba, although the stone is marketed across Canada.

In the past few decades, hundreds of Canadian buildings have been built of Manitoba Tyndall stone, such as Regina's CBC Broadcast Centre and T.C. Douglas Building, Saskatoon's University Hospital, the Winnipeg Art Gallery, the Winnipeg City Hall and Convention Centre, the Japanese Consulate in Edmonton, and the University of Manitoba's Max Bell sports complex.

Whiteshell Quarries Ltd. markets a flagstone rock called Flame Rock, as well as some limestone, sandstone, and granite. Flame Rock, the quarry's primary product, contains mica flakes which give it an attractive reflective finish. It has been used extensively as a fireplace finishing surface in Winnipeg houses.

Cold Spring Granite (Canada) Ltd. produces unfinished or semi-finished granite for its parent company in Minnesota. Final finishing is done at the Minnesota plant for marketing in Canada and the United States. Shield Quarries of Canada Ltd. produces granite which is used mainly for monuments. All of its output is shipped to eastern Canada for finishing. Both quarries produce granite with a distinctive reddish colour and an attractive grain. During the 1920s and 1930s, several small quarries along the Thompson — The Pas railroad produced a pink-red patchy ornamental dolomite used for doorposts, lintels, and similar products. However, these "Manitoba Marble" quarries are now closed.

Most Manitoba dimension stone production is shipped to markets as rough blocks. Dimension stone cutting is performed by Tyndall Stone producers, but there are no full-scale finishing plants in the province. On the other hand, for a different stone product, blocks of rough granite are imported from Quebec to be cut and polished in an automated tile finishing plant located in Winnipeg. This operator, Canital Granite Ltd., produces ornamental tiling.

Suitable granite exists within Manitoba Provincial Parks, but development hinges on satisfying all parties that commercial quarrying will not encroach on the recreational use of the park. If available deposits were exploited, granite floor and wall tile markets could be expanded to the greater part of western Canada and the United States.

Extracting cut block of Tyndall Stone for transportation to the finishing plant, Gillis Quarry, Garson.

Granite blocks being lifted from the quarry, Cold Spring Granite Quarry.

With new trends in architecture, granite is being re-discovered as a dimension stone. As a result, the market for dimension stone and other building stone products has been strengthening. With several potential granite quarries located close to transportation routes in southeastern Manitoba, opportunities exist for further expansion and development of the dimension stone industry.

A long-standing exploration program exists in Manitoba, and Manitoba Energy and Mines maintains extensive files on promising sites. To aid the industry, Manitoba Energy and Mines offers samples of honed, polished, and fired building stone from various potential new quarries to investors, stone product wholesalers, and architects.

Harvested peat being loaded for transportation to the processing plant.

Quartzite

Quartzite is a metamorphic rock containing quartz, a silica mineral. This mineral is used in the glass and ceramics industries, in the manufacture of refractories as metallurgical flux, in the manufacture of silicon carbide as an ore of silicon and ferrosilicon, as foundry sand for metal castings, in sand blasting, and as a filler material in tile, asbestos pipe, concrete, and bricks.

The distribution of quartz and quartzite in Manitoba is widespread, but except for local use by the mining industry, the product is too low in value to make commercial development likely in the Precambrian Shield.

About 20 kilometres southwest of Thompson, Inco Limited extracts a silica-rich quartzite from the Manasan quarry. The smelter furnaces use a coarsely crushed product as fluxstone and a more finely crushed product as a converter flux. The sand's 80 per cent silica content removes impurities from the molten mixture during the smelting process.

Some of the most interesting quartzite outcrops in Manitoba are those east of the port of Churchill. They are cut by quartz veins, a few of which contain small amounts of the rare blue phosphate mineral, lazulite, known elsewhere as a minor gemstone. Occurrences have also been observed near the Cape Merry historic site northwest of Churchill.

Peat Moss

Peat is not quite animal, vegetable or mineral. It comes in two types — moss peat and grass peat. While both thrive in Manitoba, only moss peat is harvested commercially. It is formed from partially transformed sphagnum moss. This moss thrives in highly acidic water, and produces acidic byproducts as it grows. This combination prevents the dead moss from decaying. So over the centuries, a peat bog is built up of layer over layer of dead sphagnum moss, mixed with bits of sand, stones, shells, and diagenetic materials produced by the moss.

The process is identical to that which produced many of the world's coal deposits. In fact, peat moss could almost be described as half completed coal. Its very high carbon content makes grass peat useful for burning. In Canada, the fibrous nature of moss peat makes it an excellent soil additive. It serves to break up heavy clay soils and help retain moisture. Its slow decomposition gives it a long life expectancy in our gardens or flower beds.

Peat moss is a significant industry in Manitoba, including bagged peat and fertilizer/peat mixes. Until 1983, the only major producer was Fisons Western Corporation, which operates east of Winnipeg from four bogs: Evergreen, North Julius and Moss Spur in the Julius area, and the Elma bog farther south. Harvesting began in 1939, and the company now has two processing plants, at Elma and Moss Spur. At the height of the season, the company employs well over 200 people, and has 80 hectares in production.

The Fisons plant is typical of peat processing procedures. The company also produces specialty products by adding fertilizer, perlite or vermiculite to the peat. This produces a ready-to use horticultural soil mix. In the spring of 1983, a new operator, Premier West Peat Moss Ltd., started production from the Giroux bog, 50 kilometres southeast of Winnipeg. They brought a second bog, south of Falcon Lake, into production in 1987.

Manitoba peat is good quality sphagnum moss, used primarily for horticultural purposes as a soil conditioner. About 90 per cent of the product is shipped to the United States, as far as Texas and California.

Phanerozoic

The Phanerozoic regions of the province (Fig. 1) contain most of Manitoba's population, and in the south is better known for its agriculture than mining and quarrying. But fortunately for us, this geological region contains a number of important industrial minerals.

Cement

Two major cement plants near Winnipeg — Canada Cement Lafarge Ltd. and Inland Cement Ltd. — constitute the industry in Manitoba. The Canada Cement plant is temporarily idle due to sluggish demand and high fuel costs. Both plants draw limestone from the Steep Rock quarry, on the northeast shore of Lake Manitoba, and clay from the Lake Agassiz multi-layered clay beds adjacent to each of the plants.

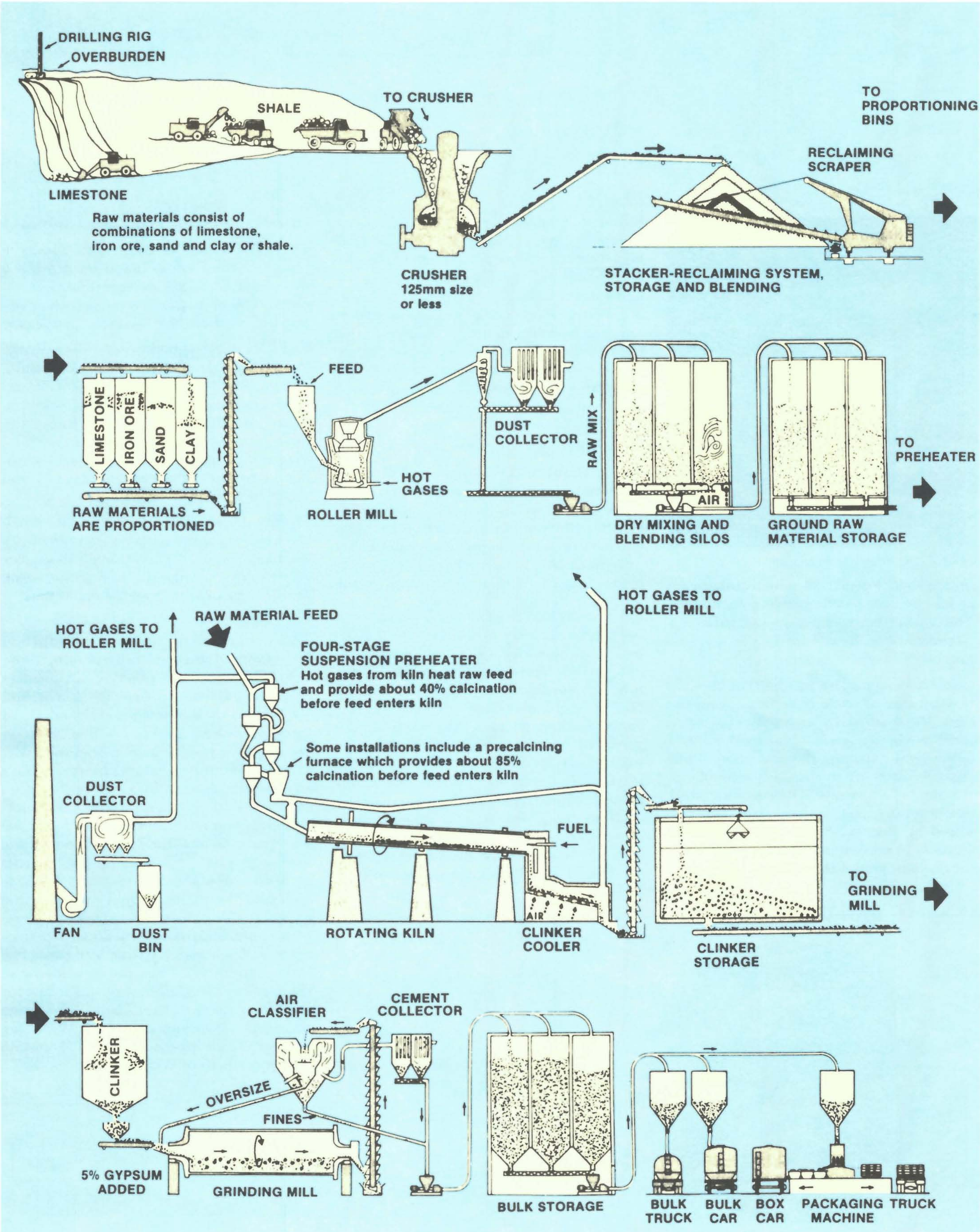
The production of portland cement (Figure 8), the industry standard, requires a carefully controlled slurry of pulverized limestone, iron oxide, sand, and clay that is heat treated in a kiln. Gypsum is added to the resulting "clinker," and this mixture is ground in ball mills to create the finished product, a fine powder.

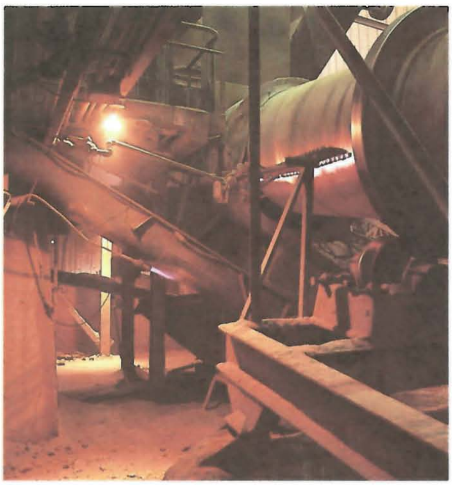
All of the raw materials are produced in Manitoba except for the small amounts of iron oxide required, which are brought in from Ontario. Clay for the cement is quarried from the fine clays deposited in glacial Lake Agassiz. Silica sands comes from a quarry at Beausejour, and gypsum from Harcus, on the west side of Lake Manitoba.

To meet modern construction standards, portland cement must have less than five per cent impurities. Cement grade limestone for the Winnipeg plants comes from quarries near Steep Rock, 240 kilometres northwest of Winnipeg. The quarry has been producing since 1913 from the Devonian Elm Point Formation. The limestone, 95 to 99 per cent calcium carbonate, contains minimal amounts of magnesium, an impurity in cement. The limestone is shipped by rail from the quarry to Inland Cement's plant at Fort Whyte.

Inland Cement also has a limestone quarry near Mafeking, south of The Pas. This operation, which began in 1956, quarries from the Point Wilkins Member of the Devonian

Figure 8 Detail of an ideal portland cement plant.


DRILLING RIG
OVERBURDEN
SHALE
TO CRUSHER
TO PROPORTIONING BINS
RECLAIMING SCRAPER
LIMESTONE
Raw materials consist of combinations of limestone, iron ore, sand and clay or shale.
CRUSHER 125mm size or less
STACKER-RECLAIMING SYSTEM, STORAGE AND BLENDING
FEED
LIMESTONE
IRON ORE
SAND
CLAY
DUST COLLECTOR
RAW MIX
HOT GASES
AIR
TO PREHEATER
RAW MATERIALS ARE PROPORTIONED
ROLLER MILL
DRY MIXING AND BLENDING SILOS
GROUND RAW MATERIAL STORAGE
HOT GASES TO ROLLER MILL
RAW MATERIAL FEED
HOT GASES TO ROLLER MILL
FOUR-STAGE SUSPENSION PREHEATER
Hot gases from kiln heat raw feed and provide about 40% calcination before feed enters kiln
Some installations include a precalcining furnace which provides about 85% calcination before feed enters kiln
DUST COLLECTOR
FUEL
AIR
TO GRINDING MILL
FAN
DUST BIN
ROTATING KILN
CLINKER COOLER
CLINKER STORAGE
AIR CLASSIFIER
CEMENT COLLECTOR
CLINKER
OVERSIZE
FINES
5% GYPSUM ADDED
GRINDING MILL
BULK STORAGE
BULK TRUCK
BULK CAR
BOX CAR
PACKAGING MACHINE
TRUCK



Cement kiln, Winnipeg.

Souris River Formation, which contains 95 to 98 per cent usable calcium carbonate. The crushed limestone is shipped to Regina, Saskatchewan by rail for use in the Saskatchewan cement industry.

Expanded aggregate production involves heating clay or shale of suitable composition. The heat partly melts the clay into a pasty mass and gas bubbles froth it into a lightweight, strong, porous solid. Lake Agassiz clays are particularly suitable for this type of aggregate. The resulting product is among the lightest and strongest found by Energy, Mines and Resources Canada in its extensive program of tests for clays or shales that swell on heating.

Kildonan Concrete Ltd. produces lightweight aggregate from Lake Agassiz clay, in St. Boniface. Immediate demand for concrete block and redi-mix concrete currently limits the volume of production. However, a construction boom or changing preferences in building materials could give this commodity a higher priority in the future. The material could be produced in larger quantities and shipped to out-of-province processors if prices warrant it.

Aggregate

Fifteen thousand years ago Manitoba was covered by an ice sheet over 3 kilometres thick in places. As the glacier advanced southward over the province, it crushed and piled up bedrock and surface materials in its path. Much of this frozen debris was incorporated into the glacier as it advanced.

Later, as a changing climate began to melt the glacier, massive meltwater rivers, flowing at tremendous velocities, picked up and carried along much of this glacial debris. As river velocities decreased, first the largest boulders settled out, then smaller cobbles, then pebbles and sand. Thousands of tons of granular material were washed out to the front of the ice as the glacier retreated northward. Meltwater rivers fed into glacial lakes, forming deltas as they deposited the remaining debris. Beaches developed along the lakeshores as wave action sorted out the gravel and sand, washing silt and clay away from the shorelines to settle in the lake bottoms.

By far the largest of these glacial lakes is Lake Agassiz. Because sand and gravel are the result of relatively recent activity — only a few thousand years ago, deposits are on or near the surface, and easily quarried.

Producing aggregate (crushed stone, sand, and gravel) for roads, construction fill, and concrete is a significant industry in any populated region. In total, it forms the most important industrial mineral category, in terms of value. Manitoba's quarries produced $36.8 million worth of sand and gravel in 1986.

Twenty large-scale producers dominate the industry, employing an average of 225 people per year. An additional 250 smaller contractors supply crushed stone, sand, and gravel from hundreds of small quarries in the province.

Fifty per cent of the aggregate production is consumed in road construction. Manitoba Highways, Manitoba Hydro, Canadian National Railway, provincial parks, and such cities as Winnipeg and Brandon are large producers and users. Fig. 9 shows the major aggregtae uses in Manitoba. The City of Winnipeg is fortunate to have excellent sources of sand, gravel and crushed dolomite within easy transportation distances. The major source of sand and gravel is at Birds Hill, just north and east of the city. These deposits are from an esker complex, used since the late 1800s as the major supplier of sand and gravel for Winnipeg. The Birds Hill complex spans approximately 20 square kilometres. While much of this is in Birds Hill Park and unavailable for development, there are still sufficient reserves to last for the foreseeable future. The major source of crushed dolomite for the Winnipeg market is the Stonewall-Stony Mountain area just north of Winnipeg.

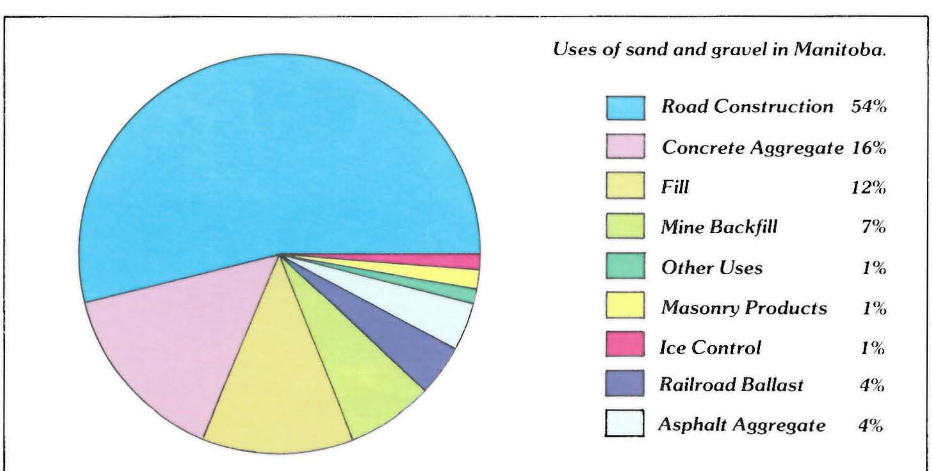


Figure 9 Uses of aggregate in Manitoba.

Northern portions of the province, particularly those underlain by the Precambrian Shield, often have a shortage of aggregate. The quarrying and crushing of basalt or other hard, brittle rock is the only alternative to expensive long distance transportation of sand and gravel into these areas. The situation is difficult for the construction of roads, as most of the shield country between Flin Flon and Thompson is very swampy, requiring extensive amounts of crushed stone. Dolomite is used in many areas, such as south of Wabowden to the area around Paint Lake Provincial Park. In the Thompson area, a glacial moraine is the major source of granular aggregate, with nearby reserves sufficient for about 70 years.

Aggregate supplies are often a critical part of large construction projects. The Limestone Generating Station, on the Nelson River in northern Manitoba, will require 553 000 cubic metres of aggregate for concrete and 2.5 million cubic metres of excavated crushed rock. In such construction projects, rock is produced from the required excavations, and any shortfall is quarried from the closest economical deposits. Although the siting of a project such as Limestone is based primarily on the contour, drop and flow of the river, sources of local raw materials is a secondary consideration which can affect the final cost of the project.

Lime and Chemical Limestone

Manitoba contains several areas of limestone with sufficient purity to be used in cement-making. Manitoba Energy and Mines staff has identified several sources of high-calcium limestone.

High-calcium limestone is produced from shallow water sediments that are almost totally made up of fossil skeletons, with a minimum of extraneous matter. The majority of the known high-calcium limestone occurrences in Manitoba are found in rocks of Devonian age, in the Steep Rock and Mafeking areas adjacent to Lakes Manitoba and Winnipegosis respectively. This production has supported a thriving portland cement, high-calcium lime, and crushed limestone industry.

Lime is produced by Steel Brothers (Canada) Ltd. at Faulkner, in the Interlake region, from a rotary kiln plant that opened in 1976, at a cost of $4 million. The plant, rated at 318 tonnes per day, uses Elm Point limestone to produce both high-calcium and high-magnesia lime for the construction industry, steel processing, the pulp and paper industry, and for municipal water softeners. Limestone is also quarried for crushed stone, and as a supplement in poultry feed.

In the long term, legislation and management practices designed to limit acid rain may stimulate lime production, as it is one of the major acid-neutralizing agents.

Bentonite Clay

Bentonite clay is an altered volcanic ash that has a high content of the clay mineral montmorillonite. In Manitoba, it occurs in the Cretaceous Vermilion River Formation, on the eastern edge of the Manitoba Escarpment near Morden. During intermittent periods of volcanic activity, the ash was laid down in thin, extensive beds in a shallow sea and thus the bentonite occurs in sheet-like deposits separated by layers of black shale. Manitoba is a major North American producer of non-swelling and acid-activated bentonite.

Established in 1939, Pembina Mountain Clays Inc. presently employs seven workers at the quarrying, grinding, and storage facilities at the deposit and in Morden. An additional 22 employees work at the treatment plant in Winnipeg. The finished product is an activated calcium bentonite in dry powder form which is sold in bulk or bags primarily to vegetable oil refineries, especially in Alberta and Ontario. The bentonite is used to remove the natural green tint of canola oil, and give it the light gold colour consumers demand in a vegetable oil. It is also used to refine waste mineral oil and tallow soaps. Pembina Mountain Clay sells several grades of bentonite and annual production is about 18 000 tonnes. The company supplies the Canadian market and the northern midwest of the United States.

A second occurrence of bentonite has been found in drill samples from the Coulter Member that underlies the Boissevain sandstone near Turtle Mountain. This occurrence contains a swelling variety of bentonite, which is used primarily as an oil well drilling mud and as a reservoir sealant. Although not presently mined, it may be correlated with the swelling bentonite produced commercially at Truax, Saskatchewan. Additional exploration of the Coulter Member is required in order to define near-surface occurrences before commercial production can be considered.

Quarrying bentonite clay near Morden.

Kaolin Clay

Kaolinite is a white specialty clay formed from weathered igneous rock. It is used as a raw material in whiteware ceramics, coating material in the paper industry, brickmaking, and filler for plastics, rubber, and paper. Kaolinite is also a potential raw material input for aluminum production.

Deposits in Manitoba are confined to the Swan River Formation and to ancient weathered surfaces on Precambrian basement rocks in the Reed Lake area, Black Island, and Deer Island. The only location currently exploited is the Red River Brick and Tile Company pit, south of Ste. Rose du Lac, where kaolinitic shales are being quarried for use in brick-making.

Red River Brick and Tile Company, owned by I-XL Industries Ltd., of Medicine Hat, Alberta, now has the only operating brick plant in Manitoba. Located in Lockport, plant capacity is 15 million bricks per year. The plant has been operating below capacity but still provides work for 30 employees for nine months of the year. Red River Brick produces about 12 shades of building brick in three sizes, as well as two sizes of paving brick. The company sells most of its product in Manitoba, although Alberta constitutes a significant market, followed by Ontario and Saskatchewan. Although I-XL Industries Ltd. has three brick plants in Ontario, the company imports large quantities of Manitoba bricks because of their unique purple-brown colour.

Other locations which have been tested for kaolinite indicate a problem of quartz, lignite and pyrite contamination, making them commercially marginal.

Gypsum

Gypsum is formed in warm evaporite seas. This leads to gypsum deposits with abundant lenses and layers of dolomite, very similar to the occurrence mined at Amaranth.

Gypsum is used mainly for gyprock wallboards (Figure 10), as a cement additive and for plaster of paris all of which are produced in Manitoba, although plaster of paris is produced only under contract. The only regularly producing quarry in Manitoba is operated by Westroc Industries Ltd.

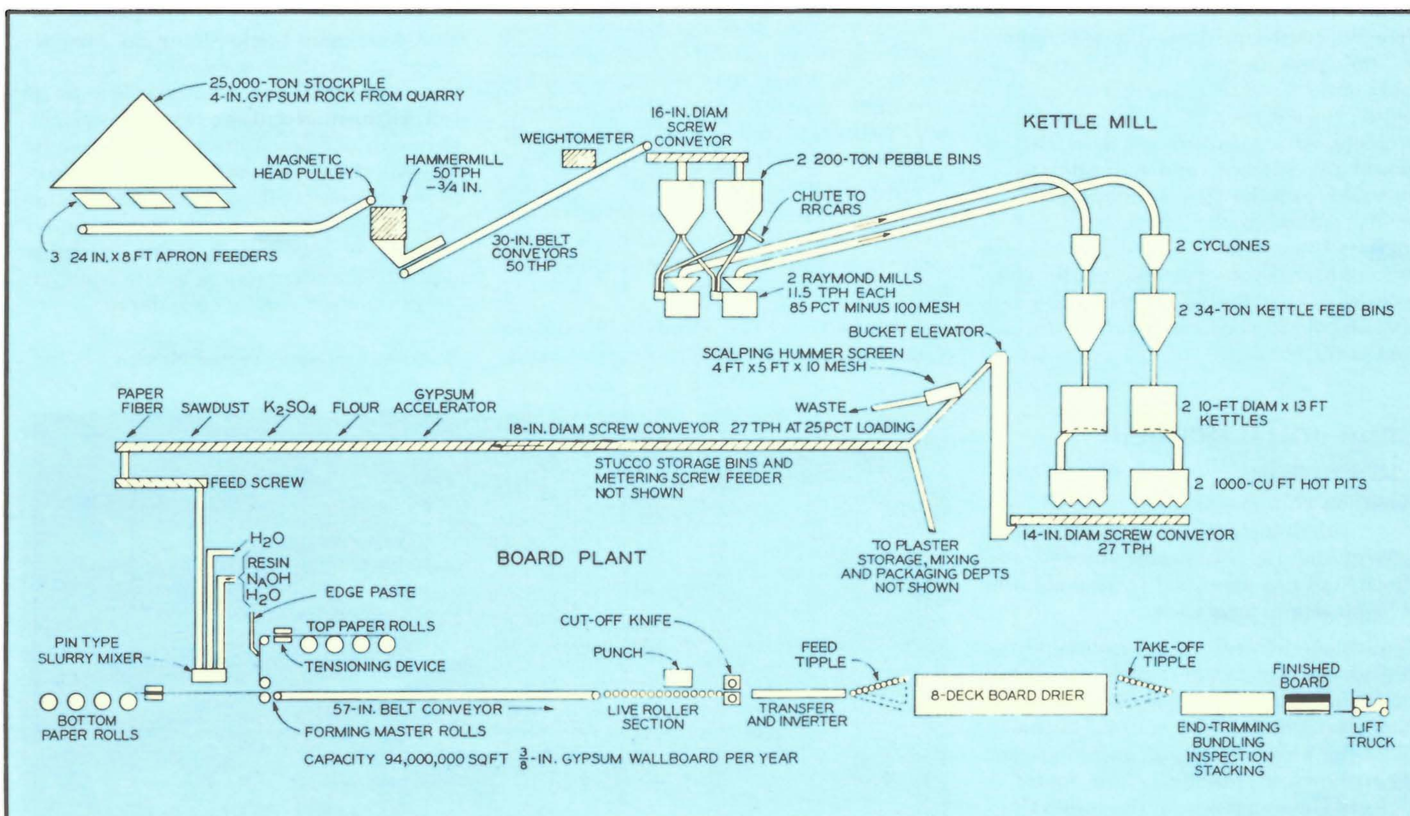


Figure 10 Simplified flow diagram for a complete small gypsum plant. Acknowledgement: reproduced with permission from "Industrial Minerals and Rocks" 3rd edition (1960).

It has been open since 1978, drawing gypsum from the Amaranth Formation at Harcus, 16 kilometres north of Amaranth. Westroc operates the quarry on a seasonal basis, trucking the gypsum to its wallboard plant in Winnipeg.

The Amaranth underground mine operated in the same area from 1932 to 1963, when Westroc moved its operations to the Silver Plains deposit, closer to the Winnipeg wallboard plant. South of Winnipeg, the Silver Plains underground gypsum mine produced from 1964 to 1975, when flooding forced it to close. An underground gypsum mine is a rarity, and the Silver Plains mine was only made economical by its proximity to the Winnipeg market.

The oldest gypsum producing region in Manitoba occurs near Gypsumville. There Jurassic deposits accumulated within the 25-kilometre-wide Lake St. Martin crater, probably formed by a meteorite during Permian time. Domtar Construction Materials Ltd. operated at Gypsumville from 1953 to 1984, shipping the gypsum by rail to the company's wallboard plant in Winnipeg. The wallboard plant now buys its gypsum from the Westroc quarry. The Gypsumville quarry is now operated by Bergner Construction, which opens it only to meet specific contracts.

Under the Gypsum Comminution Project, a joint federal-provincial program, research is being done to find new fine grinding processes that will reduce the cost of producing gypsum wallboards. With large mineral reserves and increasing efficiency, Manitoba's gypsum industry has excellent potential to expand on its established market. Traditionally, Saskatchewan wallboard and cement plants have been the major out of province consumers.

Silica sand conveyor belt and raw material storage, Black Island.

Silica Sand

Silica is produced during the summer months by Steel Brothers (Canada) Limited, from a quarry that began in 1956 on the southeast side of Black Island on Lake Winnipeg. The silica comes from a 10 to 15-metre-thick sandstone bed in the Ordovician Winnipeg Formation, which outcrops for 2 125 metres along the shore. The sandstone is quarried, then hauled to a nearby washing plant that separates the sand grains and removes impurities.

The Black Island quarry is one of the purest deposits in North America, averaging 95.5 to 97.5 per cent silica oxide before processing.

The washed sand is barged to the company's Selkirk plant, where it is processed into foundry sand, or sent to Redcliff, Alberta, where it is used in glassmaking. The finished glass sand contains 99.5 to 99.7 per cent silica oxide. The Selkirk plant operates year-round, in the winter using sand stockpiled during the summer.

In 1988, Dow Corning used silica sand from the Black Island quarry to test a new silicon metal manufacturing process under development in Austria. The new process involves a gas plasma furnace instead of a conventional furnace to smelt the silica sand. If successful, the new process could lead to an important new industry in Manitoba using the province's high grade silica sand and low cost hydro-electricity. The project offers excellent potential for a new Manitoba mineral product on the world market.

Agate

Agate is microcrystalline quartz which is used as a semi-precious stone. The agate beds in Manitoba are found in Tertiary gravels, which are believed to have been redeposited into Pleistocene age material. The best known deposit is about 1.2 kilometres east of Souris in southwest Manitoba, where the gravel is quarried for road aggregate. Other reported agate beds are found on the north slope of Turtle Mountain and the north and east slopes of Duck Mountain.

The Souris gravel and sand deposit differs from the typical glacial gravels of this region in that it contains a large proportion of pre-glacial material brought in from the Rocky Mountain regions by streams that existed before the (Quaternary) Ice Age. About a quarter of the pebbles at the Souris pit are agate, jasper, or chert; about a fifth are quartz and volcanic or associated rocks; the rest are mainly from metamorphic rocks such as quartzite and argillite.

Agate is usually found as nodules, and distinguished by attractive colour-banding. The different coloured bands or layers are concentric to the shape of the nodule, the centre of which may be occupied by quartz. The agate pebbles in the Souris pit are generally less than four inches across. They show various colours and patterns, including yellow, light blue with black inclusions, clear with red or white inclusions, banded, and jet black.

The Souris River agate deposits are located primarily in a 10-acre, privately-owned open pit area operated by Souris River Gem Ltd. During the snow-free months, the deposits attract hundreds of visitors, including rock enthusiasts from Canada, the U.S., and other countries. Within the agate pit, rock enthusiasts may also find jasper, petrified wood, flint, opal, and epidote. Approximately four tonnes of these rocks are removed annually.

Souris River Gem Ltd. also cuts the agate into various ornamental shapes (such as wind chimes, clock faces, and other novelty items) for sale. In addition, the company imports rough agate from Brazil for finishing. More uniform and colourful than the Souris agate, the Brazilian agate commands a higher price. Rough agate sells for about $1.50/pound to over $25/pound, depending on origin, colour, and size.

The major international producers include Africa, Brazil, Uruguay, and India. These countries ship rough and finished agate worldwide for use as costume jewellery. Taiwan is the major distribution and gem-cutting centre for agate and other gemstones. However, it is unlikely that any Canadian agate is exported for cutting. Instead, it is used by hobbyists for ornament and jewellery-making.

Helicopters are a vital tool in mineral exploration. Here peat samples are being collected.

For geologists, extended stays in field camps, where exploration tasks are balanced by camp chores of cooking and washing up, are all part of the job.

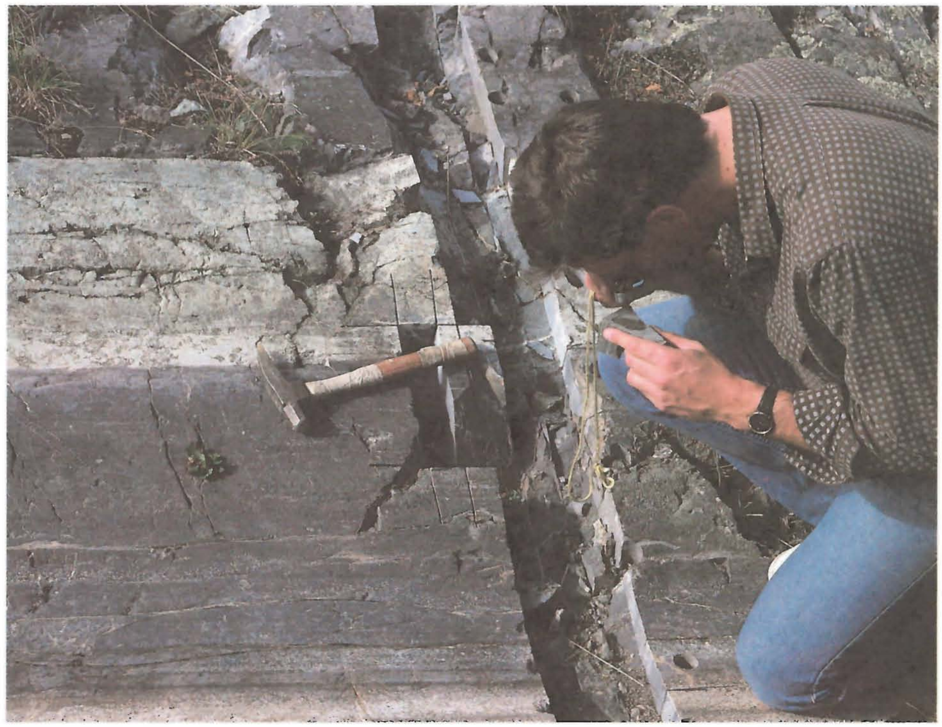
Future Mineral Potential

Alumina

In Manitoba, all sources of high-alumina material are in the form of kaolinite. Several studies have been carried out by the Canada Centre for Mining and Energy Technology (CANMET), the U.S. Bureau of Mines, and Norwegian interests to develop feasible alumina recovery processes from anorthosite and kaolinitic clays. To date, known deposits are not of a high enough grade to be commercially feasible.

Aluminum hydroxide, in the form of bauxite, is a major ingredient in the production of aluminum, but is not known to occur in Manitoba. In the 1980s, when various aluminum companies investigated Manitoba as a location for an aluminum smelter, the companies planned to import bauxite from offshore suppliers.

Alumina is used in the fabrication of refractories, or heat-resisting ceramic materials. When of high purity, it is applied to chemical processes requiring catalytic or binder support. It is also a component of high-quality abrasives.



Examining chrome seam at the Bird River sill.

Amber

Amber is a fossil resin, normally associated with lignite beds. When amber is transparent, it can be cut to make a very expensive gem. The major world supplier of gem-quality amber is the Dominican Republic. An 18-inch strand of Dominican Republic amber, cut and polished, sells for about $75. High-quality Baltic Sea amber in a 24-inch strand, cut and polished, may be purchased for about $300.

Cedar Lake's islands and shore were the source of Manitoba's amber before the Grand Rapids dam was built in the mid-1960s. Small quantities of low-quality fragments were recovered by companies interested in using the amber as a raw material for the production of varnish. The project was abandoned when no large accumulations were uncovered. All the known locations are now flooded.

Asbestos

Asbestos is a fibrous magnesium, aluminum silicate formerly used for insulation and fire resistance. Its extensive uses are now hampered by reports of health hazards. All known asbestos occurrences in Manitoba are small and occur in fractured, serpentinized ultramafic rocks. The Pipe Lake mine, near Thompson, is one major source of asbestos in the province, but has no commercial asbestos potential.

Barite

Because of its unusual density and weight, barite is used as a weighting agent in drilling fluids in the oil and gas industry. Two major producers, one in B.C. and the other in Ontario, supply the bulk of their barite production to this use. It is used also in pharmaceuticals, paints, plastics, rubber friction (brake) materials, glass, and ceramics, but Canadian barite producers cannot meet all of the domestic demand. Imports come primarily from Ireland and Morocco.

In Manitoba, barite occurs in small cavities within a limestone quarry south of Camperville, and in minor amounts associated with gold-bearing veins of the San Antonio mine near Bissett and base metal mines in northern Manitoba. None of these occurrences is commercially significant.

Chromite

Chromite is a commodity of strategic importance because its world supply, though abundant, is concentrated in politically unstable countries and the U.S.S.R. Since there are no chromite mining operations in North America, it is crucial to ensure a reliable supply of chromium for use in the fabrication of stainless steel, refractories, various chemicals, and pigments.

Chromite is only found in ultramafic rock which has a low silica content. Of all the chromite occurrences known in North America, the deposits in southeast Manitoba's Bird River Sill are currently receiving the most attention. The deposit consists of several layered seams of solid and disseminated chromite.

Bird River Sill chromite contains a high concentration of iron which new processing technology makes economically interesting for the stainless steel industry.

Both Manitoba Energy and Mines and the Geological Survey of Canada have studied the sill intensively, most recently under the Canada-Manitoba Mineral Development Agreement. These studies evaluate the feasibility of mining and processing the low-grade chromite using a fully integrated facility to produce competitive stainless steel products.

Coal (Lignite)

Lignite is plant material that has been compressed and gently heated to drive off impurities and raise the fixed carbon content. The variety of lignite coal found in Manitoba has a high volatile component. It is found as thin seams within the Tertiary Turtle Mountain Formation on the northern and western slopes of Turtle Mountain. Several small mines were in production in this area around the turn of the century, and again between 1931 and 1943, providing heating fuel for neighbouring homesteads. Thin coal seams, poor quality, and bad roof conditions contributed to the short life span of these operations.

Many companies and individuals have re-evaluated the coal seams in an attempt to operate them commercially. None were deemed economical so far, but new occurrences of lignite are reported every year. It is unlikely any major new occurrence will be uncovered, as the extent of Tertiary strata in Manitoba is well-documented.

Fluorite

Fluorite, commercially known as fluorspar, is a major industrial mineral used in the manufacture of hydrofluoric acid and as a fluxing agent for the aluminum and steel industries. Minor occurrences of fluorite are known in Manitoba, but none has commercial significance.

Kyanite

Kyanite is an alumino-silicate mineral which is used mainly in the production of synthetic and acid refractories. Kyanite is not produced in Canada. Though small in scope, the world industry is experiencing steady growth.

Minor kyanite occurrences are found scattered throughout the Precambrian. Manitoba's known occurrences of kyanite are the product of clay-rich alteration zones developed beneath massive sulphide deposits and later metamorphosed under high pressure and temperature. Several occurrences are known in the Snow Lake area, including the Anderson mine, which contains several lenses of kyanite-rich rock. Other sulphide mineral occurrences also contain aggregates of kyanite. The mineralogy of these zones is chemically controlled, and can vary dramatically over a short distance. Little is known of the extent and concentration of this potentially valuable by-product of the zinc-copper mines.

Iron

Iron oxide is used as a colouring agent in paint and a source of iron and steel production. There are several occurrences of iron oxide in Manitoba, but none has a sufficiently large volume or is accessible enough to be mined. These deposits include the Black Island hematite, and the iron formations at Shatford Lake, Neepawa, Pipestone Lake, and Wallace Lake.

Iron silicate is also produced as a by-product of the Thompson and Flin Flon smelting operations. At Thompson, this material is used as grit for sand blasting and rock sawing. The grit (Norgrit) is close to silicon carbide in hardness, and much cheaper. It has several other desirable properties for rock sawing, such as not being self-cementing, that make it an economically attractive product.

Magnesite

Magnesite is one of the minerals in which magnesium is found. Magnesium's valuable qualities include light weight, high strength and stiffness, and excellent heat dissipation. The major use of magnesium metal is as an alloying agent for aluminum. Magnesite is also used in refractories in the iron and steel industry. At present, the only producer of primary magnesium in Canada is located in Ontario.

Magnesite occurs in both ultramafic rocks and in certain dolomitic marbles. Ultramafic rock at Loonfoot Island on Island Lake has a talc-magnesite-hematite phase, but the location is too remote for development. Further geological work is required to define the extent of this form of magnesite deposit in Manitoba.

Another source of magnesium is dolomite. The Interlake area of Manitoba contains abundant reserves of dolomite in the Ordovician and Silurian strata, especially in the Stony Mountain Formation near Stonewall.

Manganese

The iron and steel industry consumes about 95 per cent of the total manganese production in the world. A strategic commodity, manganese has no substitute, and is essential in the production of nearly all types of steel. Canada currently imports all of its manganese metal as an important additive in speciality steels and aluminum alloys.

All Manitoba deposits of manganese occur at or near the outcrop of the Odanah and Millwood Members of the Cretaceous Riding Mountain Formation. Samples from manganese occurrences in the Swan River and Riding Mountain areas were collected in 1985, however, all of the known deposits are too small and too low grade to be economical.

Marl

Marl is a sediment composed of a mixture of clay minerals and calcite. It is the calcite which has applications in the fertilizer industry. For example, it can serve as an acid

Mineral samples collected in the field are then carefully analysed for chemical composition.

Bentonite dryer, after acid treatment, Pembina Mountain clays, Winnipeg.

buffer to coat fertilizer and ease its spreading.

Samples of marl from north of Riverton were collected and tested in 1960 as a fertilizer coating agent. The material had excellent buffering capacity, but retention of the fertilizer chemicals was too low to make the product viable. No further work has been done on this material. However, a mixture of peat and marl, or bentonite and marl, might be more effective as a fertilizer carrier and could offer future commercial potential.

Phosphate

Manitoba has three types of phosphate occurrences, all of which are small and currently subeconomic. These include sedimentary phosphate-rock, apatite-bearing metasediments, or carbonatites, and pegmatitic phosphates.

The sedimentary phosphate-rock deposits are of marine origin, and either occur as highly fossiliferous beds or as concentrated phosphate nodules. Thin, widespread phosphatic layers, occurring in the Cretaceous shales of the Wilson River area, are derived mostly from fossil fish bones. One four-centimetre-thick layer has an 18 per cent phosphate content. A second occurrence is located in the upper portion of the Ordovician Winnipeg Formation. Two recorded analyses give a phosphate content of 0.09 per cent and 4.8 per cent.

The second type of deposit occurs as disseminated apatite and veins in the highly metamorphosed dolomite of the Nickel Belt. The quantity and phosphate content of this type of material are not known.

Phosphates also occur within the pegmatites of the Bernic Lake area and are recovered as a by-product of the mining of spodumene and tantalite. Tanco and Manitoba Energy and Mines are studying the commercial potential of this production.

Carbonitites are very similar in mineralogy to this type of deposit. Carbonitites often contain economically interesting deposits of apatite, niobium and rare earth minerals. To date, none have been found in Manitoba but exploration is ongoing. There are known occurrences in Northern Ontario right up to the Manitoba border, and aeromagnetic mapping is being used to search for the "signatures" which characterize this type of deposit.

Common and Potter's Clays

Clays are a series of minerals composed mainly of silica, alumina, and water. To be economic, deposits require the desirable property of forming a hard, glossy surface upon heating. Common clays include potter's clay and most brick clays, whereas specialty clays, such as bentonite and kaolin, have more specialized applications. Common clays are characterized by high bulk, low unit value, and sensitivity to transport cost. Common clays are found in all parts of Canada, but deposits with excellent drying and firing properties are rare in Manitoba.

Common clay has a specific use at the smelter in Thompson. Local clay, called "swampy clay," is used as a lining for certain portions of the furnace used in the smelting process, where rigid thermal behaviour is not required. At present, an abundant supply of this type of clay is available from the local Lake Agassiz clay.

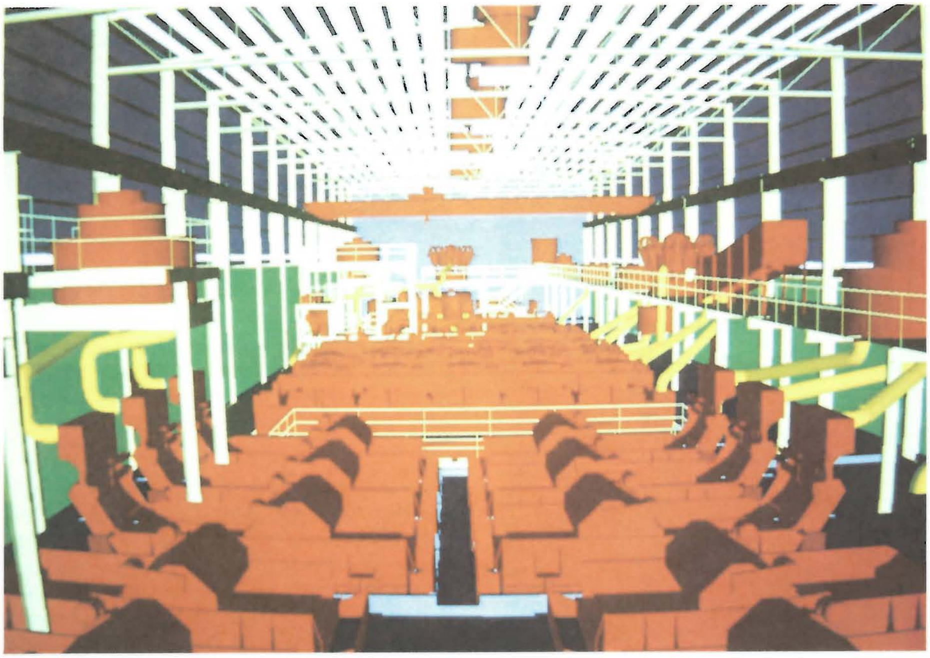
Garnet

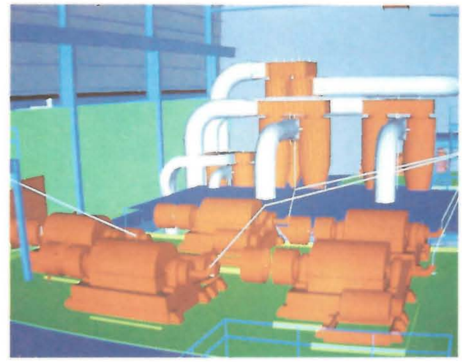
Garnet is a common metamorphic mineral whose use as an abrasive takes advantage of the mineral's hardness and tendency to break into sharp edged fragments.

Under certain metamorphic and chemical conditions, a high iron and magnesium, rock will recrystallize at 600°, into almost pure garnet. These rocks exist in Manitoba, and can produce ideal material for an abrasive product.

Manitoba's garnet deposits occur in rocks that have undergone regional metamorphism. The size and form of some crystals found to date are of sufficient quality to be considered mineral specimens. Good specimens were recovered from File Lake, west of Snow Lake. Garnets more commonly occur as multi-crystalline "snowballs." These aggregates are embedded into the surrounding rock and are often extensively fractured.

Snowball garnet, if pure enough, is the type used for abrasives. The fractures allow the garnet to be crushed to produce sharp edges that act as cutting surfaces. Several locations in Manitoba contain the correct rock chemistry and have sufficient garnet to be of interest of a source of abra-





Left: A computer generated model of the proposed potash mill. In the foreground is the wet sizing (screening) equipment. In the centre is the flotation equipment, which separates the potash from salt crystals. The centrifuges are in the background.

Above: A blown up rendition of the centrifuges used in drying.

sive. The most promising is the garnet-anthophyllite-cordierite-sillimanite gneiss at Star Lake, east of the town of Sherridon. The gneiss is a relatively thin stratiform unit with concentrations of quartz-sillimanite and abundant garnet. A study done by the Canada Centre for Mineral and Energy Technology indicates that this garnet is easily separated from the other minerals. The garnet's fracture pattern is chisel-like, a pre-requisite for a good abrasive material. Other known sources include: the Chisel Lake Mine alteration zone, near Snow Lake; the Lar, New Fox, and Gran occurrences near Lynn Lake; and the Osborne Lake mine dump near Snow Lake.

Glauconite

Glauconite is formed in sediments containing both iron and potassium, after the materials were deposited. The environment is typically a lagoon bottom with a low pH and low dissolved oxygen. In Manitoba, glauconite was discovered recently within the Swan River Formation, in the Mafeking area.

The chemistry and mineralogy of glauconite are fairly well known. However, the specific character of Manitoba's glauconitic beds is not well known, since there is little outcrop in the Mafeking area and the northeastern slope of Porcupine Mountain is an area of massive landslides.

The demand for glauconite is limited to its use in water treatment and soil conditioning. Also known as green sand and commercially as zeolite, glauconite production is valued at about $50 to $55 per tonne for water treatment grades. Manitoba deposits may become of interest in the near future, as pressures increase to strengthen water quality standards.

Potash

Potash is a term that describes naturally occurring potassium salts and products derived from them. More than 95 per cent of world potash production is used as a chemical fertilizer component.

The word "potash" is derived from the old method of producing potassium carbonate by leaching wood ashes and evaporating the solutions collected in large iron pots. The white residue left in the pot was called "pot ash."

Potassium is one of three essential primary plant nutrients. The other two nutrients are nitrogen and phosphorus. Potash helps plants synthesize starch and sugars, stimulates good flower colour and ripeness in fruits, stiffens straw in cereal crops, and enables plants to withstand adverse conditions of soil, climate, and disease. Even in soils with sufficient potassium, the application of potash ensures the maximum effectiveness of other fertilizers.

More than 90 per cent of potash fertilizers are sold as potassium chloride (KCl), also referred to as muriate of potash. Potassium chloride occurs naturally as the mineral sylvite in the deposit near Russel, in southwest Manitoba. This deposit is an extension of the potash-rich members of the Prairie Evaporite, which have been mined for the past 30 years in Saskatchewan. Extensive geological and geophysical work on this deposit has confirmed the availability of large reserves.

The high potash content in the sylvite located in the Russell deposit has stimulated a joint venture between Canamax Resources Ltd. and the Manitoba government. To date, detailed engineering and economic studies indicate that potash production commencing in the early 1990s is feasible. This world-class deposit could support low-cost production of two million tonnes of muriate of potash annually for more than 30 years. Transportation and marketing studies have shown positive results.

Improving market conditions in the 1990s, combined with low production costs, make the potash project an attractive investment. As a result, Canamax and the Manitoba government are working with potential equity partners to form a consortium to develop the project.

Potash fertilizer products must meet minimum purity and size specifications. The potassium content of potash minerals and products is measured in terms of potassium oxide (K_2O). Manitoba's average mining ore grade of 24.5 per cent K_2O makes it one of the richest deposits in the world.

Six countries account for about 90 per cent of world potash production: the U.S.S.R., Canada, the U.S., France, West Germany, and East Germany. While Canada's deposits are the world's largest, the Soviet Union produces roughly 35 per cent of the world's potash, followed by Canada at about 25 per cent.

Most Canadian reserves are in Saskatchewan, although substantial deposits occur in New Brunswick and Manitoba. Canadian potash ore grade is relatively high, with typical values between 21 per cent and 26 per cent K_2O. By comparison, the average grade of ore mined in New Mexico and Europe is about 15 per cent K_2O. The ore grade ranges from 14 per cent to 21 per cent K_2O in the Soviet Union.

Because of a growing world population, demand for potash will increase steadily to help grow the food needed to feed the world. In order to feed this new population, 75 million more hectares of agricultural land will be needed by 1994. In addition, the land now in use must be made more productive. So, there is considerable scope for potash market growth in developing countries such as Brazil, India, China, and other southeast Asian countries.

Salt

The Canadian Salt Company, in Neepawa, closed its salt production plant down in 1970 after 60 years of production. The closure was due to cheaper salt produced as a by-product from the solution mining of potash at Belle Plaine, Saskatchewan.

Dryden Chemicals Ltd., and later Hooker Chemicals Canada Ltd., produced brine for their plant east of Brandon. Salt was extracted from the brine and used to manufacture sodium carbonate and soda ash, both commercially important products. The brine was in production from the early 1970s to the early 1980s. Production was halted for environmental reasons, and because of competition from the Saskatchewan salt.

Talc and Soapstone

Talc is valuable due to its whiteness, smoothness, low thermal and electrical conductivity, chemical inertness and its high fusion temperature. Soapstone is an impure compact form of talc. Talc is primarily used in a fine ground state. It has many industrial applications. These include use in pulp and paper manufacture as a filler and coating pigment, use as an extender pigment in paints, and use in the ceramic, plastics, and pharmaceutical industries.

Metamorphosed ultramafic bodies are the best locations in which to find talc deposits. However, studies have uncovered no large talc bodies in the ultramafic rocks of the Nickel Belt, Fox River Sill, Rice Lake, or Bird River belts of Manitoba. Asbestos-bearing ultramafic rocks such as the Pipe Lake mine cannot be used as a source of talc for health and safety reasons.

The most promising locations for talc deposits in Manitoba are on islands in Iskwasum Lake, and along the Grass River in Grass River Provincial Park, east of Flin Flon. The area has moderate-to-abundant talc, mixed with dolomite. Improved processing techniques pioneered by Baker Talc, with a similar deposit in the Eastern Townships of Quebec, suggest that a re-examination of this location may prove valuable.

Another noteworthy use of soapstone is by the arts community. Native Canadian soapstone carvings are known for their beauty and value. Although only minor quantities of soapstone blocks are quarried, sculptors require high-quality pieces devoid of cracks or impurities. While Manitoba has no commercial production of soapstone, Manitoba soapstone is used extensively by hobbyists for carving.

Sulphur

Sulphur is a by-product of refining natural gas and oil products. Because Manitoba has no refining industry, and a relatively small petroleum industry, there is no commercial production locally.

Close-up photograph of a finished brick, Red River Brick and Tile, Lockport.

Manitoba Energy and Mines

Minerals Division

The Minerals Division is responsible for administration and management of all provincial mineral resources, including industrial minerals. The Division:

- administers The Mines Act and Regulations governing mineral rights, and the exploration, development and production of provincial mineral resources;
- conducts geological investigations which provide a data base for mineral resource exploration, evaluation and development;
- advises other government agencies on matters relating to the environment, land use planning, regional development, etc.;
- maintains research and policy staff to monitor the effect of provincial policy on the mining industry and to develop mineral resource policies.

Geological Services Branch

This Branch undertakes geological mapping and research, designed to provide a framework and data base for the province. The minerals industry and various levels of government use this information in mineral resource appraisal, management, and exploration. The branch also undertakes detailed and regional geoscientific investigations. Findings are made available to the public through maps and technical reports. Mapping, research and deposit investigations concentrate on areas judged to be favourable for economic mineralization, on the geological setting of known ore deposits and on the updating of geological mapping used in current mineral exploration activities.

Mines Branch

Administration of all matters under The Mines Act governing the minerals management of operating mines and quarries and the recording and collection of relevant fees and royalties, is done by the Mines Branch. Regulations under The Mines Act govern the acquisition of claims, permits and leases for the right to prospect, develop and mine Crown minerals. The mining recorders, located in Winnipeg and The Pas, process applications for mining claims, monitor staking activities, collect performance deposits, maintain records, and respond to inquiries relating to these functions. Many of the record keeping and data gathering functions are being computerized. The result will be faster, more accurate service, and increased ability to provide a variety of timely data to Manitoba's minerals industry.

The branch collects and stores exploration data and drill core samples and conducts aggregate resource inventory studies. Geophysical, bibliographic and mineral inventory reports are compiled and distributed. Branch responsibilities also include monitoring the rehabilitation of mining lands and the implementation of the provincial land use policy concerned with the conservation of mineral and aggregate resources.

For much of this century, aggregate resources were managed by the Department of Highways — a legacy of the days when they were used primarily for road construction. In 1979, they were added to Energy and Mines, as a separate Aggregate Resources Section of the Mines Branch.

Canada-Manitoba Mineral Development Agreement

The work of the Minerals Division is enhanced by a five-year mineral development agreement between the Federal and Provincial Governments. Under the agreement, which began in 1984, $24.7 million is allocated for activities keyed to strengthening Manitoba's mineral industry. These include a number of geoscientific studies designed to stimulate and assist exploration for new reserves. Activities also include a variety of projects to strengthen the technology and efficiency of the industry and to explore new mineral products and markets.

In the field of industrial minerals, the province of Manitoba and several departments have jurisdiction over various factors of exploration and production.

Table 2 is a flow sheet that demonstrates the steps necessary for the approval of a Quarry Mineral Lease. The lease, and other regulations, fall under the Mines Act, Manitoba Regulation 433/87R, Quarry Minerals Regulation 1976. A copy of this regulation is available from the Exploration Services Branch of Manitoba Energy and Mines. It outlines all the terms, conditions, and exceptions that may be encountered in the exploration, and bringing into production, of an industrial minerals deposit.

Manitoba Energy and Mines specialists deal directly with the industrial minerals operations. The department maintains an inventory of all past and present industrial minerals producers and an overview of current and potential markets for the industrial mineral endowment of the province.

Table 2

Application for Quarry Mineral Lease: Flow Chart

Name ______________________ File No. __________

	Date	Initial
Application received	______	______
Checked and plotted on plat book	______	______
Checked crown lands record	______	______
Document to cash	______	______
Clearance memo or letter to:		
Regional services, highways, and mining engineering	______	______
PFRA	______	______
Holder: mining claims	______	______
Rural municipality: road allowances	______	______
Agriculture	______	______
Forestry	______	______
Parks	______	______
Northern affairs (if applicable)	______	______
Letter for development plan	______	______
Memo to surveys for legal description	______	______
Returned from surveys	______	______
Quarry mineral lease typed	______	______
Check acreage form: any fees owing ex. rental	______	______
Forwarded for signature: company or individual	______	______
Quarry mineral lease mailed: certified cheque	______	______
Forwarded to accounting clerk to enter on ledger and alpha list	______	______
Check for cash deposits: cash deposits are forwarded to finance, or returned to company if a conversion from exploration permit to quarry mineral lease	______	______

Commodity Reports for Industrial Minerals

Manitoba Energy and Mines' industrial minerals geologists conduct extensive surveys to produce commodity-specific geological reports. These are available for most major producing, and some significant non-producing, products (see table).

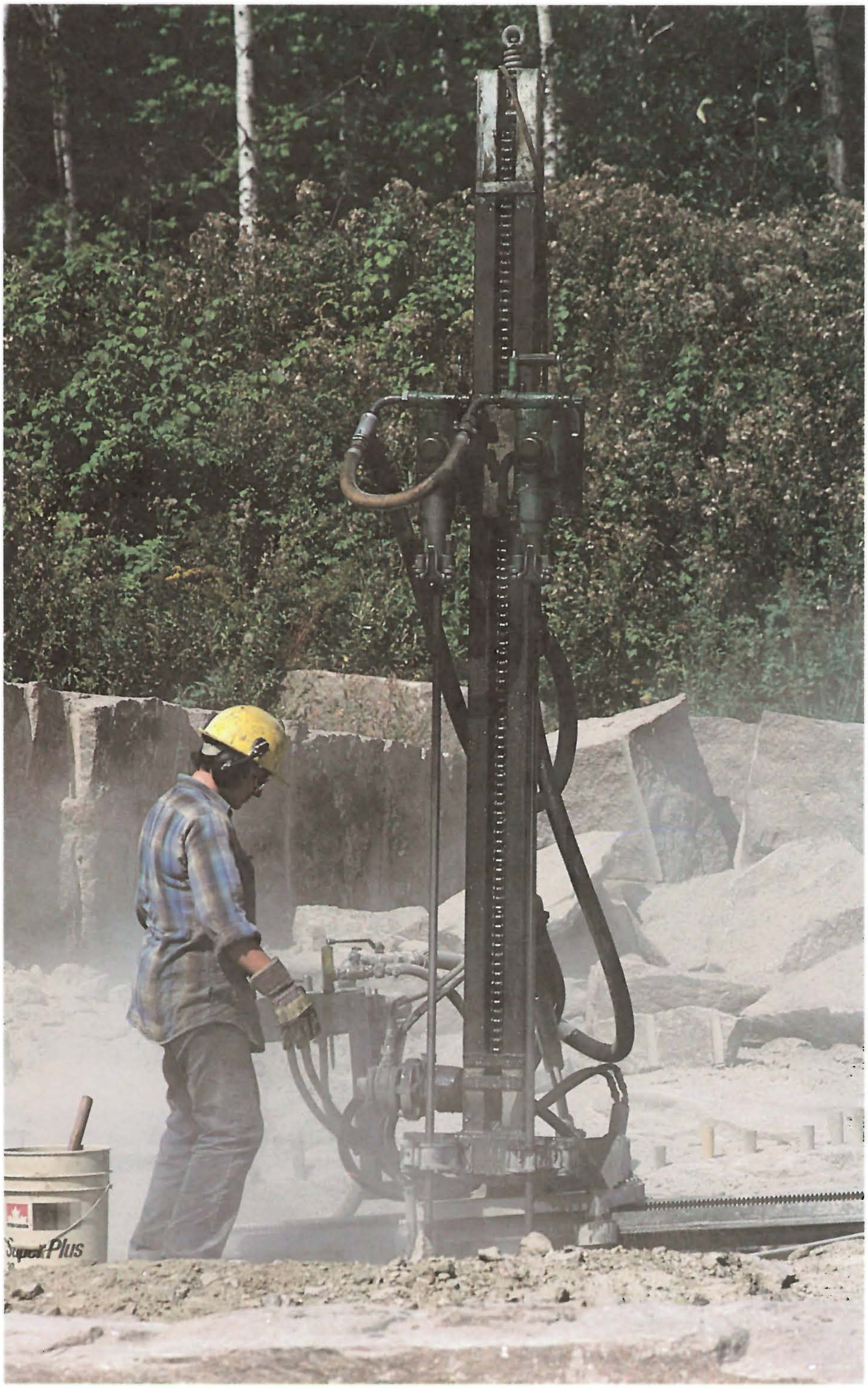
Table 3

Reference Number	*Title*
GR62-5	*Cretaceous Bentonite Deposits in Manitoba.*
GR67-1	*The Clays and Shales of Manitoba.*
ER77-1	*Summary of Available Data on Lignite Deposits, Turtle Mountain, Manitoba,* with a Note on Other Occurrences in the Province.
ER79-7	*Sphagnum Bogs in Southern Manitoba and their Identification by Remote Sensing.*
ER80-1	*The Cat Lake-Winnipeg River and the Wekusko Lake Pegmatite Fields, Manitoba.*
ER84-1	*Industrial Minerals in Rare-Element Pegmatites in Manitoba.*
ER84-2	*Silica in Manitoba.*
OF82-1	*Chromite Reserves and Geology of the Bird River Sill, Manitoba.*
OF83-3	*Devonian Potash Deposits in Manitoba.*
OF85-2	*Silica Potential of the Libau-Beausejour Area.*
OF85-7	*Industrial Minerals of Manitoba.*
OF85-8	*Chromite Reserves of the Bird River Sill.*
MRD-5	*Manitoba Stone.*
ES78-1	*Minerals of Manitoba,* Volume 1: Non-Metallic and Pegmatitic.
ES79-1	*Lignite in Manitoba.*
ES1987	*Gypsum in Manitoba.*
ER85-1	*Dolomite Resources of Southern Manitoba.*

In addition, two studies are in progress:

Dimension Stone in S.E. Manitoba (Schmidtke); and *Selected Occurrences of Industrial Minerals in Northern Manitoba* (Gunter).

Postscript



Mining stands out as one of the most rapidly changing sectors of the economy. New ore bodies are discovered, old ones are exhausted. Corporate mergers shift ownership, and joint ventures form to bring new quarries and mines into production. As commodity prices fluctuate, what was uneconomical to mine yesterday may be a prime mine or quarry site tomorrow. All of this is in addition to a rate of technological change that is at least as rapid as in other parts of the economy.

While all of this makes Manitoba's minerals industry a fascinating subject, it also makes it a difficult one to describe in print. A booklet such as **Industrial Minerals in Manitoba** is a snapshot of a moving object. We cannot prevent it from becoming outdated, but we have tried to keep the information in the booklet as timely as possible.

Production drilling at a granite quarry in southeastern Manitoba.

Glossary

Acid-activated Bentonite — a non-swelling bentonite treated with acid to increase its absorptive properties.

Aeromagnetic Survey — a magnetic survey made with an airborne magnetometer.

Agate — microcrystalline quartz often used as a semi-precious stone when coloured by iron oxides.

Aggregate — materials such as sand, gravel, and crushed stone used for mixing in various-sized fragments with cement or bituminous material to form concrete, asphalt, etc.; or alone for road base or railroad ballast; or in manufacturing processes.

Alteration Zone — rock that has been chemically changed by circulating heated water; usually forms as a pipe-like mass beneath sulphide zones.

Amber — fossil resin, usually yellow-brown to dark brown with a waxy lustre; occasionally contains fossil insects.

Angular Unconformity — younger overlying sediments rest upon the eroded surface of tilted or folded older rocks.

Archean — rocks formed during the earlier part of Precambrian time (older than 2.5 billion years).

Bentonite — a montmorillonite type clay formed by the alteration of volcanic ash. Manitoba bentonites are primarily of the calcium, or non-swelling, variety.

Cleavage — the breaking of a mineral along its crystallographic planes, thus reflecting the crystal structure.

Coal — a solid, brittle, more or less distinctly stratified combustible carbonaceous rock formed by partial to complete decomposition of vegetation.

Diagenetic — all the chemical, physical and biological changes, modifications or transformations undergone by a sediment after its initial deposition, and during and after its hardening into a rock, exclusive of weathering and metamorphism.

Dimension Stone — naturally occurring rock material cut, shaped, or selected for use in buildings, monuments, curbing, paving, flagging, bridges, or other purposes.

Diorite — a group of plutonic rocks intermediate in composition between acidic and basic rocks, characteristically composed of dark coloured amphibole, acid plagioclase, pyroxene and sometimes a small amount of quartz.

Disseminated — fragments of mineral dispersed in a rock.

Dolomitic Limestone — a limestone containing less than half dolomite and greater than half calcite.

Drift Ridge — an elevated landform composed of any rock material transported by a glacier and deposited by or from the ice, generally used for Pleistocene glacial deposits.

Electromagnetic Survey — a survey made with an electromagnetometer that measures alternating magnetic fields associated with currents in the subsurface, the strength of which are dependant upon the nature of the rock.

Esker — a long, narrow, often sinuous ridge or mound of sand, gravel, and boulders deposited between ice walls by a stream flowing on, within, or beneath a stagnant glacier.

Fault — a fracture or fracture zone along which there has been displacement of the two sides relative to one another, parallel to the fracture.

Foundry Sand — sand used to make molds for metal castings.

Fusion Point — the point whereby the solids in a mixture first become liquid by the application of heat.

Geochemistry — all geological study involving chemical change.

Geological Province — an extensive region, all parts of which are characterized by similar geologic history or by particular structural, petrographic, or physical geography.

Geologist — one who studies the constitution, structure, and history of the earth's crust.

Geophysics — the study of the physical properties of the earth and its rocks, such as magnetism, density, and conductivity.

Glauconite — a clay mineral composed of primarily a hydrous silicate of iron and potassium, but almost always found mixed with other minerals.

Gneiss — a rock formed by regional metamorphism, in which bands of granular minerals alternate with flaky minerals.

Greenstone — generalized name given to Precambrian volcanic and associated sedimentary rocks.

Greenstone Belt — an elongated area of metamorphosed volcanic and sedimentary rocks in the Precambrian Shield.

Hudsonian — refers to the mountain building episode that occurred between 1700 and 1820 million years ago during Precambrian time.

Igneous — rock or mineral solidified from molten or partly molten material.

Inclusion — a term applied to a crystal of one mineral surrounded by another, and to fragments of one rock enclosed in another.

Isotopic Age — an age expressed in years and calculated by measuring the disintegration rate of radioactive elements.

Kenoran — refers to the mountain building episode at the end of the Archean time, about 2 500 to 2 670 million years ago during Precambrian time.

Kiln — a large furnace used for baking, drying, or burning firebrick or refractories, or for heat-treating ore or other substances.

Lens — a body of ore or rock thick in the middle and thin at the edges; similar to a double convex lens.

Magnetometer — an instrument that measures the earth's magnetic field and its changes, or the magnetic field of a particular rock.

Marl — a calcareous clay or an intimate mixture of clay and particles of calcite or dolomite.

Massive — a homogeneous structure without stratification, flow banding, foliation, schistosity, etc.; descriptive of the structure of some rocks.

Metamorphism — the mineralogical and structural adjustment of solid rocks to changes in physical and chemical conditions, usually deep within the earth.

Metasediments — sediments that have undergone metamorphism.

Mineral Deposit — a mass of naturally occurring minerals, usually of economic value, without regard to mode of origin. Organic fuels such as coal and petroleum are sometimes called mineral deposits.

Mineral Disposition — a disposition under The Mines Act that takes the form of a permit, claim, or lease.

Mineralization — the nature and processes of the concentration of minerals in rocks which may result in an economically valuable deposit.

Mining Claim — a plot of Crown land containing a mineral and staked out for mining purposes.

Moraine — an accumulation of earth and stones carried and finally deposited by a glacier, often in the form of a ridge.

Noble Gas — any of a group of rare gases that include helium, neon, argon, krypton, xenon and sometimes radon, and that exhibit great stability and extremely low reaction rates.

Non-swelling Bentonite — a commercial term applied to variously coloured clay deposits containing montmorillonite as an essential mineral, characterized by the ability to be slaked and to be activated by acid.

Ore — naturally occurring material from which a mineral or minerals of economic value can be extracted.

Outcrop — that part of a geological formation or structure that is exposed at the surface of the earth.

Phanerozoic — that part of geologic time (more recent than the Precambrian) for which, in the corresponding rocks, the evidence of life is abundant. The Phanerozoic includes the Paleozoic, Mesozoic, and Cenozoic eras.

Pilot Plant — a small-scale concentrator in which representative tonnages of ore can be tested under conditions that imitate those of a proposed full-scale operation.

Pleistocene — that period of recent geologic time when glaciers covered much of northern North America.

Plutonism — formation of igneous rocks deep within the earth under the influence of high heat and pressure.

Precambrian — very old geologic time before the Phanerozoic; it is equivalent to about 90 per cent of geologic time and contains only very primitive forms of life.

Proterozoic — the more recent division of Precambrian time and its corresponding rocks (younger than 2.5 billion years).

Relief — the elevation or differences in elevations of a land surface.

Reserves — quantity of mineral calculated to lie within given boundaries. Deposit thickness, depth, quality, geological conditions, and contemporary economic factors are limits on reserves.

Reworked — said of a sediment, fossil, rock fragment or other geological material that has been removed or displaced by natural agents from its place of origin and incorporated in recognizable form in a younger formation.

Sediment — fragmental material, either organic or inorganic, that forms in layers on the earth's surface at ordinary temperatures in an unconsolidated form.

Serpentinite — a rock consisting almost wholly of serpentine group minerals, derived from the alteration of previously existing ferro magnesium silicate minerals such as olivine and pyroxene.

Shield — a large region of exposed Precambrian rocks surrounded by younger sediment-covered areas, e.g. Canadian Shield.

Signature — a track recorded on a geophysical instrument by an earthquake or other source of mechanical or electrical energy.

Strata — layers of sedimentary rock of varying thickness, each of which possesses characteristics different from the layer above and below.

Stratiform — having the form of a layer, bed or stratum, consisting of roughly parallel bands or sheets.

Supracrustal — rocks that overlie the basement.

Tertiary — the first period of the Cenozoic era, thought to have covered the period between 2 and 65 million years ago.

Trend — the direction or bearing of the outcrop of a bed, dyke, sill, or the like with the surface of the ground.

Ultramafic — rocks that contain less than 45 per cent SiO_2.

Unconsolidated Sediments — rock material that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either above or below the surface.

Volcanic Rock — any rock of volcanic origin. Volcanic igneous rocks erupted as molten masses, forming lava flows, dykes in the crater walls, volcanic plugs, etc. Volcanic sedimentary rocks are the fragmental materials ejected in explosive eruptions.

Mineral Identification Chart

Mineral	Composition	Colour	Streak	Lustre	Cleavage and/or Fracture	Hardness	Remarks
Agate	SiO_2	Variable	White	Greasy	None	H (7)	Crypto or crystalline variety of quartz.
Albite	$NaAlSi_3O_8$	White, Pink	White	Vitreous	2 Good, 1 Poor -90°	H (6)	Blue colour play. Striations on cleavage faces.
Amblygonite	$LiAl(PO_4)F$	White	White	Vitreous	1 Good, 2 Poor	H (6)	Associated with granite pegmatites.
Anhydrite	$CaSO_4$	White-Blue Purple	White	Glassy	3 Good	M (3)	Occurs with gypsum or as vein gangue.
Apatite	$Ca_5F(PO_4)_3$	Green-Pink	White	Vitreous	Imperfect Cleavage	M (5)	Pegmatites and other igneous rocks.
Asbestos	$Mg_3Si_2O_5(OH)_4$	Green	White	Vitreous	Fibrous	S (2 /2)	Alters from basic rocks.
Augite	$Ca(MgFe)Si_2O_6$	Brown, Black	White	Vitreous	Good cleavage at 93°	H (5 1/2)	Intermediate and basic rocks.
Barite	$BaSO_4$	White-Blue	White	Glassy	2 Perfect 1 Fair	M (3)	Very heavy for a non-metallic mineral. SG 4.3 - 4.6
Beryl	$Be_3Al_2Si_6O_{18}$	Green-White	White	Vitreous	Cleavage indistinct	H (6)	Granite pegmatites.
Biotite	$K(MgFe)_3AlSi_3O_{10}$	Brown, Black	White	Vitreous	Perfect in 1 plane	M (3)	Found in igneous rocks.
Calcite	$CaCO_3$	White, Trans.	White	Vitreous	Perfect in 3 planes	M (3)	Sediments. Vein gangue. Optical uses.
Cassiterite	SnO_2	Dark Brown	Pale Brown	Resinous	Rough fracture	H (6 1/2)	Tin ore. Test with zinc and hydrochloric acid. Pegmatites.
Chlorite	$(FeMg)_5Si_4O_{10}$	Green	White	Pearly	Perfect in 1 plane	M (3)	Occurs abundantly in greenstone.
Chromite	$FeCr_2O_4$	Dark Brown	Pale Brown	Sub-Metallic	Even fracture	H (5 1/2)	Segregations and replacements in basic rocks.
Corundum	Al_2O_3	Green, Variable	White	Vitreous	Parting almost cubic	H (9)	Syenite pegmatites.
Dolomite	$CaMg(CO_3)_2$	White, Trans.	White	Vitreous	Perfect in 3 planes	M (3 1/2-4)	Sediments. Vein gangue. Tyndall stone.
Epidote	$Ca_2(Al,Fe)_3(SiO_4)_3(OH)$	Green	White	Dull	Indefinite cleavage	H (6 1/2)	An alteration product. Usually in igneous rocks.
Fluorite	CaF_2	Variable	White	Vitreous	Perfect cleavage 3 planes	M (4)	Occurs as a vein gangue. Lesser amounts in pegmatites.
Garnet	$Fe_3Al_2(SiO_4)_3$	Red, Variable	White	Vitreous	No cleavage	H (7)	Usually found in metamorphic rocks.
Gossan	Weathered Mineral Outcrop	Red-Brown	Brown	Dull, earthy	Usually earthy	S-M	Source of pigments (red or brown).
Gypsum	$CaSO_4 + 2H_2O$	White	White	Pearly	1 Good, 2 Imperfect	S (2)	Sedimentary rock (vein gangue).
Halite	$NaCl$	White	White	Glassy	Perfect cubic	S (2 1/2)	Tastes salty.
Hematite	Fe_2O_3	Red-Black	Red	Metallic, Earthy	Scaly to rough	H (6)	S.G. 5.2. Principal iron ore.
Hornblende	$CaFe_2Al_5Si_8O_{22}(OH)_2$	Green, Brown, Black	White	Vitreous	Good cleavage at 124°	H (5 1/2)	Intermediate and basic rocks.

Mineral	Composition	Colour	Streak	Lustre	Cleavage and/or Fracture	Hardness	Remarks
Jarosite	$KFe_3(So_4)_2(OH)_6$	Yellow	Yellow	Earthy	1 Perfect	S-M (2-3)	Represents a large group of very similar minerals that form crusts on weathering shale.
Kaolinite	$Al_2Si_2O_5(OH)_4$	White	White	Earthy	Compact, earthy masses	S (2)	Alters from feldspar. Forms clays.
Kyanite	Al_2SiO_5	Blue-Grey	White	Glassy	1 Perfect	H (5-7)	Usually in metasediments. Best occurrences in metamorphosed alteration zones.
Labradorite	$CaAl_2Si_2O_8$	Grey	White	Vitreous	2 Good at 86°	H (6)	Blue colour play. Striations on cleavage faces.
Lepidolite	$K(Li,Al)_3Si_4O_{10}(OH)_2$	Lilac	White	Vitreous	Perfect 1 plane. Scaly	M (3)	Lithium ore. Finely micaceous. Pegmatites.
Limonite	$Fe_2O_3.3H_2O$	Yellow	Light Brown	Metallic, Earthy	Rough. Uneven fracture	S-M	Occurs in oxidized zone of ore bodies.
Magnesite	$MgCO_3$	White	White	Glassy	3 Perfect	M (3-5)	Very similar in appearance to calcite but will not fizz in HCL.
Magnetite	Fe_3O_4	Black	Black	Metallic	Rough fracture	H (6)	Magnetic. Iron formation. An ore of iron.
Manganese Oxides (Pyrolusite)	MnO_2	Black	Black	Earthy to Metallic	1 Perfect	S-H (1-6)	Only sooty pyrolusite occurs in Manitoba.
Muscovite	$KAl_2Si_4O_{10}(OH)_2$	Pale Yellow	White	Pearly	Perfect in 1 plane	M (3)	Found in igneous rocks.
Olivine	$(FeMg)_2SiO_4$	Pale Green	White	Vitreous	No cleavage. Fractures	H (6 1/2-7)	Basic rocks. Never with quartz.
Orthoclase	$KAlSi_3O_8$	White, Pink	White	Vitreous	2 Good, 1 Poor Rt angles	H (6)	No striations. Common to granite.
Pollucite	$(CsNa)_2Al_2Si_4O_{12}.H_2O$	White	White	Glassy	3 Poor	H (5 1/2)	A pegmatite mineral with spodumene, albite.
Quartz	SiO_2	Variable	White	Vitreous	No cleavage. Fractures	H (7)	Vein former. Has no cleavage. Harder than calcite.
Scheelite	$CaWO_4$	Cream White	White	Vitreous	3 Good cleavages	M (4 1/2-5)	Associated with granite pegmatites.
Serpentine	$Mg_3Si_2O_5(OH)_4$	Green	White	Waxy	Fractures only	M (3-4)	Alters from basic rocks.
Siderite	$FeCO_3$	Yellow-Grey	White	Vitreous	Perfect 3 planes	M 3 1/2-4)	Weathers rusty brown. A vein gangue.
Spodumene	$LiAlSi_2O_6$	White-Grey	White	Vitreous	Platy cleavage	H (6 1/2)	Associated with granite pegmatites.
Sylvite	KCl	White	White	Glassy	Perfect cubic	S (2)	Similar to halite. Red colour in potash is due to carnallite $KMgCl_3.6H_2O$.
Talc	$Mg_3Si_4O_{10}(OH)_2$	Grey, Green, White	White	Pearly	Perfect in 1 plane	S (1)	Alters from basic rocks.
Tantalite	$(Fe,Mn)(Ta,Nb)_2O_6$	Brown, Black	Brown	Resinous	2 Good	H (6)	Represents a large group of very similar Ta minerals.
Topaz	$Al_2SiO_4(F)_2$	White	White	Glassy	Perfect basal	H (8)	Found in pegmatites often with rose quartz.
Tourmaline	$CaFe_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$	Black, variable	White	Vitreous	No cleavage	H (7-7 1/2)	A pegmatite mineral.

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Metric Conversion Chart

Into Metric

If you know	multiply by	to get
Length		
inches	25.40	millimetres
inches	2.54	centimetres
feet	0.30	metres
yards	0.91	metres
miles	1.61	kilometres
Area		
square inches	6.45	square centimetres
square feet	0.09	square metres
square yards	0.84	square metres
square miles	2.59	square kilometres
acres	0.40	hectares
Mass (Weight)		
ounces	28.35	grams
pounds	0.45	kilograms
tons	1.02	tonnes
Volume		
Imperial (not U.S.)		
fluid ounces	28.41	millilitres
pints	0.57	litres
quarts	1.13	litres
gallons	4.54	litres
cubic inches	16.39	millilitres or cubic centimetres
cubic feet	0.03	cubic metres
cubic yards	0.76	cubic metres
Temperature		
Fahrenheit	Subtract 32, then multiply by 5/9ths	Celsius

Out of Metric

If you know	multiply by	to get
Length		
millimetres	0.04	inches
centimetres	0.39	inches
metres	3.28	feet
metres	1.09	yards
kilometres	0.62	miles
Area		
square centimetres	0.15	square inches
square metres	10.76	square feet
square metres	1.19	square yards
square kilometres	0.40	square miles
hectares	2.47	acres
Mass (Weight)		
grams	0.035	ounces
kilograms	2.20	pounds
tonnes	0.98	tons
Volume		
		Imperial (not U.S.)
millilitres	0.03	fluid ounces
litres	1.76	pints
litres	0.88	quarts
litres	0.22	gallons
millilitres or cubic centimetres	0.06	cubic inches
cubic metres	35.31	cubic feet
cubic metres	1.31	cubic yards
Temperature		
Celsius	Multiply by 9/5ths, then add 32	Fahrenheit


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