INDUSTRIAL AND METALLIC MINERAL RESOURCES OF ALBERTA

compiled by

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INTRODUCTION

This report describes the industrial and metallic mineral resources of Alberta. It has been prepared with a view to emphasizing those commodities:

(1) which have some potential for export in an essentially unprocessed or bulk state; or

(2) which might provide the basic raw materials for development of a major metallic or industrial minerals industry within the province.

There are few mineral resources in the first category: Alberta has no metallic minerals production, and the types of raw or semi-processed industrial minerals with export potential (other than sulphur) are limited. Mineral resources with a potential for development and processing in Alberta -- for subsequent use by local industries or for export in processed form -- comprise a more diverse array of materials. These include metallic mineral commodities such as sedimentary iron ore and trace minerals (titanium oxides, zirconium) in the Athabasca Oil Sands. However, the word "potential" should be stressed, for a number of formidable technical and marketing problems must be overcome before these resources can be extracted and developed on a commercial basis. On the other hand, the abundance and widespread distribution of relatively cheap energy resources in Alberta, necessary for smelting or processing of metallic minerals, provides an incentive to find solutions to these problems, especially if markets for the relevant mineral products can be found.

A summary of specific mineral resources considered to have some potential for development within and possibly export from Alberta is given in Table 1.

TABLE 1. SUMMARY OF POTENTIAL MINERAL RESOURCES

Commodity	Type of Deposit	Location	Grade	Reserves
NONMETALLIC				
Bentonite	Sedimentary	Central and southern Alberta	Variable	Large
Helium	By-product (natural gas)	Various areas	Low	Large
METALLIC				
Copper	Sedimentary (sulphides)	Southwestern Alberta	Low	Unknown
Iron	Sedimentary (oxides and carbonates)	Northwestern Alberta	Low	Large
Lead-zinc	Sedimentary (sulphides)	Southwestern Alberta	Variable	Limited ?
Magnesium	Brine	Central Alberta	Variable	Large
Titanium	(1) By-product (oil sands)	Northeastern Alberta	High*	Large
	(2) Sedimentary (ilmenite)	Southwestern Alberta	Moderate	Limited
Zirconium	By-product (oil sands)	Northeastern Alberta	High*	Large

*In oil sand concentrates.

INDUSTRIAL (NON-METALLIC) MINERALS

Industrial minerals comprise those rocks and minerals used in industries and construction of all kinds, but exclude those used as fuels or from which metals are extracted. Most are of low value per unit weight or volume and cannot be economically transported long distances; therefore, they less commonly enter into the export trade than do many of the metallic minerals and fossil fuels. The utilization of industrial mineral resources accordingly provides a reliable indicator of the degree of industrial development within the regional economy.

The value of industrial minerals production in Alberta amounted to $65,000,000 in 1971, of which approximately $27,000,000 is accounted for by sulphur. This amount is about 4 per cent of the total value of the province's mineral production and shows a decline from the previous few years owing to a marked drop in sulphur prices. Few of these commodities, other than sulphur, have much potential for export, and their utilization will depend to a large extent on the growth of local construction and primary manufacturing industries. A reasonably up-to-date summary of Alberta's industrial minerals (limestone, silica sand, gypsum, etc.) is given in the 1970 edition of Alberta Industry and Resources; those deposits with some potential for export or for development of new industries in the province are described below.

Bentonite

Bentonite is a clay composed largely of montmorillonite, a chemically active mineral with well-developed adsorptive, absorptive, and ion-exchange capacities. It has a wide variety of industrial uses, the most important of which are as an iron ore pelletizing agent, as an additive in drilling muds, and as a foundry clay. Bentonite is the only type of clay in Alberta which has some export potential as an essentially unprocessed bulk commodity.

Bentonite deposits of variable grade and thickness have been reported from a number of localities in Alberta. Most are associated with sandstone and shale formations of Late Cretaceous age, which crop out extensively in the Plains region of southeastern and central Alberta, and in the Peace River district of northern Alberta. The quality and extent of the deposits varies widely from one locality to another, depending on such factors as silt content, exchangeable cations, and the degree of oxidation of the deposit. In fact, bentonite samples from adjacent sections of the same deposit or bed can exhibit noticeable differences in swelling properties which directly affect the "yield" and other characteristics of the deposit.

Two Alberta bentonite deposits have been mined in recent years: along the Battle River about 70 miles southeast of Edmonton (by Dresser Industries Inc.), and at Onoway about 30 miles northwest of Edmonton (by Baroid of Canada Ltd.). Dresser Industries produces at least six types of bentonite from the Battle River deposit, some of which are beneficiated to meet specific consumer requirements. Total production is approximately 12,000 tons per year, and most is sold as foundry clay. The Onoway deposit has not been mined since 1968; however, about 2,000 tons per year currently are processed from stockpiles, mainly for use in drilling muds.

The major problem facing Alberta bentonites is distance from markets, especially the iron ore industries of Ontario and Quebec which consume about 70 per cent of the bentonite used in Canada (about 150,000 tons in 1968, all of which was imported). Attempts have been made, some involving full-scale plant tests, to promote the use of Alberta bentonites in the iron ore pelletizing industry of eastern Canada, but have met with little success. Obviously, an alternative export market, such as Japan, would be most useful in promoting the growth and stability of the Alberta bentonite industry.

Helium

Helium is an inert gas with a wide variety of specialized industrial and research applications. It is found in small amounts (generally less than 1 per cent) in natural gas from which it is produced as a by-product. Most of the non-Communist countries' richest reserves and production are in the United States; the only Canadian production is from a plant in Saskatchewan.

Several small gas fields in Alberta contain helium in amounts ranging from 0.3[1] to 0.9 per cent, none of which is currently recovered. In addition to these relatively rich but small reserves, many of the larger gas fields in Alberta contain helium in amounts ranging from 0.01 to 1 per cent, values well below the limit for economic recovery. Currently, the Research Council of Alberta is carrying out an industry-supported program to determine a technique for the recovery of helium from natural gas deposits with large reserves but low helium contents. The process is based on selective permeation of helium through polymer films, and the results to date appear promising. However, further development and commercial application of the process will depend on the availability of export markets or on a government-supported conservation (storage) program similar to that now operating in the United States. Otherwise, the province's helium resources will continue to be dissipated as the natural gas reserves are utilized or exported.

Kaolinitic Clays and Shales

Kaolinitic clays, shales, and sandstones are found at several widely scattered localities in Alberta, but none of these deposits appears to be of sufficient quality or size to be developed for export. However, the general lack of good quality fireclays and china clays in all parts of Canada suggests that the deposits deserve closer attention than they hitherto have received.

Stoneware-quality clays are extracted from the Upper Cretaceous Whitemud Formation which is exposed about the flanks of the Cypress Hills

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[1] Considered to be the lower level for economic recovery. The average helium content of the richer U.S. reserves is 0.53 per cent.

in southeastern Alberta. The clays are processed and blended in Medicine Hat where a variety of ceramic and structural clay products are manufactured. Thin but extensive beds of kaolinitic shale are interbedded among sub-bituminous coal deposits utilized for thermal power generation at Wabamun, west of Edmonton. The shale is white-burning and has the properties of a good quality fireclay, with some potential for manufacture of refractory and ceramic products. Approximately 200,000 tons of this material are being strip-mined each year, all of which is being used for backfill. Kaolinitic clays and sandstones also are reported from the Fort McMurray area in northeastern Alberta and from the Wapiti River area south of Grande Prairie. However, the extent and grade of these deposits is presently uncertain or unknown.

METALLIC MINERALS

Relatively few metallic minerals deposits have been recorded in Alberta compared to other parts of Canada. The only metallic minerals production has been small amounts of placer gold recovered from river gravels in scattered parts of the province. Nevertheless, some potential exists for production of such minerals in Alberta, either by primary extraction from ore-bearing rocks or brines, or as a by-product of oil sands processing.

The potential for metallic minerals exploration and production can be best summarized with reference to the geologic framework of the province:

Canadian Shield

This small area in northeastern Alberta, underlain by Precambrian crystalline rocks, provides an excellent geologic setting for metallic minerals exploration, although no commercial deposits have been found to date. The terrain is similar to the uranium-producing region in nearby Saskatchewan, and some minor uranium and molybdenite showings have been found in the area north of Lake Athabasca. The region is only partly mapped, and considerable scope exists for more detailed exploration.

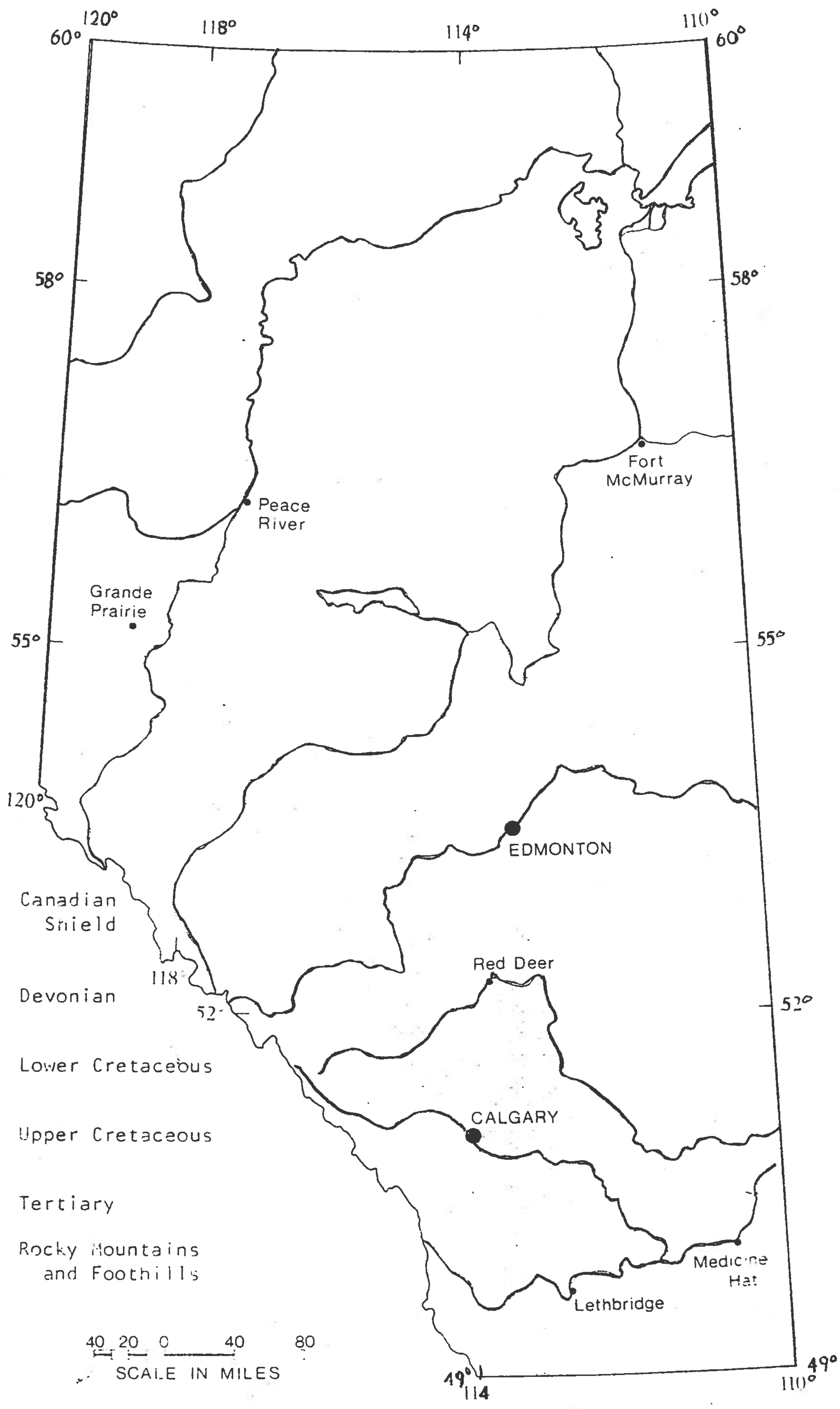
Interior Plains

The area underlain by Devonian carbonate and evaporite rocks in northeastern Alberta is contained largely within Wood Buffalo National Park and is therefore interdicted from mineral exploration. Moreover, the region is remote and the bedrock is largely covered by glacial drift. However, copper mineralization has been found in Devonian strata along the eastern boundary of the area, and there is some basis for expecting the presence of lead and zinc minerals in some of the limestone and dolomite formations. Farther south, beneath the cover of younger Cretaceous and Tertiary formations, Devonian strata contain substantial reserves of magnesium-rich brines, associated with oilfield formation waters.

The Cretaceous and Tertiary strata which form the near-surface bedrock over most of the Plains region contain a large deposit of sedimentary iron but otherwise have little potential for metallic minerals production, except possibly for uranium. The sandstone formations show some gross similarities to the uranium-bearing sedimentary rocks of the Colorado Plateau region in the United States; however, no significant uranium showings have been recorded from the Cretaceous or Tertiary strata of Alberta to date, although some prospecting has been carried out.

Rocky Mountains and Foothills

The Rocky Mountains and Foothills provide a relatively diverse geological terrain. However, the formations are almost entirely of sedimentary origin, and few indications of metallic minerals have been found apart from scattered copper and lead-zinc showings in southwestern Alberta. Also, the areas which normally would be considered most suitable for metallic minerals deposits -- along the western ranges of the Rocky Mountains -- are contained within federal or provincial parks. Thus, only limited scope exists for metallic minerals exploration in this region, outside the parks boundaries.



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Fort McMurray
Peace River
Grande Prairie
EDMONTON
Red Deer
CALGARY
Medicine Hat
Lethbridge
Canadian Shield
Devonian
Lower Cretaceous
Upper Cretaceous
Tertiary
Rocky Mountains and Foothills
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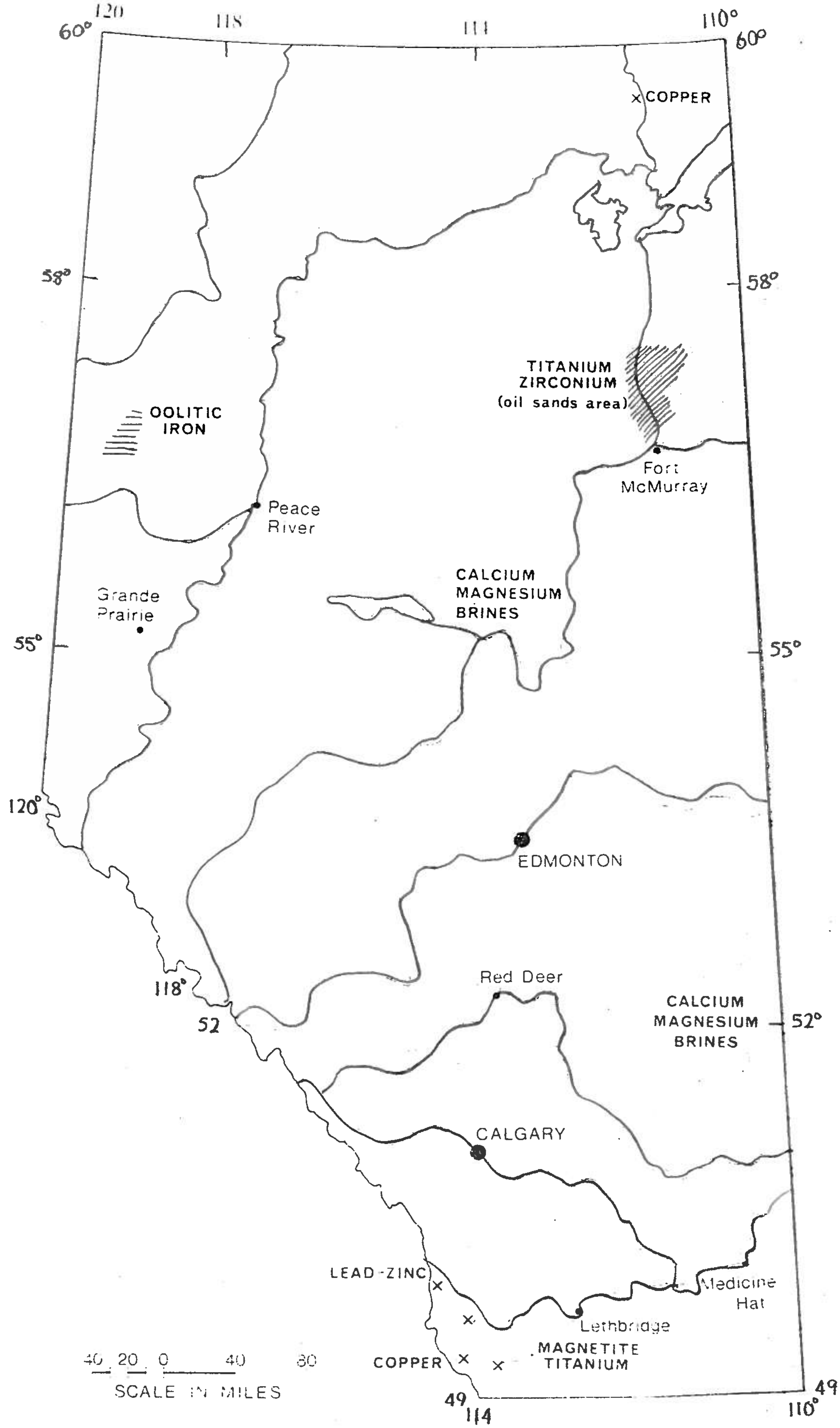

COPPER
TITANIUM
ZIRCONIUM
(oil sands area)
OOLITIC
IRON
Fort
McMurray
Peace
River
CALCIUM
MAGNESIUM
BRINES
Grande
Prairie
EDMONTON
Red Deer
CALCIUM
MAGNESIUM
BRINES
CALGARY
LEAD-ZINC
Medicine
Hat
Lethbridge
COPPER
MAGNETITE
TITANIUM
40 20 0 40 80
SCALE IN MILES

Known deposits or potentially economic showings of metallic minerals in Alberta are described below.

Copper

At least two showings of copper minerals have been recorded from Alberta, the most extensive of which is in the Clark Range of the Rocky Mountains, adjacent to Waterton Lakes National Park in the southwestern corner of the province. In this region, scattered showings of copper sulphide minerals (chalcocite, bornite, chalcopyrite) are found in sedimentary rocks (quartzite, dolomite) of Precambrian age over an area of approximately 250 square miles. The copper-bearing zones are generally thin (from a few inches to 5 feet) and the grades are low (less than 1 per cent Cu); moreover, the terrain is rugged and presents some local access problems. However, the deposits are relatively close to transportation facilities near Pincher Creek and also to the large natural gas processing plant in the Waterton area. Consequently, the showings are still being actively explored, although the grades and thicknesses of ore-bearing strata found to date appear to be noncommercial.

A second copper mineral showing which merits some attention has been recorded from a small island in the Slave River, near the margin of the Canadian Shield in northeastern Alberta. The copper is present as veins of copper sulphides and carbonates in Devonian sedimentary rocks which overlie granitic rocks of the Canadian Shield at this locality. The grade and extent of the mineralized zone are unknown, but a soil sample from the adjacent mainland on the west side of the Slave River has an anomalously high copper content, indicating that this area deserves further attention.

Iron

Oolitic Iron

Two types of sedimentary iron deposits are found in Alberta. The largest and most important deposits are situated in the Peace River district of northern Alberta, about 300 air miles northwest of Edmonton. The main deposits are exposed about the flanks of the Clear Hills, a dissected upland region underlain by flatlying sandstone and shale formations of Late Cretaceous age. The iron beds consist of widespread bodies of oolitic sandstone 5 to 20 feet thick with an average iron content (Fe) of 35 per cent, present in the form of hydrous iron oxides and siderite ($FeCO_3$). The sulphur content of the ore is low, but the silica and water contents are high; analyses indicate that much of the ore is in an amorphous or opalline state. Tests carried out by the Research Council in 1960 show that some of the ore (the oxidized material near the outcrop face) can be smelted by a modified RN process, but the bulk of the deposit (which consists of unoxidized material) has not been tested.

Estimates of reserves based on drilling data indicate that approximately 200,000,000 tons of strippable ore grading between 32 and 35 per cent iron are present in the Clear Hills. In addition, much larger tonnages are buried at depths considered too great for strip-mining. Although the low grade and complex mineralogy of the ore, together with the remoteness of the deposits from potential markets has prevented development to date, the Clear Hills beds contain the only deposit of iron ore in Western Canada with reasonable economic potential, apart from scattered deposits along the west coast in British Columbia. Consequently, should the development of an integrated steel industry in Alberta be considered feasible, the Clear Hills deposits must be given serious attention as a source of iron ore.

Magnetite

Widely scattered deposits of sedimentary magnetite (Fe_3O_4) are present in the Crowsnest Pass region of southwestern Alberta. The deposits form thin lenses in complexly folded and faulted Cretaceous sandstones exposed along the eastern margin of the Foothills. The average grade of the deposits is low (less than 35 per cent iron), and the magnetite-bearing beds tend to be thin and discontinuous. The deposits also contain relatively high amounts of titanium (4 to 5 per cent TiO_2, present as ilmenite and titaniferous magnetite) and small but significant amounts of zirconium and vanadium. However, tests have shown that the titanium minerals cannot be economically separated from the magnetite, a necessary step in beneficiating the deposits for conventional smelting techniques. Consequently, the deposits have little potential value as a major source of iron ore, although some attempts are being made to process them locally for use as coal-washing sand.[2]

Lead-Zinc

Scattered showings of lead-zinc minerals are present in the Rocky Mountains of southwestern Alberta, but none has proven to be of commercial grade at the present time. The best known and most promising showings are in the High Rock Range, about 30 miles north of Coleman in the Crowsnest Pass, near the interprovincial boundary. There, disseminated lead and zinc sulphide minerals (galena, sphalerite) are found in faulted limestone beds of Devonian age, on the northeast flank of Mount Gass. The extent and average grade of the deposits is uncertain, but the lead content is locally quite high (40 per cent or more). No reserve estimates are available, although some drilling and tunnelling has been done in the area.

Few reliable data are available on the other lead-zinc showings in southwestern Alberta (north of Waterton Lakes National Park and near Canmore).

Magnesium

Most of the magnesium metal produced in North America is extracted by an electrolytic process (Dow process) which uses magnesium chloride ($MgCl_2$) precipitated from sea water. Alternative sources of magnesium chloride are found in salt lakes (e.g., Great Salt Lake, Utah) and in

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[2] Magnetite is the heavy aggregate used in the Conklin sand-flotation process, employed in Alberta for cleaning bituminous coking coals.

deep subsurface brines associated with oil- and gas-producing formations.[3] The only Canadian manufacturer of magnesium metal (in Ontario) uses calcined dolomite as the raw material from which magnesium is extracted by reduction in an electric furnace.

In Alberta magnesium-rich brines are present in oil-producing carbonate and evaporite formations of Devonian age at depths ranging from 5,000 to 12,000 feet. The richer brines underlie relatively large areas in central and southeastern Alberta; they contain up to 15,000 mg/l magnesium in association with even larger concentrations of sodium and calcium salts (mainly chlorides) and trace amounts of bromine and iodine. These concentrations are eight to ten times the magnesium content of sea water and compare favorably with the magnesium content of Great Salt Lake (12,400 mg/l). Thus, the economic potential of the Alberta brines merits closer investigation, especially in view of the favorable energy resources situation in the province.

Titanium and Zirconium

Titanium and zirconium are both present as minor constituents in the Athabasca Oil Sands of northeastern Alberta, which are on the verge of large-scale development. The Oil Sands, contained within the McMurray Formation of Lower Cretaceous age, are composed of the following materials, given as approximate weight-percentages:

Solid mineral matter (mainly sand with minor silt and clay)...	84%
Bitumen (heavy oil)...	12%
Water...	4%

The mineral matter is mainly fine- to medium-grained sand composed largely of quartz (silica) with lesser amounts of feldspars and mica. In

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[3] Magnesium metal also can be produced from dolomite, a calcium-magnesium carbonate mineral ($MgCa[CO_3]_2$) which forms thick beds or rock formations throughout the Rocky Mountains of Alberta. However, the main industrial use of dolomite is in the production of magnesium compounds, or as a fluxing agent in the steel and other metals industries. Little if any metallic magnesium is now being produced from dolomite in the United States.

addition to these major constituents, the oil sands contain small amounts of accessory "heavy" or "trace" mineral grains which form approximately 0.3 per cent of bitumen-free oil sand by weight.

The "trace" minerals consist of titanium minerals (rutile, anatase, "leucoxene") in addition to zircon, tourmaline, garnet and a number of other constituents. They have a higher specific gravity than the bulk of the other mineral grains and therefore tend to segregate in the bitumen "froth" when the oil sands are processed by a conventional hot water technique. An analysis of a typical sample of "froth" solids shows that they contain about 30 per cent "trace" minerals by weight. The "trace" minerals in turn assay 25 per cent metallic titanium (Ti) by weight and, in addition, contain significant amounts of zircon (possibly as much as 10 to 20 per cent zirconium metal by weight).

If it is assumed that 100,000 bbls of crude oil per day are extracted from an oil sands deposit using a hot water process (equivalent to processing 140,000 tons of raw oil sand), then approximately 350 tons per day of "trace" minerals will be processed together with the other constituents.[4] It may be expected that a significant (but as yet uncertain) amount of the "trace" minerals will be collected in the bitumen "froth" and therefore may be available for subsequent beneficiation and treatment. In summary, although there are still many uncertainties associated with the economic recovery of trace minerals from the Athabasca Oil Sands, available data indicate that the distribution, composition, and processing of these constituents merit detailed investigation.

Titanium and zirconium also are present in sedimentary magnetite deposits in southwestern Alberta (see under Iron, above).

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[4] Syncrude Canada Ltd. proposes to extract 91,800 bbl/day bitumen from its plant in the oil sands area. The figure given here (350 tons per day), based on 100,000 bbl/day bitumen, simply indicates in a very general way the amount of "trace" minerals that might be processed (although not necessarily retained or recovered) in a plant the same size as Syncrude's and using the same process. The figure also assumes that 85 per cent of the raw oil sand is solid mineral matter, and that the average "trace" mineral content of the solid mineral matter is 0.3 per cent.

INFORMATION AND TECHNICAL ASSISTANCE

Geological Maps and Reports

Maps and reports describing the geology and mineral resources of Alberta are published by both provincial and federal government agencies. These publications may be obtained from:

Publications Section
Research Council of Alberta
Edmonton, T6G 2J2

and

Institute of Sedimentary and Petroleum Geology
Geological Survey of Canada
Calgary, T2L 2A7

In addition, the Research Council maintains an extensive file of unpublished reports and memoranda dealing with the industrial and metallic minerals of the province.

Analytical Services

The Research Council's Geology Division has a complete array of equipment for mineralogical and chemical analyses of most rocks and minerals found in Alberta. The Division's professional expertise and analytical services are available on a contract basis to other government departments and agencies and to private companies concerned with investigations or utilization of the province's mineral resources.

In addition, the federal Department of Energy, Mines and Resources maintains the Mines Branch Western Regional Laboratory in the Research Council's Clover Bar building in Edmonton. This laboratory is set up to do certain types of industrial and metallic minerals beneficiation work for companies operating in Western Canada; more elaborate facilities are available at the main laboratories of the Mines Branch in Ottawa.

TABLE 1. SUMMARY OF POTENTIAL MINERAL RESOURCES

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