RESEARCH COUNCIL OF ALBERTA

GEOLOGICAL DIVISION

Preliminary Report 58-2

# INDUSTRIAL MINERALS OF ALBERTA

by

G. J. S. Govett and P. J. S. Byrne

Price 75 cents

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Research Council of Alberta
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# INDUSTRIAL MINERALS OF ALBERTA

## INTRODUCTION

Industrial minerals form an integral part of an expanding industrial economy, and an adequate and accessible supply is essential for the full development of any region. Because of comparatively low value per unit weight or volume, evaluation of deposits should consider fully the proximity to cheap transportation, and existing and potential markets.

This report is intended to summarize published and unpublished information which is available on the industrial mineral resources of Alberta. Data on the more important minerals have been reviewed a number of times in the post-war years (e.g. Collins and Gregory, 1954), and a number of individual minerals have also received some attention, for example, bentonite (Byrne, 1955), and salt (Crockford, 1949). However, there has been no comprehensive account for this vital post-war period during which the production of industrial minerals has quadrupled in value (Figs. 1 and 2).

The value of Alberta's production of industrial minerals was 1 million dollars in 1936, 5 million in 1946, and over 20 million in 1956. These figures are equivalent to 3.65, 5.01 and 5.18 per cent respectively of the total Canadian production of industrial minerals. The rapid expansion of the petroleum industry after 1947 naturally favored an increase in population, and the resultant increased demand for industrial minerals is indicated by the industrial minerals production statistics (Fig. 2).

A map (Fig. 3) and a stratigraphic table (Fig. 4) are included to show the distribution of the more important industrial mineral deposits. These minerals receive full consideration in individual chapters. Furthermore, a number of mineral deposits which are not yet developed have also been treated in detail with the aim of creating interest in further expansion of the economy of Alberta. To maintain the comprehensive nature of this report, data on mineral deposits of only minor importance have been briefly mentioned.

Most of the information contained in this report has been derived from published accounts, although some material taken from the Research Council of Alberta files has not hitherto been published. A list of references has been given at the end of each chapter and, although this procedure has led to some duplication of references, it is hoped that the arrangement will aid the reader who is interested in one particular mineral. To further this latter aim, a list of general references has been included in most chapters, in addition to those actually cited.

## Acknowledgments

The assistance of Mr. S. J. Groot in the preparation of drafting of the diagrams is gratefully acknowledged.

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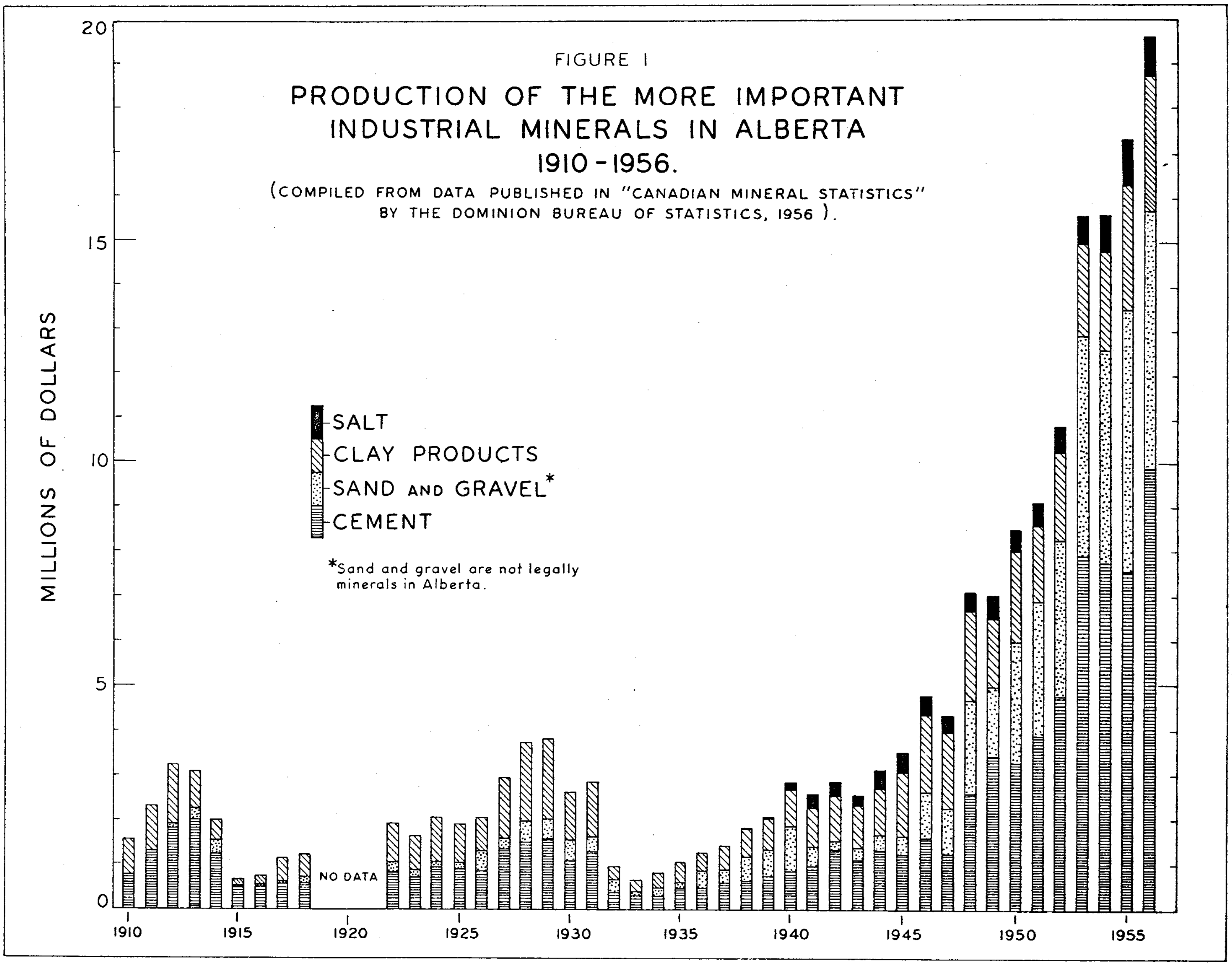


FIGURE I
PRODUCTION OF THE MORE IMPORTANT INDUSTRIAL MINERALS IN ALBERTA 1910 - 1956.
(COMPILED FROM DATA PUBLISHED IN "CANADIAN MINERAL STATISTICS" BY THE DOMINION BUREAU OF STATISTICS, 1956).
MILLIONS OF DOLLARS
SALT
CLAY PRODUCTS
SAND AND GRAVEL*
CEMENT
*Sand and gravel are not legally minerals in Alberta.
NO DATA
0
5
10
15
20
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955

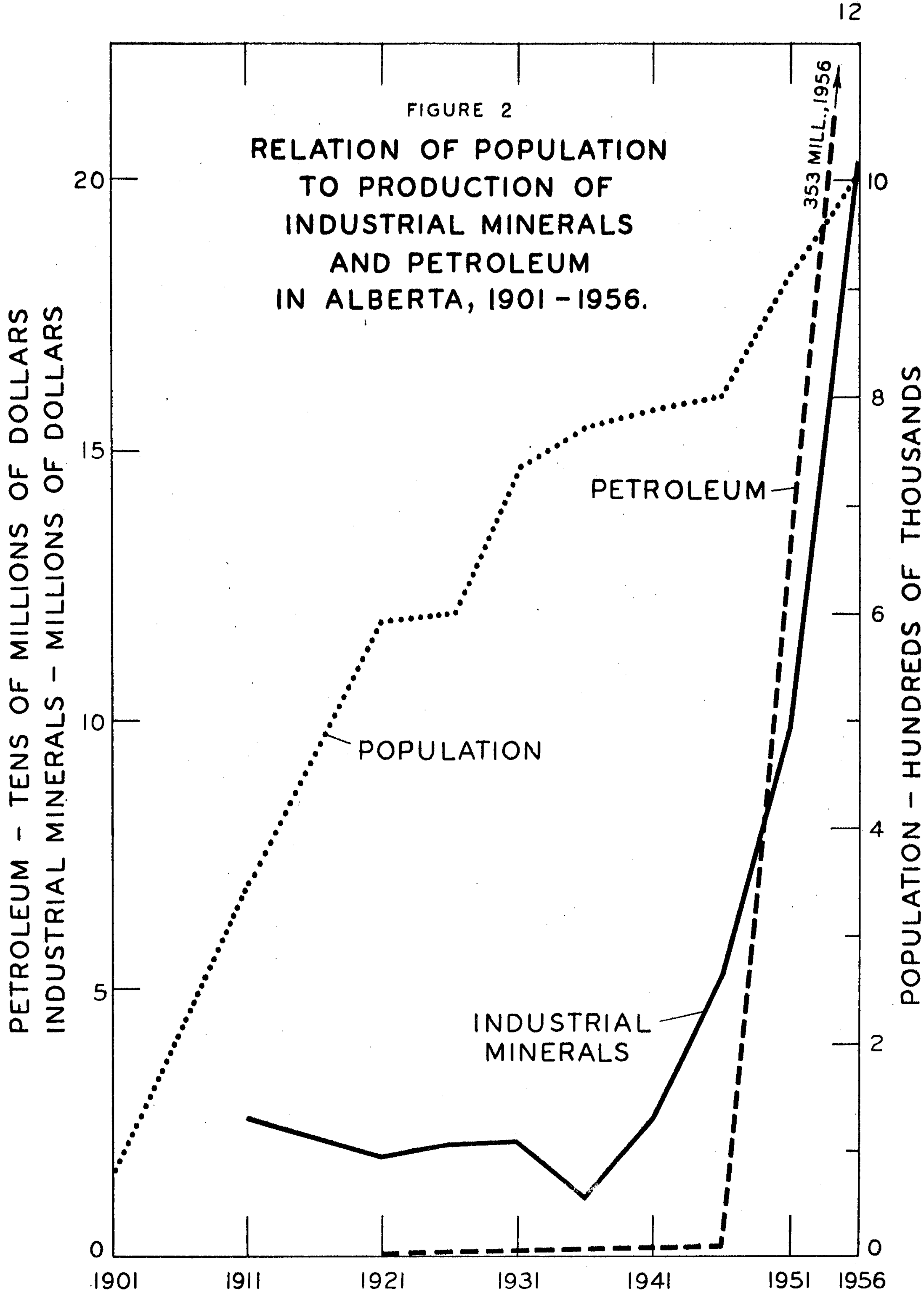


FIGURE 2
RELATION OF POPULATION
TO PRODUCTION OF
INDUSTRIAL MINERALS
AND PETROLEUM
IN ALBERTA, 1901 - 1956.
PETROLEUM - TENS OF MILLIONS OF DOLLARS
INDUSTRIAL MINERALS - MILLIONS OF DOLLARS
POPULATION - HUNDREDS OF THOUSANDS
353 MILL., 1956
PETROLEUM
POPULATION
INDUSTRIAL
MINERALS
0
5
10
15
20
0
2
4
6
8
10
12
1901
1911
1921
1931
1941
1951
1956

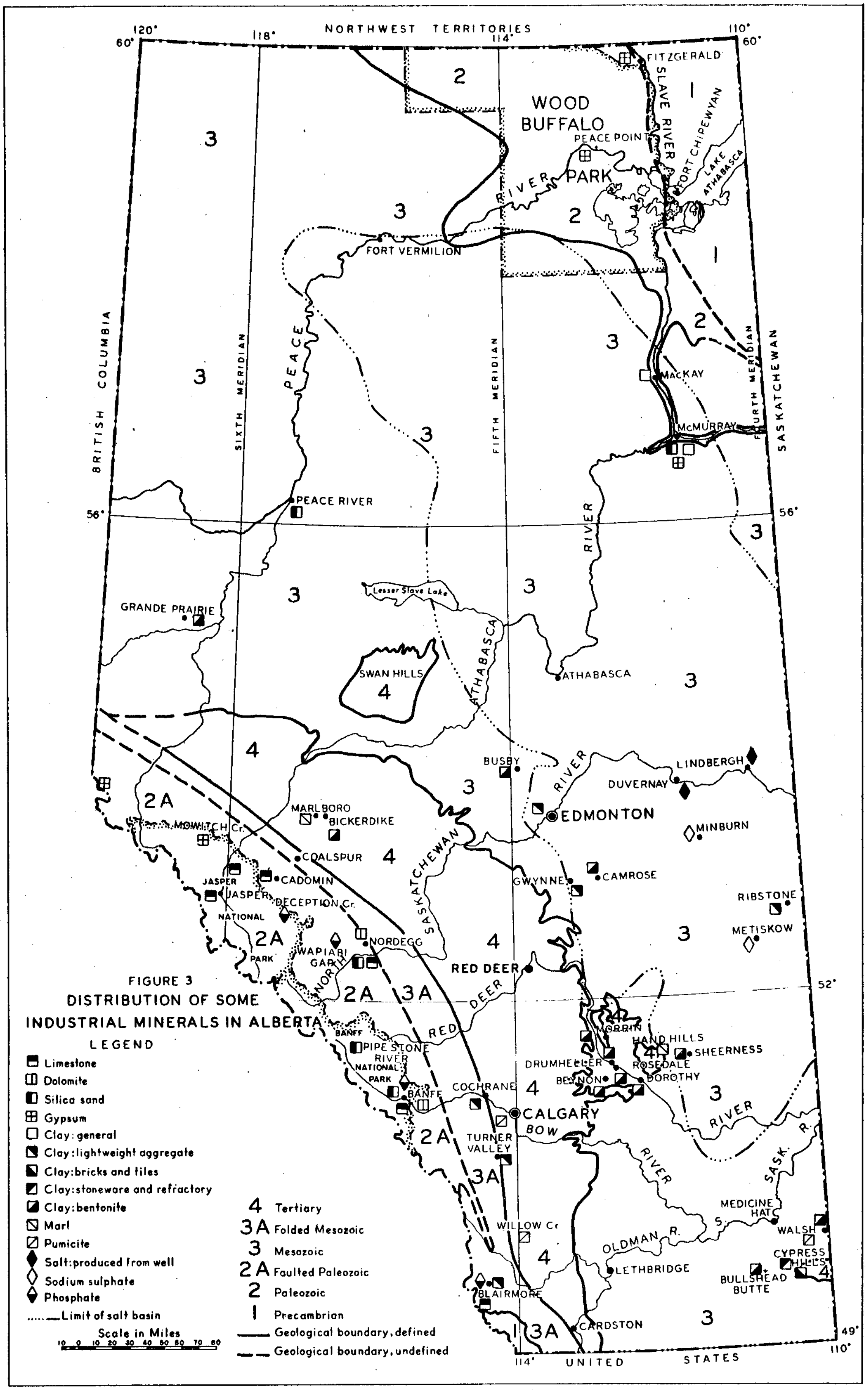



FIGURE 3
DISTRIBUTION OF SOME INDUSTRIAL MINERALS IN ALBERTA

| Generalised Stratigraphic Table of Alberta: System | Stratigraphic Unit | Occurrences of the More Important Industrial Minerals | |
|---|---|---|---|
| QUATERNARY | GLACIAL, FLUVIAL, LACUSTRINE | BRICK CLAY | |
| TERTIARY | CYPRESS HILLS<br>PASKAPOO | BUILDING STONE, BRICK CLAY | |
| UPPER CRETACEOUS | WILLOW CREEK | | |
| | EDMONTON | BENTONITE<br>BRICK CLAY, SEMI-REFRACTORY CLAY | |
| | BEARPAW | BENTONITE | |
| | BELLY RIVER | BUILDING STONE, BRICK CLAY | |
| | ALBERTA | BRICK CLAY | |
| LOWER CRETACEOUS | BLAIRMORE | SILICA SAND<br>BRICK CLAY<br>SEMI-REFRACTORY CLAY | |
| | KOOTENAY | PHOSPHATE | |
| JURASSIC | FERNIE | PHOSPHATE | |
| TRIASSIC | SPRAY RIVER | BUILDING STONE, GYPSUM | |
| PERMIAN<br>PENNSYLVANIAN | ROCKY MOUNTAIN | PHOSPHATE | |
| MISSISSIPPIAN | RUNDLE | BUILDING STONE | LIMESTONE |
| | BANFF | | LIMESTONE |
| DEVONIAN | EXSHAW | PHOSPHATE | LIMESTONE |
| | WABAMUN | SALT<br>BUILDING STONE | LIMESTONE |
| | WINTERBURN | | LIMESTONE |
| | WOODBEND | PHOSPHATE | LIMESTONE |
| | BEAVERHILL LAKE | | LIMESTONE |
| | ELK POINT | SALT, GYPSUM | LIMESTONE |
| SILURIAN | | | |
| ORDOVICIAN | | | |
| CAMBRIAN | | BUILDING STONE | |
| PRECAMBRIAN | | | |

FIGURE 4. STRATIGRAPHIC TABLE AND ASSOCIATED IMPORTANT INDUSTRIAL MINERAL DEPOSITS IN ALBERTA

# CLAYS AND SHALES

## Introduction

Clays and shales are widely distributed throughout Alberta (Fig. 3). Strata of the Tertiary and Cretaceous systems contain variable quantities of bentonitic clay, and although those deposits so far investigated do not, on the whole, have sufficiently high yields for use as a drilling fluid, the quantities available in some places are large. Non-marine shales of Cretaceous and Tertiary age outcrop over large areas of the plains and are used as the raw material for local brick and tile industries and, in the Cypress Hills area, are considered a potential source of fireclays, stoneware clays, and perhaps kaolin. The considerable quantities of glacial clays in the province are suitable only for the manufacture of bricks and tiles. Marine shales are generally unsuitable for the ceramic industry, but may be used in the production of cement, rock wool, and lightweight aggregates.

In 1956 Alberta accounted for eight per cent of Canadian clay products, an output valued at about 2,800,000 dollars. This figure does not include products manufactured from high-grade clays imported from Saskatchewan and the United States, nor does it include lightweight aggregate, valued at 400,000 dollars in 1957, manufactured from Alberta clays and shales. Bentonite is produced only intermittently in small amounts and most of Alberta's requirements are supplied from the United States.

# Bentonite

## Introduction

Bentonite is a very fine-grained clay essentially composed of members of the montmorillonite group. Most bentonites are believed to have been derived from volcanic ash.

Bentonite is used chiefly to control the viscosity of oil-well drilling mud; other major uses are as a decolorizing agent of various oils and as a bonding agent in foundry sand molds. This clay also has an extensive range of minor uses, for example as a carrier for insecticides, as a detergent in cleaners, as a filler in paper and rubber products, and as a catalyst for the cracking of petroleum.

Most of the bentonite consumed in Canada is imported from the United States, although some is mined in Manitoba and a small quantity in Alberta. Bentonite also occurs in British Columbia and Saskatchewan, and the latter deposits, although of low grade, have been reported to give a high quality product suitable for drilling muds and decolorizing agents following beneficiation (Tomkins, 1952; Winer, 1953). Deposits of bentonite are widespread in Alberta, being present in Cretaceous and Tertiary strata. Thick accumulations, up to 30 feet, have been reported only from the Upper Cretaceous, particularly the Edmonton and Bearpaw formations.

In the following account of Alberta bentonites, which is derived almost entirely from Byrne's report (1955), the yield of bentonite is given as the number of barrels of 15 centipoise mud obtained from one ton of dried bentonite. Thus the higher the yield in terms of barrels of mud, the better the quality of bentonite.

Bentonites in current commercial use as a constituent of drilling fluid have yields of about 100 barrels per ton.

Locations of bentonite deposits described are shown on figure 5.

Beynon

The Edmonton formation along the Rosebud River in SE. 1/4, Sec. 32, Tp. 27, R. 20, W. 4th Mer., contains a bed of bentonite 3.5 feet in thickness. This bed has a yield of 51 barrels per ton and a silt content of 0.2 per cent. The extent of the bentonite bed is not known. A chemical analysis is given in Table 1.

Bickerdike

A bed of white bentonite six to eight feet thick in the Saunders group (Cretaceous-Tertiary) outcrops along the McLeod River valley 200 yards upstream from a railway bridge in Sec. 6, Tp. 52, R. 18, W. 5th Mer. The bentonite has a low yield and has inferior decolorizing properties. A small quantity was mined in the past for use in cosmetics.

Busby

The Edmonton formation in Tps. 56, 57, 58, Rs. 1, 2, W. 5th Mer. contains lenses of bentonite 3 to 30 feet thick beneath 10 to 50 feet of overburden. The bentonite is characterized by foreset bedding, and the deposits consist of interbedded pure and contaminated bentonite. In general, the yield ranges from 40 to 60 barrels per ton, although some smaller areas having much higher yields (up to 115 barrels per ton) have been reported.

Drilling in one area has proved estimated reserves of 71,000 tons of bentonite, of which 29,000 tons may be suitable for the production of drilling mud. In another area there are 250,000 tons, of which 9,800 tons may be suitable for the production of drilling mud.

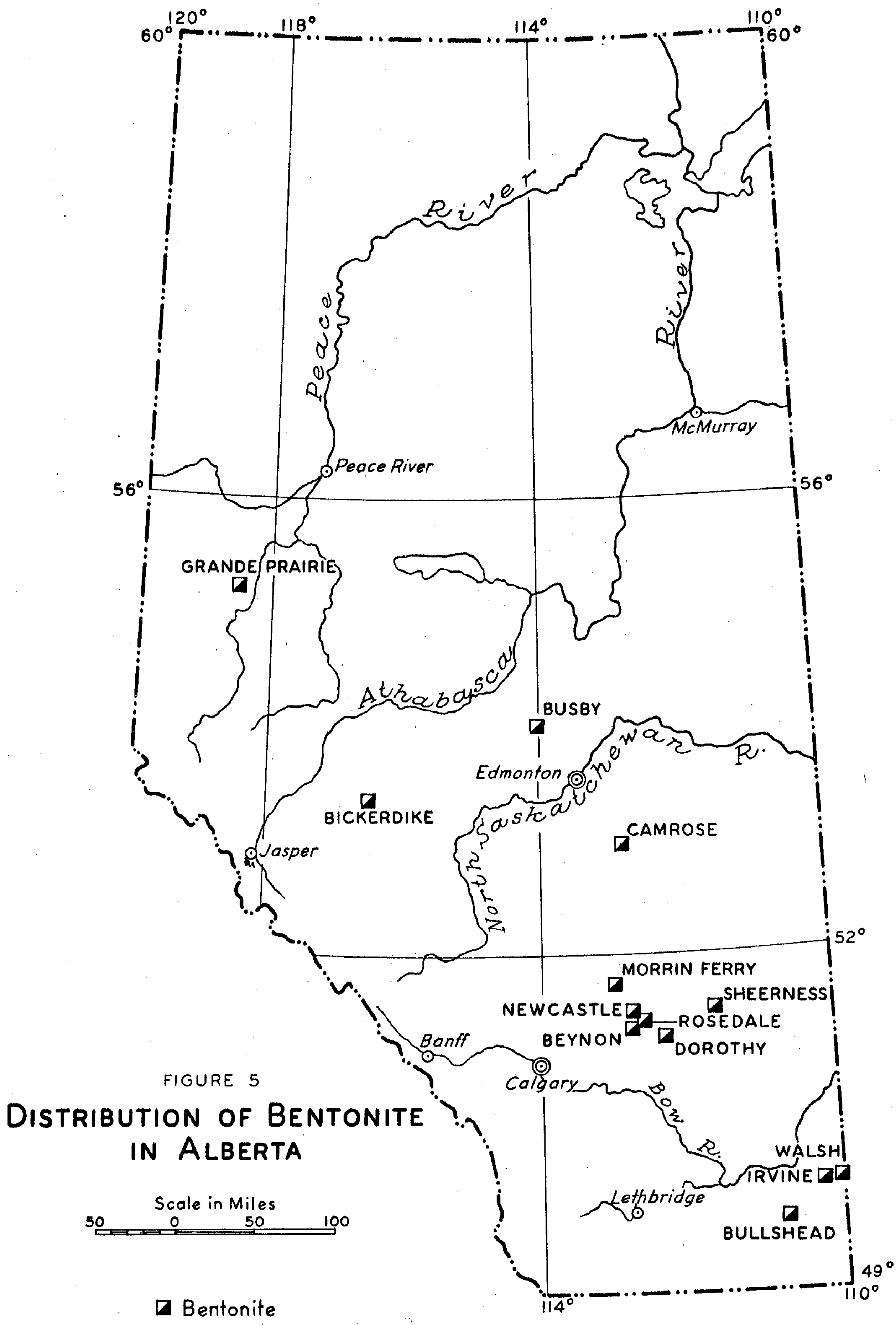



FIGURE 5
# Distribution of Bentonite in Alberta

The bentonite deposits in the Busby area are the best known at present in Alberta, and warrant further exploration.

Dorothy

The upper part of the Bearpaw formation in the vicinity of Dorothy contains a bed of bentonite 20 feet thick. This bed outcrops in the Red Deer River valley, and, although the tonnage available is probably considerable, the quality is poor — the yield being about 30 barrels per ton. A chemical analysis is given in table 1.

Drumheller

A bed of bentonite three feet thick, in the Edmonton formation, has been mined for a number of years on a ridge 15 miles north of Drumheller (NW. 1/4, Sec. 14, Tp. 29, R. 20, W. 4th Mer.). A single sample of the bentonite gave a yield of 56 barrels per ton and had a sand content of 2.3 per cent. An untreated sample of this bentonite was found to have a decolorizing ability equal to 60 per cent of that for commercial Floridin clay.

Grande Prairie

Byrne (1955) reported an occurrence of bentonite in the Wapiti formation (Upper Cretaceous) on the north flank of the Kleskun Hills (SE. 1/4, Sec. 27, Tp. 72, R. 4, W. 6th Mer.). Subsequent work indicates that this bentonite is in the form of small lenses of limited extent (Research Council of Alberta files). The yield is 40 to 60 barrels per ton.

Irvine and Bullshead Butte

A bed of bentonite and pumicite 5 to 10 feet in thickness occurs 100 feet above the base of the Bearpaw formation in the area surrounding the Cypress

Hills. Near Irvine (NW. 1/4, Sec. 30, Tp. 11, R. 2, W. 4th Mer.) pure bentonite ranges from one to five feet in thickness and passes laterally in an irregular fashion into volcanic ash or ashy-bentonite. The bentonite has a yield of 38 barrels per ton.

The bed described above is also present at Bullshead Butte (NE. 1/4, Sec. 2, Tp. 8, R. 7, W. 4th Mer.). At this locality the bentonite is only two feet thick and has a yield of 58 barrels per ton.

Newcastle

A bed of silty bentonite 5 to 10 feet thick in the Edmonton formation outcrops under light overburden in the SE. 1/4, Sec. 9, Tp. 29, R. 20, W. 4th Mer. Three samples from the deposit gave yields ranging from 42 to 66 barrels per ton and had silt contents of 3.9 to 11.6 per cent.

Rosedale

A thin bentonite bed is present in the Number 1 coal seam of the Edmonton formation throughout the Drumheller coal mining area. The bentonite is best developed in the Rosedale district, where it attains a thickness of six to eight inches. A single sample taken from the Aetna coal mine at Rosedale had a yield of 90 barrels per ton and a negligible sand content. A chemical analysis of a sample from this deposit is given in table 1.

Sheerness

J. G. Matthews (quoted in Byrne, 1955) described a bed of bentonite, occurring in the Edmonton formation above the coal seam mined by Western Dominion Coal Mines at Sheerness, as follows:

"The bentonite bed which occurs in the Edmonton formation appears to vary from one to five feet in thickness. . . . . . The bed is olive green in colour and is overlain by brown bentonite of slightly lower quality."

The olive-green bentonite has a yield of 58 barrels per ton and contains 0.5 per cent sand, and the brown bentonite has a yield of 43 barrels per ton and contains 1.7 per cent sand.

### Other Areas

In addition to those occurrences already described, Byrne (1955) has noted deposits of bentonite at Morrin, Camrose, and Walsh (Fig. 5).

### Conclusions

Although bentonite deposits are common throughout the Cretaceous and Tertiary strata in Alberta, it has been suggested (Byrne and Farvolden, 1958) that future exploration should be concentrated upon the Edmonton formation (Cretaceous).

## Brick and Tile Clays

### Introduction

Clays and shales suitable for the manufacture of brick and tile are common in Alberta. The principal requirements of brick and tile clays are that they should burn at a low temperature, have moderate plasticity to facilitate easy molding, and they should be free from drying defects such as cracking. The majority of brick and tile clays are red-burning.

The recent trend in the manufacture of brick and tile has been towards the establishment of a few large, central plants rather than numerous small plants such as existed in Alberta in the past. In view of this trend, and because of the large amount of information on test results on clays and shales as compared to a small number of deposits whose location is known with any accuracy, the following discussion will deal in generalities regarding the suitability of shales in various formations for manufacturing brick and tile rather than with specific, individual deposits.

TABLE 1: Chemical Analyses of some Bentonites in Alberta * (Byrne, 1955)

| | Rosedale | Beynon | Dorothy |
|---|---|---|---|
| $SiO_2$ | 57.18 | 63.61 | 65.74 |
| $Al_2O_3$ | 20.25 | 17.37 | 13.89 |
| $TiO_2$ | 0.11 | 0.24 | 0.33 |
| $Fe_2O_3$ | 2.08 | 3.18 | 3.32 |
| FeO | 0.51 | 0.60 | 0.09 |
| MnO | 0.00 | 0.01 | 0.01 |
| MgO | 2.72 | 1.86 | 1.75 |
| CaO | 1.09 | 1.19 | 1.10 |
| $Na_2O$ | 2.21 | 2.18 | 2.40 |
| $K_2O$ | 0.30 | 0.63 | 0.69 |
| $H_2O$ - | 8.44 | 4.16 | 6.00 |
| $H_2O$ + | 4.79 | 3.99 | 3.89 |
| Loss on ignition | 0.67 | 1.11 | 0.93 |
| | 100.35 | 100.13 | 100.14 |

* These analyses were performed by the Rock Analysis Laboratory, University of Minnesota, Minneapolis, Minn.

Blairmore Shales (Lower Cretaceous)

A number of tests quoted by Worcester (1932) and Ries and Keele (1912) suggest that many Blairmore shales would make brick and tile of good quality. Blairmore shales are generally free of the drying defects commonly associated with clays and shales in Alberta. Their chief disadvantage is the small number of places where large tonnages of shale of uniform character are available for stripping operations.

Alberta Shales (Upper Cretaceous)

A small number of tests suggest that some of the Alberta shales have very low plasticity. In other respects, many of them appear to be suitable for the manufacture of brick.

Foremost and Oldman Shales (Upper Cretaceous)

The Foremost and Oldman formations are characterized by variable lithology and rapid horizontal changes, and although material suitable for brick and tile manufacture may be found, many of the clays and shales in these formations are highly plastic and give difficulty in air drying. This difficulty can be overcome by preheating the clays, by suitable chemical treatment (Phillips, 1938), or by using the more sandy clays or shales in these formations. The last procedure is less desirable since sandy clays produce weaker and more porous bricks.

Bearpaw Shales (Upper Cretaceous)

A small number of tests on samples from the bearpaw shales suggest that their tendency to form white scum on bricks during firing makes them undesirable as brick clays (Crockford, 1951).

Edmonton Shales (Upper Cretaceous)

Clays and shales in the Edmonton formation are similar to those in the Oldman and Foremost formations, except for a tendency toward higher plasticity and higher air shrinkage. As a result of this feature, the majority of them are unsatisfactory raw materials for brick manufacture. Some of the better Edmonton clays might be utilized if suitable pre-heating or chemical treatments were used.

Whitemud Clay (Upper Cretaceous)

Clay of the Whitemud formation in the Cypress Hills area (Crockford, 1951) is in places suitable for the manufacture of bricks (Fig. 7), although the distance from manufacturing centres is probably too great for economic development at present.

Paskapoo Shales (Tertiary)

In some areas shales of the Paskapoo formation are quite suitable for the manufacture of bricks, but most of the outcrops of the formation consist of sandstone or interbedded sandstone and shale. Thicker shales possibly occur in the Paskapoo and may be found by a thorough investigation.

Some of the shales of the Paskapoo are calcareous, and therefore tend to form a buff brick with high porosity.

Pleistocene Clays

Pleistocene clays in Alberta seem to bear a general similarity to the bedrock of the province. Many of them have high plasticity and high air shrinkage, and some of them derived from the Paskapoo formation are calcareous. Bricks may be made from the siltier Pleistocene clays, and many of the less silty clays probably would respond to one or more of the various treatments suggested by Phillips (1938) to overcome drying defects.

Conclusions

Brick and tile clays are fairly common in Alberta. The chief defect of many clays is their tendency to crack when drying, but suitable pre-heating and chemical treatments for overcoming this defect have been devised by Phillips (1938).

## Lightweight Aggregate

The addition of lightweight aggregate to cement is capable of effecting a decrease in deadload of from 30 to 80 per cent, the amount being pre-determined by the particular use of the concrete.

Matthews (1952) carried out a preliminary survey of Alberta clays and shales to determine their suitability for use in the manufacture of lightweight aggregate. Matthews found that the most suitable materials contained 60 to 80 per cent silica, 15 to 30 per cent alumina, and 10 to 20 per cent combined calcium, magnesium, sodium and iron oxides. The raw materials should yield a product having the following properties:

1. High strength-to-weight ratio
2. Low absorption
3. Smooth spherical particles
4. Uniform size gradation
5. Chemically inert

Since Matthews' survey, plants have been set up in Calgary and Edmonton for the manufacture of lightweight aggregate. The Calgary plants use

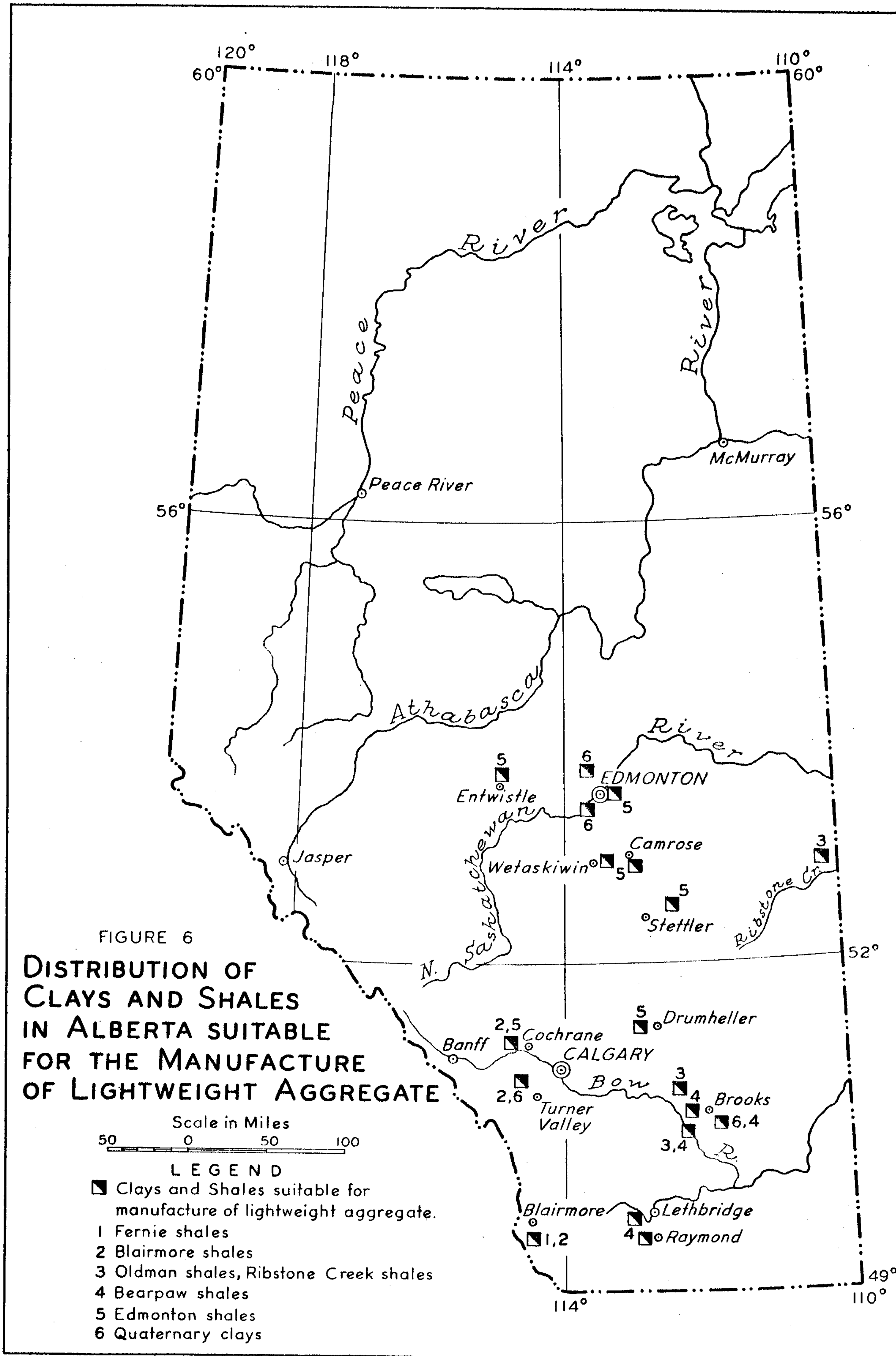



FIGURE 6

**Distribution of Clays and Shales in Alberta suitable for the Manufacture of Lightweight Aggregate**

shales from the Paskapoo and Oldman formations, whilst the Edmonton plant uses Recent clays.

In the course of his survey, Matthews collected and tested 108 samples of marine and non-marine shales, and Pleistocene and Recent clays. A far greater percentage of the marine shales proved to be suitable for the manufacture of lightweight aggregate than the other types. However, both marine and non-marine shales of Jurassic and Cretaceous age have been noted by Matthews as possible sources of raw material at various localities. The more important occurrences are shown in figure 6.

## Stoneware and Refractory Clays

### Introduction

Large workable deposits of clay suitable for the manufacture of high quality china or refractory bricks have not been discovered in Alberta. However, kaolinitic sands occur in the Whitemud formation in Saskatchewan and Alberta, and Crockford (1951) suggested that the Alberta deposits (Cypress Hills area, Fig. 7) may be a suitable source of kaolin.

There are considerable deposits of stoneware and lower-grade refractory clays in the Cypress Hills area of southeastern Alberta, and along the Athabasca River in northeastern Alberta. These two areas will be described separately.

### Cypress Hills

Many of the clays occurring in the Whitemud formation (Upper Cretaceous) in Saskatchewan have proved to be of high quality (Worcester, 1950), and for this reason Crockford (1951) conducted a detailed survey of the Whitemud formation in southern Alberta.

The Whitemud formation consists of up to 25 feet of light-grey clays, brown clays and argillaceous silts. Erosion has resulted in the absence of the Whitemud formation over a large part of the area. The formation is characterized by thin beds showing rapid horizontal changes in lithology and ceramic properties. The high air shrinkage of all except the most silty clays suggests the presence of montmorillonite in the clays.

Fireclays should have a fusion point greater than 1605°C. The refractory properties are expressed in terms of the pyrometric cone equivalent (P.C.E.) which is a measure of the softening temperature. The fireclays and semi-fireclays of the Cypress Hills area have a P.C.E. ranging from 20 to 30, which corresponds to softening temperatures of 1532°C. to 1649°C. The localities considered by Crockford (1951) as most favorable for development are recorded in figure 7. These beds are generally about 3 feet in thickness, and covered by 10 to 30 feet of overburden, some of which is clay of stoneware grade. Similar clays in the Whitemud formation in Saskatchewan are presently being exploited.

Stoneware clays should have good plasticity, good working strength, low shrinkage and refractory properties sufficient for the ware to hold its shape during burning. This type of clay is used for the manufacture of general crockery and sewer pipes, and low grades may be used for terra cotta works, such as vases and teapots. Most of the Saskatchewan output is of this type, and the large-scale manufacture of sewer pipes at Medicine Hat uses clays from Saskatchewan.

Crockford (1951) considered that suitable clay of stoneware grade is abundant in the Whitemud formation in Alberta. The most favorable locations of

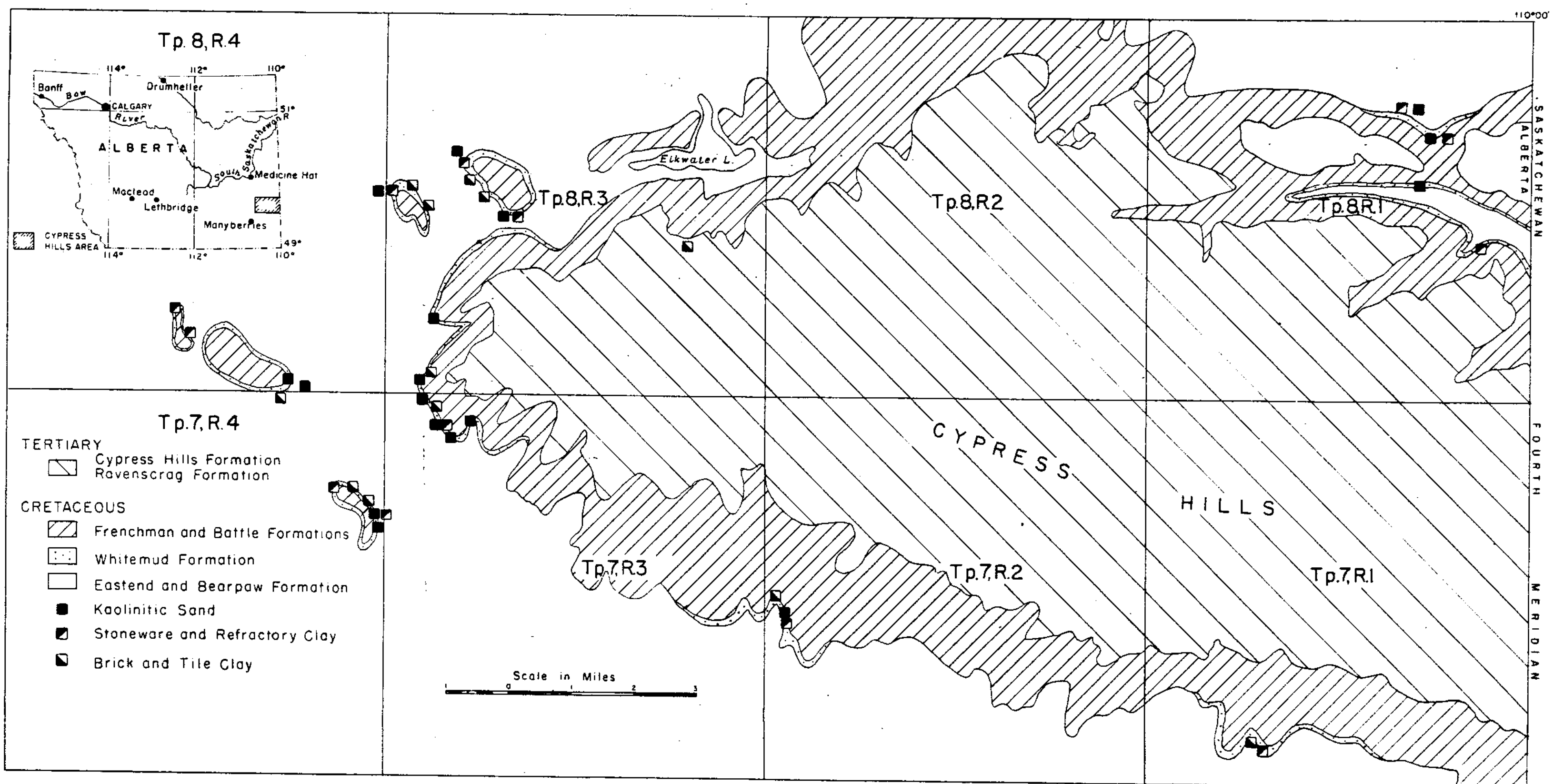



FIGURE 7. LOCATIONS AND TYPES OF CLAY DEPOSITS IN THE CYPRESS HILLS, ALBERTA. (MODIFIED AFTER CROCKFORD 1951)

the deposits in the Cypress Hills area are shown in figure 7. The beds are 3 to 10 feet in thickness, covered by up to 30 feet of overburden. Some of the clays are high grade, others would require blending with clays above or below in the succession.

Athabasca River

Some clays lying on the pre-Cretaceous erosion surface of Devonian limestone beneath and within the bituminous sands of the McMurray formation north of McMurray have been shown by Ells (1914, 1915, 1926) and Hume (1923) to be of possible value as semi-fireclays or stoneware clays.

The clays at the base of the McMurray formation are extremely variable, ranging from clays which have no ceramic value to semi-fireclays. The more promising of the occurrences are listed below, the reference numbers being the same as used by the reference wherein a more complete description of the clay may be found. The location of the clay deposits is shown in figure 8, and it must be emphasized that those listed below represent the best of 39 samples collected by Ells (1915, 1926) and Hume (1923).

Ells, 1915, No. 190: This sample and three others were collected along the lowest four miles of Muskeg River. Sample 190 is plastic, has good drying qualities, has a P.C.E. of 27, and is classed as a semi-fireclay. The three other samples rank as brick clays, but are probably from the same horizon.

Ells, 1926, No. 2: A sample of clay taken from the bank of the Athabasca River in Sec. 17, Tp. 91, R. 9, W. 4th Mer. has low plasticity, fires to a light buff, and has a P.C.E. of 27.

Hume, 1923, No. I: A bed of clay eight feet thick beneath 11 to 30 feet of overburden close to the location of the Ells No. 2 sample was sampled by Hume. However, the ceramic properties of the "Hume No. 1" are somewhat different from "Ells No. 2" in that it is plastic, has moderately high air shrinkage, burns to a light buff, and has a P.C.E. of 18. This clay might be suitable for use as a stoneware clay.

Ells, 1915, No. 310: This clay is of unknown thickness and was sampled 11.2 miles above the mouth of the McKay River. The clay burns buff to grey in color, has a P.C.E. of 10 to 15 and, apart from a moderately high shrinkage, has good working qualities.

Ells, 1915, No. 187: A clay deposit of unknown thickness is located 6.8 miles above the mouth of the Ells River. This clay burns buff to grey and has a P.C.E. of 16. Another sample taken 0.25 miles downstream from this location, and presumably in the same horizon, was too sandy to be of much value.

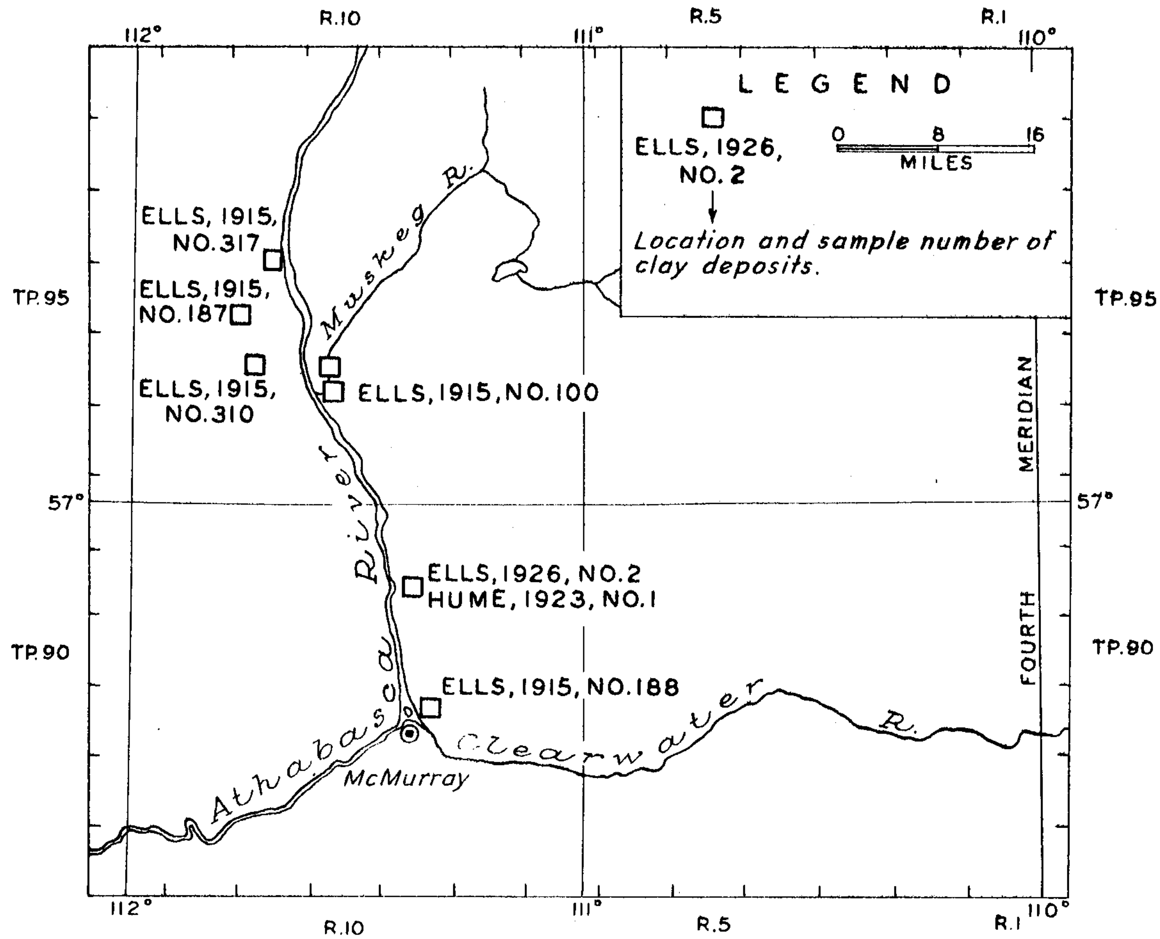
Ells, 1915, No. 317: A sample collected 1.8 miles above the mouth of the Ells River from a bed of unknown thickness has good working and drying properties, burns buff to grey, and has a P.C.E. of 16. Another sample taken 0.4 miles upstream from this location, and probably from the same horizon, had no ceramic value.

Ells, 1915, No. 188: A sample of clay collected on the east bank of the Athabasca River, one-third of a mile above McMurray, proved to be grey-burning and had a P.C.E. of 16. Ells' sample was contaminated with bitumen from the overlying sands, which prevented adequate testing, but it may be of stoneware grade.

Ells (1926) also collected several samples of Pleistocene clay along the Firebag River. These samples may have use as brick clays, but are prone to the development of scum during firing.

FIGURE 8

## LOCATION OF CLAY DEPOSITS IN THE ATHABASCA RIVER AREA



## Conclusions

The Whitemud formation of the Cypress Hills contains stoneware clay, fireclay and other high-grade clays. Crockford (1951) considered that many of these clays could be improved by simple treatment or blending. Although the clays show a general increase in thickness and quality eastwards, the deposits in the western part of the Cypress Hills are somewhat more accessible and covered by thinner overburden; thus, further investigations should be concentrated here.

Insufficient work has been done in the Athabasca River area to permit more than general recommendations. Despite the wide variation in quality exhibited by the clays, some show promise as stoneware clay and deserve further investigation.

The major constituent of high-grade whiteware and refractory clays is kaolinite. This clay mineral is rarely present in significant concentrations in marine shales and clays, and hence future exploratory work should be concentrated upon non-marine formations. However, tests upon samples from the Foremost, Oldman, Edmonton and Paskapoo formations in central and southern Alberta show them to be unsuitable for ceramic purposes (Ries and Keele, 1912, 1913; Ries, 1914, 1915). Nevertheless, any clay which is low in iron, has below average plasticity, and is non-calcareous, is worthy of investigation.

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# DOLOMITE

## Introduction

Dolomite has a wide variety of uses, for example, in various refractory compositions, as a source of agricultural magnesium, and in the extraction of magnesium hydrate from sea water.

Large quantities of dolomite are available in the Rocky Mountains of Alberta but few deposits have been tested for purity and, as far as the writers are aware, none is being quarried in the province. Goudge (1944) sampled several dolomite deposits in the course of a survey on limestones, and the following sample descriptions have been taken from his report. Analyses of samples collected by Goudge are given in table 2. Locations of the deposits discussed below are shown in figure 9.

## Kananaskis

Goudge (1944) described this deposit as follows:

> "The easternmost mountain, just north of the railway at Kananaskis, is composed very largely of pure dolomite with lesser bands of high-calcium limestone interbedded with mottled magnesium limestone at the summit and the base. The strata strike N. 60° W. and dip at an angle of 35° southwest" (p. 106).

Analysis 1, table 2, is representative of a 200-foot band of grey-weathering steel-blue dolomite; analysis 2 is representative of 500 feet of brown rusty-weathering dolomite; and analysis 3 is representative of a 70-foot band of light-grey dolomite (Goudge, 1944). Goudge did not give any further details of the stratigraphic relationship of these beds.

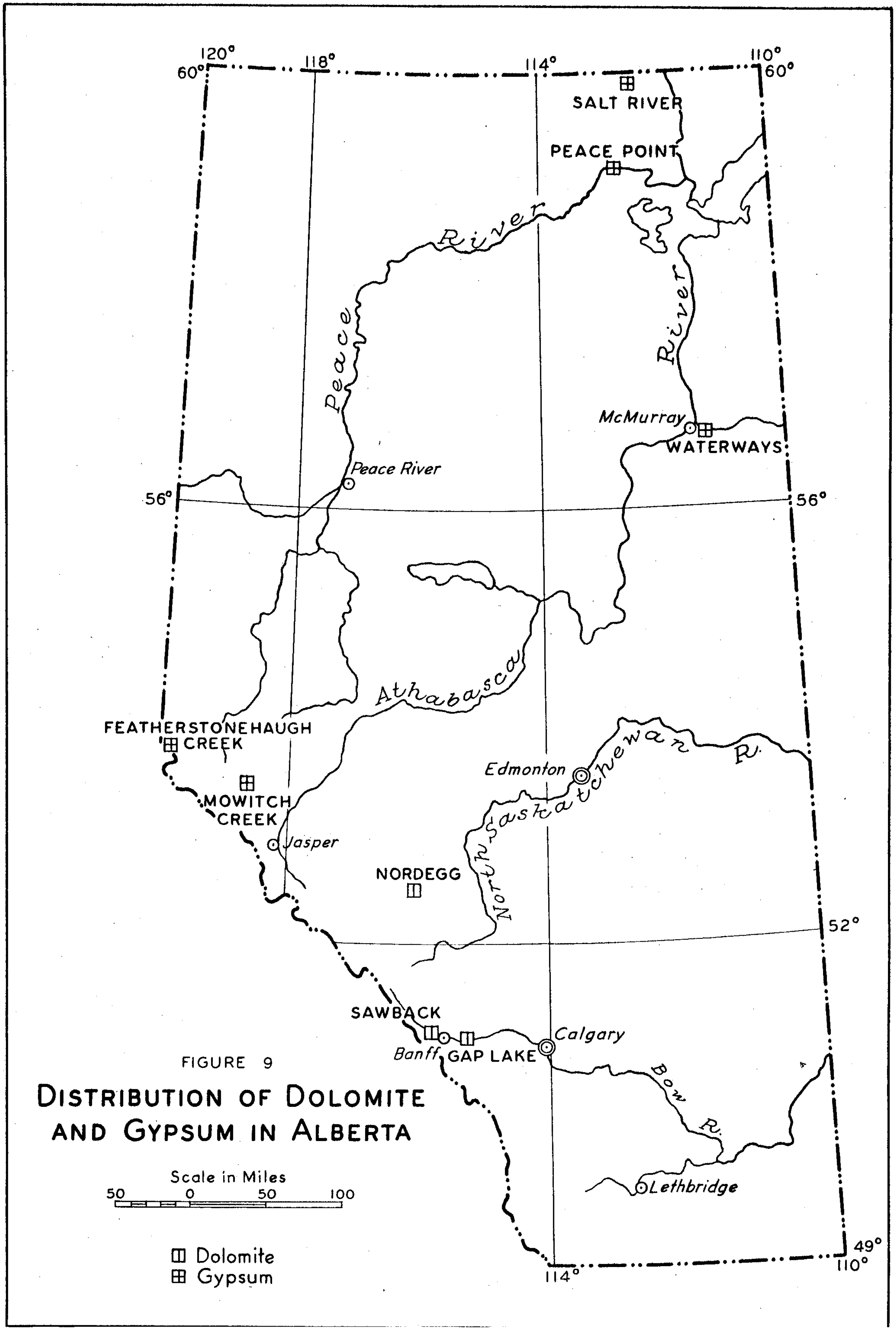


FIGURE 9

DISTRIBUTION OF DOLOMITE AND GYPSUM IN ALBERTA

TABLE 2: Chemical Analyses of Dolomites Described in this Report (after Goudge, 1944)

| Sample Number and Name of Deposit | Thickness Represented (feet) | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $Ca_3(PO_4)_2$ | $CaCO_3$ | $MgCO_3$ | Total | CaO | MgO |
|---|---|---|---|---|---|---|---|---|---|---|
| Pure dolomite (theoretical) | | --- | --- | --- | --- | 54.27 | 45.73 | 100.00 | 30.41 | 21.86 |
| 1. Kananaskis | 200 | 0.52 | 0.20 | 0.22 | 0.04 | 56.05 | 42.79 | 99.82 | 31.41 | 20.46 |
| 2. " | 500 | 0.42 | 0.26 | 0.04 | tr | 55.41 | 43.58 | 99.71 | 31.03 | 20.84 |
| 3. " | 70 | 0.40 | 0.12 | 0.18 | tr | 55.70 | 43.98 | 100.38 | 31.19 | 21.03 |
| 4. Gap Lake | 40 | 0.36 | 0.17 | 0.19 | 0.02 | 55.39 | 44.28 | 100.41 | 31.03 | 21.17 |
| 5. Banff | 1000 | 1.06 | 0.53 | 0.24 | 0.02 | 55.71 | 43.25 | 100.81 | 31.21 | 20.68 |
| 6. " | 1000 | 1.16 | 0.48 | 0.26 | 0.04 | 55.39 | 42.79 | 100.12 | 31.03 | 20.46 |
| 7. Sawback | ? | 0.82 | 0.34 | 0.20 | 0.02 | 55.84 | 43.48 | 100.70 | 31.28 | 20.79 |
| 8. " | ? | 1.74 | 0.51 | 0.35 | 0.02 | 55.25 | 44.24 | 101.11 | 30.95 | 21.15 |
| 9. " | 80 | 0.12 | 0.38 | 0.12 | tr | 55.82 | 44.34 | 100.78 | 31.26 | 21.20 |
| 10. Nordegg | 250 | 0.90 | 0.19 | 0.33 | tr | 57.29 | 41.33 | 100.04 | 32.08 | 19.76 |
| 11. " | " | 0.68 | 0.20 | 0.42 | tr | 60.20 | 39.46 | 100.97 | 33.71 | 18.87 |
| 12. " | 15 | 1.60 | 0.30 | 0.57 | 0.02 | 55.14 | 42.83 | 100.46 | 30.89 | 20.48 |

Gap Lake

A considerable thickness of dark-blue Devonian-Carboniferous dolomite is reported to be present in the vicinity of Gap Lake about 4 miles west of Exshaw. Analysis 4, table 2, represents a 40-foot band of dolomite exposed in a suitable position for quarrying north of the highway and opposite the centre of Gap Lake (Goudge, 1944).

Banff

On the east face of Sulphur Mountain, Warren (1927) described a thick section of dolomite which he assigned to the upper and middle members of the Lower Minnewanka limestone (Upper Devonian). Analysis 5 in table 2 represents grab samples taken by Goudge (1944) at intervals through the middle member, which is nearly 1,000 feet thick. The overlying upper member consists of about 250 feet of dolomite which was not sampled.

Goudge described 1,000 feet of a similar dolomite exposed "in a gully on the east face of Sulphur Mountain, south of Upper Hot Spring". Analysis 6 is representative of grab samples taken at intervals over 1,000 feet.

Sawback

Beds of pure dolomite of Cambrian age, interbedded with shales and impure limestones, are exposed for about 1,500 yards along the southern slopes of Mt. Edith; the beds dip southwest at 60 degrees or more. Three analyses of this dolomite are given in table 2 as analyses 7, 8 and 9 (Goudge, 1944). Analysis 9 represents 80 feet of strata, but Goudge did not specify the thicknesses represented by his other three analyses.

Nordegg

Goudge (1944) reported a thickness of 250 feet of brown, medium-grained, compact dolomite within Devonian-Carboniferous formations in a cutting at Mile 146 of the Canadian National Railway. Analysis 10 is representative of this material.

Three hundred and fifty yards west of Mile 147, the dolomite described above is repeated by faulting. Analysis 11 is representative of this material.

Fifteen feet of porous dolomite exposed beyond the eastern railway yard limit at Nordegg is represented by analysis 12.

Conclusions

The deposits described above were discovered in the course of a survey primarily designed to discover limestone deposits. Discovery of further dolomite deposits adjacent to rail transportation should not be too difficult if a demand for dolomite should arise.

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# GYPSUM

## Introduction

The chief uses for gypsum are for the manufacture of plaster of Paris and wallboard, and as an ingredient of Portland cement. Plaster and wallboard are manufactured at Calgary, Alberta, utilizing gypsum from British Columbia and Manitoba.

In 1954 Nova Scotia accounted for 80 per cent of the total Canadian production of nearly four million short tons, and 70 per cent of the year's total was exported, almost entirely to the United States.

Gypsum and anhydrite are common minerals in Alberta, but no surface deposits of gypsum have yet been located in readily accessible areas, although deposits do occur at a moderate depth in the vicinity of Waterways. The location of known deposits is shown in figure 9, and a description of the individual deposits follows.

## Peace Point

Gypsum of Middle Devonian age is exposed on both banks of the Peace River for a distance of 18 miles from a point 5 miles below Peace Point, to Little Rapids upstream. The general nature of this deposit has been described by Camsell (1917) in the following terms:

> "The lowest bed exposed is of gypsum, the thickness of which is variable but has an exposed maximum of 50 feet. The next overlying bed is a fractured and broken dolomite from 10 to 30 feet thick, above which is an argillaceous, sometimes sandy limestone containing fossils. Overlying all is the drift from 5 to 20 feet in thickness" (p. 136-137).

"The gypsum is usually white and massive. In places it is earthy and thin bedded, or holds narrow bands of dolomitic limestone. Selenite is rare, but thin veins and beds of satin spar are common. Anhydrite is occasionally present in rounded nodules or in thin beds" (p. 139).

Camsell remarks on the undulatory character of the gypsum beds, which he ascribes to volume increase consequent upon hydration of primary anhydrite. Because of these undulations, the gypsum is in some places brought to the top of the river banks (which form cliffs 20 to 60 feet above the level of the river), where the limestone has been removed by erosion and the gypsum has no cover excepting the drift.

This gypsum deposit was examined in greater detail by Cameron (1930) who collected and analysed samples (table 3) from 10 measured-sections of the outcrops along the Peace River. These measured-sections are reproduced below, and Cameron states that a particular bed of gypsum varies within a few hundred feet from a "dense, hard, white to grey, thin bedded material, to a coarse, soft, massive saccharoidal type" (p. 43).

The following stratigraphic sections of the Peace Point gypsum deposit are taken from the account by Cameron (1930, p. 41-43):

"All sections except No. 1 were unit sections measured vertically on an exposed cliff. Section No. 1 is a composite section giving maximum thickness of beds exposed along a distance of about one-quarter mile.

"Description of each section measured, together with its approximate location and identification of particular beds in each section which were sampled follows:

Section No. 1. North side Peace river at Peace Point.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Surface till and glacial clays . . . . . . . . . . . | 2 | |
| 2 | Brecciated dolomite . . . . . . . . . . . . . . . . . | 18 | |
| 3 | Thin bedded grey gypsum . . . . . . . . . . . . . | 9.5 | |
| 4 | Massive white to light grey gypsum with thin stringers of fibrous gypsum parallel to and cutting massive beds . . . . . . . . . . . . . . . | 6 | 1 |
| 5 | Massive white saccharoidal gypsum . . . . . . | 3.3 | 2 |
| 6 | White gypsum with lenses of grey anhydrite . . | 3.25 | 3 |
| 7 | Massive white to grey gypsum to river level. . | 10 | 4 |
| | Bottom not exposed. | | |

Section No. 2. South side of river at Peace Point.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Glacial lacustrine sands and silts . . . . . . . . | 50 (approx.) | |
| 2 | Massive grey gypsum . . . . . . . . . . . . . . . . | 17.5 | 5 |
| 3 | White flinty hard gypsum . . . . . . . . . . . . . | 8 | 6 |
| | Bottom not exposed. | | |

Section No. 3. North side Peace river about 2 miles above Peace Point. West limb of a flat anticline, dipping 35°E. West end of exposure is cut off by sharp syncline bringing down brecciated dolomite and thin bedded flaggy dolomite to river level.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Thin bedded shaley grey anhydrite and gypsum | 12.25 | |
| 2 | Massive grey saccharoidal soft gypsum . . . . | 5.5 | 7 |
| 3 | Interbedded massive white gypsum with lenses of hard grey gypsum . . . . . . . . . . . . . . . | 11 | 8 |
| 4 | Massive grey to white saccharoidal soft gypsum | 4 | |
| 5 | Hard white gypsum with thin layers of dark shale and some white fibrous gypsum . . . . . | 2.5 | 9 |
| 6 | Massive soft grey to white saccharoidal gypsum to river level . . . . . . . . . . . . . . . . . . . . | 4.5 | |
| | Bottom not exposed. | | |

Section No. 4. North side Peace river about 4 miles above Peace Point. Vertical cliffs of purple tinted gypsum with interbedded dolomite are exposed as a broad anticline, apparently pitching steeply to the north. The section was measured at crest of this structure where strata are lying practically horizontal.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Loam, silt and sand . . . . . . . . . . . . . . . . | 10 | |
| 2 | Thin bedded dolomite and gypsum . . . . . . . . | 5 | |
| 3 | Massive soft white gypsum with thin stringers of dark shale . . . . . . . . . . . . . . . . . . . . . | 12 | 10 |
| 4 | Interbedded dolomite and gypsum with gypsum impregnated dolomites . . . . . . . . . . . . . . . | 7 | |
| 5 | Hard dark grey gypsum . . . . . . . . . . . . . . | 10.5 | 11 |
| 6 | Interbedded dark grey anhydrite and white gypsum, probably lensy . . . . . . . . . . . . . . | 9.5 | |
| 7 | Massive hard flinty gypsum to river level . . . | 7 | |
| | Bottom not exposed. | | |

Section No. 5. North side Peace river, about 4 miles below Little Rapids and at eastern end of Gypsum cliffs which are continuous on north side of river from Little Rapids to this point. Strata are practically flat lying with broad gentle folds periodically bringing dolomites down to river level.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Loam, silt and sand . . . . . . . . . . . . . . . . | 3 | |
| 2 | Intimately interbedded white to grey gypsum and dark hard siliceous gypsum . . . . . . . . . | 18 | 12 |
| 3 | Interbedded gypsum and dolomite . . . . . . . . | 2 | |
| 4 | Grey white saccharoidal gypsum . . . . . . . . | 4 (part) | 13 |
| 5 | Thin bedded dolomite with fibrous gypsum seams and stringers. . . . . . . . . . . . . . . . . . . . . | 3.25 | |
| 6 | Soft bluish white gypsum. . . . . . . . . . . . . . | 6 (part) | 13 |
| 7 | Hard bluish white anhydrite with seams and stringers of gypsum . . . . . . . . . . . . . . . . | 9 | |
| 8 | Soft bluish white gypsum. . . . . . . . . . . . . . | 3 (part) | 13 |
| 9 | Hard, creamy colored, shaley dolomite with thin seams and stringers of gypsum . . . . . . | 2.5 | |
| 10 | Massive soft brown to white gypsum . . . . . . | 3 (part) | 13 |
| 11 | Dark brown hard anhydrite . . . . . . . . . . . | 1 | |
| 12 | Massive soft white gypsum with brown stringers | 4 (part) | 13 |
| | Bottom not exposed. | | |

Section No. 6. North side of river about 2 miles below Little Rapids. Vertical cliffs of gypsum up to 50 feet high. Only the lower 25 feet available for sampling.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Sand, silt and loam . . . . . . . . . . . . . . . . . | 20 | |
| 2 | Massive white to grey gypsum . . . . . . . . . . | 25 to 30 | |
| 3 | Massive white to grey, soft gypsum, some layers saccharoidal. . . . . . . . . . . . . . . . . . . . . . | 25 | 14 |
| | Bottom not exposed. | | |

Section No. 7. North side Peace river about 1 mile below Little Rapids. Vertical cliffs of soft white to grey gypsum with lower 18 feet only available for sampling.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Loam, silt and sand. . . . . . . . . . . . . . . . . | 10 to 16 | |
| 2 | Massive grey gypsum . . . . . . . . . . . . . . . | 15 to 20 | |
| 3 | Massive soft grey saccharoidal gypsum . . . . | 18 | 15 |
| | Bottom not exposed. | | |

Section No. 8. South side of Peace river about 2 miles below Peace Point. Cliffs of white to grey gypsum are exposed for a distance of about one mile. Above the cliffs and south about 500 feet, are sands and silts to a thickness of 65 to 100 feet (estimated).

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Loam, sands and silt . . . . . . . . . . . . . . . | 7 | |
| 2 | Thin bedded limestone or dolomite . . . . . . . | 10 | |
| 3 | Thin bedded shaley anhydrite or hard gypsum . | 12 | |
| 4 | Massive hard white gypsum . . . . . . . . . . . . | 8 | |
| 5 | Interbedded hard white gypsum and dark shale. | 6 | |
| 6 | Massive hard white gypsum as at base of section 2 | 5 | |
| | Bottom not exposed. | | |

Owing to the proximity of section No. 2, and the apparent continuity of the strata between the two sections, no samples were taken at this point.

Section No. 9. North side of Peace river about 3 miles below Peace Point. Cliffs 25 to 50 feet high are exposed all along this bank of the river for over one mile. They show as gently undulating beds of limestone and gypsum. The cliffs are practically inaccessible, but at one spot about 200 yards from the west end of the outcrop, the bottom 12 feet of beds could be sampled.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Sand, silt and talcs . . . . . . . . . . . . . . . . | 10 to 15 | |
| 2 | Thin bedded flaggy dolomite . . . . . . . . . . . | 8 to 12 | |
| 3 | Massive soft saccharoidal gypsum . . . . . . . | 18 to 20 | 16 |
| | Bottom not exposed. | | |

Section No. 10. This section was measured only 100 feet upstream from No. 9, and it conforms with that section. It was sampled in order to determine if the very apparent changes in the appearance of the gypsum noted over this short distance was accompanied by a corresponding change in quality.

| Bed No. | Strata | Thickness (ft.) | Sample No. |
|---|---|---|---|
| 1 | Sand, silt and talcs . . . . . . . . . . . . . . . . | 15 | |
| 2 | Flaggy limestone or dolomite. . . . . . . . . . . | 10 to 12 | |
| 3 | Thin bedded hard white to dark grey gypsum. . | 18 | 17 |
| | Bottom not exposed." | | |

When Camsell and Cameron examined the Peace Point gypsum deposit, consideration of the economics of development was largely academic. However, with the recent recommendation that a railway passing near the deposit be built from Waterways to Great Slave Lake (MacGregor, 1958) it becomes important to assess the reserves and grade of the gypsum deposit.

Before reliable quantitative estimations of the reserves of gypsum may be made, it is essential to know the distance the gypsum beds persist away from the river, thickness and continuity of the beds, and the purity of the gypsum. Because the topography is essentially flat with few streams and the strata apparently are little disturbed, outcrops are rare. However, the prevalence of sinkholes on both sides of the river in this region, suggests that the gypsum is widespread. The presence of gypsum along the Salt and Slave Rivers (see below) of approximately the same age lends support to this contention. The continuity, thickness, and purity of the gypsum in the area are more in doubt for, whereas the top of the gypsum bed is commonly exposed, the base is never seen in this locality, although thicknesses of gypsum up to 50 feet have been observed. On the other hand, the gypsum deposits along both the Salt and Slave Rivers are notably poorer, and it seems reasonable to suppose a change to marine-type deposits in this direction.

Moreover, if Camsell's belief is correct that some (or all) of the gypsum beds are secondarily hydrated anhydrite, then there is a possibility that the amount of anhydrite will increase (relative to gypsum) away from the river.

In the absence of a thorough assessment which, by virtue of the nature of the deposit and topography, would require exploration by drilling, little can be added to Cameron's view of the economic potential of the deposit (1930, p. 45):

> "From the rather general examination made, it appears as though Camsell's estimate of 217,000,000 tons is quite conservative. The sections described (see above) indicate that the average thickness of the gypsum beds is very considerably in excess of the 15 feet assumed by Camsell, while the broad meanderings of the Peace river clearly show an area of at least 60 square miles as underlain by the gypsum series as against the 8 to 10 square miles used by him. Altogether it would appear that Camsell's estimate can be increased at least five times and the figure would still be quite conservative.
>
> "Peace river forms a ready means of access to much of the gypsum. It has cut deep into the gypsum seams and at a number of points has removed much of the overburden so that large quantities of material are very favourably situated for mining or quarrying."

Salt and Slave Rivers

Camsell (1917) recorded several occurrences of Middle Devonian gypsum along the Salt and Slave Rivers. These are described briefly below.

1. Salt River: About four miles south of the forks of Salt River 40 to 50 feet of impure thinly-bedded gypsum are exposed in an escarpment. This escarpment continues northwestwards across the Little Buffalo River and continues in the same general direction for about 40 miles. Camsell expressed an opinion that gypsum was present at the base of this escarpment for the greater part of its length. However, the gypsum decreases in thickness northwards, for eight miles southwest of Fort Fitzgerald only 20 feet of thinly-bedded gypsum are exposed.

2. Slave River: A few miles downstream from La Butte 10 feet of thinly-bedded impure gypsum are exposed. The gypsum is overlain by 20 feet of fractured limestone which Camsell suggested to be similar to that at Peace Point. Below Point Ennuyeux, also on the Slave River, four feet of thinly-bedded impure gypsum are exposed near water level. The Devonian strata are seen to lie on Precambrian rocks at a number of localities along the Slave River.

Cameron (1922) reported thin beds of impure gypsum interbedded with arenaceous limestones at Gypsum Point on Great Slave Lake. Cameron believed these gypsum beds to be Silurian in age, but it is more probable that they are of Middle Devonian age and should be correlated with the deposits on the Peace, Salt and Slave Rivers.

Waterways

Several wells in the general vicinity of Waterways have encountered gypsum. Varying proportions of anhydrite are associated with the gypsum, but unfortunately cores of the wells are no longer available for study to determine whether an economic thickness of gypsum is present in any of the wells. Allan (1930, 1943) published core descriptions of four wells which indicate that gypsum is present in thicknesses suitable for mining purposes, although it is of uncertain purity. The most promising bed occurs between 515 and 580 feet below ground level (Alberta Government Salt Well No. 2) and is described by Allan (1930) as an upper mottled gypsum and a lower massive white gypsum.

A particularly noticeable feature of the gypsum is its tendency to grade laterally into anhydrite, a feature which is shown clearly on the logs of Industrial Minerals Nos. 1 and 3 wells which were drilled only 560 feet apart.

TABLE 3. Chemical Analyses of Gypsum from Mowitch Creek Deposit (from Allan, 1943) and Peace River Deposit (from Cameron, 1930).

| Area | Sample Number | Section Name or Number | Bed Number | Thickness of bed (feet) | $SiO_2$ | $Fe_2O_3$ $Al_2O_3$ | MgO | CaO | $SO_3$ | Ignition loss | Gypsum calc. from $SO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mowitch Creek | | McDonald Gulch | | 3 | 1.51 | 0.59 | 1.10 | 32.12 | 43.38 | 21.40 | 93.09 |
| | | " | | 9.4 | 1.51 | 0.49 | 1.41 | 31.90 | 43.28 | 20.70 | 88.88 |
| | | East McDonald Gulch | | 7 | 11.91 | 0.40 | 1.51 | 27.80 | 38.42 | 19.90 | 82.44 |
| | | Corser Gulch | | 13 | 3.30 | 0.00 | 0.58 | 31.08 | 44.58 | 20.27 | 95.67 |
| Peace | 1 | 1 | 3, 4 | 15.5 | 2.54 | 0.92 | 2.02 | 31.58 | 42.10 | 20.74 | 90.34 |
| Point | 2 | 1 | 5 | 3.3 | 1.10 | 0.74 | 0.30 | 32.56 | 45.30 | 19.95 | 97.21 |
| | 3 | 1 | 6 | 3.3 | 1.76 | 0.96 | 4.54 | 32.19 | 34.83 | 25.59 | 74.74 |
| | 4 | 1 | 7 | 10.0 | 0.82 | -- | -- | 32.63 | 45.60 | 21.00 | 97.85 |
| | 5 | 2 | 2 | 17.5 | 1.42 | -- | 0.20 | 31.82 | 45.00 | 21.37 | 96.57 |
| | 6 | 2 | 3 | 8.0 | 4.18 | 1.10 | 0.30 | 31.39 | 43.10 | 19.98 | 92.49 |
| | 7 | 3 | 2 | 5.5 | 1.34 | -- | 0.25 | 31.64 | 45.20 | 21.43 | 96.99 |
| | 8 | 3 | 3 | 11.0 | 2.04 | -- | 0.33 | 31.80 | 44.32 | 21.34 | 95.11 |
| | 9 | 3 | 4, 5, 6 | 11.0 | 1.46 | -- | 0.31 | 31.80 | 44.70 | 21.74 | 95.93 |
| | 10 | 4 | 3 | 12.0 | 0.58 | -- | 0.20 | 32.11 | 46.00 | 20.50 | 98.71 |
| | 11 | 4 | 5 | 10.4 | 1.48 | -- | 0.20 | 32.00 | 45.00 | 21.37 | 96.57 |
| | 12 | 5 | 2 | 18.0 | 6.28 | -- | 0.76 | 30.97 | 41.09 | 20.80 | 88.18 |
| | 13 | 5 | 4, 6, 8, 10, 12 | 16.5 | 1.04 | -- | 0.22 | 32.18 | 46.02 | 20.54 | 98.95 |
| | 14 | 6 | 3 | 25.0 | 0.64 | -- | 0.22 | 32.18 | 45.91 | 21.02 | 97.52 |
| | 15 | 7 | 3 | 18.0 | 1.42 | -- | 0.10 | 32.50 | 45.68 | 20.24 | 98.02 |
| | 16 | 9 | 3 | 18.0 | 0.88 | -- | 0.30 | 32.35 | 45.60 | 20.57 | 97.85 |
| | 17 | 10 | 3 | 18.0 | 5.02 | 0.60 | 0.40 | 31.24 | 42.50 | 20.15 | 91.20 |

In general, there appears to be an increase in the amount of gypsum from the westernmost well to the easternmost, coincident with the decreasing depth of the gypsum. Allan (1930) gave his opinion that the gypsum is secondary, and was produced by hydration of anhydrite; thus it can be expected that the proportion of gypsum will increase with a decrease in depth. On this basis, it is possible that pure gypsum may exist towards the theoretical outcrop belt of the gypsum in the east or northeast. The general decrease in the total thickness of evaporites from west to east suggests proximity of the wells to the northeastern edge of the evaporite basin, but this apparent thinning may be due to removal of salt from the section by solution (Carrigy, 1958).

From the economic point of view, the location of a gypsum deposit on the railway would be very desirable. From a combined economic and geological point of view, the best location of an economic deposit of gypsum would be in the vicinity of the mouth of the Christina River.

Mowitch Creek

A gypsum deposit occurring near the northern boundary of Jasper Park has been described by Allan (1932). The deposit is located on the east slope of a tributary of Mowitch Creek in the northern part of Tp. 51, R. 5, W. 5th Mer.

Allan (1932) described the gypsum as follows:

"The gypsum occurs in beds of Triassic age. The strata are all steep dipping. . . . . The rock succession consists of beds of pure white gypsum and lenses of gypsum, interbedded with impure gypsum, chert and shale intermixed and other beds of red, buff, yellow, brown and grey limestone, siliceous and cherty limestone, quartzite and shale.

"The thickest bed of pure white gypsum examined measured about 12 feet, but much thicker beds of gypsiferous rock occur. . . . But the gypsum content is too low in these beds to be considered of economic importance.

"The purest gypsum is lensy in character, that is the bed changes character laterally, so that although samples of pure gypsum can be obtained, yet the quantity of this quality of mineral in one bed was not found to be large" (p. 28).

Chemical analyses of channel samples collected by Allan from the Mowitch Creek deposit are shown in table 3.

D. J. McLaren discussed the occurrence of gypsum in the Rocky Mountains with E. J. W. Irish and contributed the following comments (personal communication) on the Mowitch Creek gypsum:

"The gypsum deposit exposed on Mowitch Creek just within Jasper Park and described by Allan in 1934 is not within the area that has been mapped by the Survey. A brief visit was made to this deposit and the following points noted:

1. The gypsum is associated with yellow, buff and red coloured shales.
2. The top of the shale facies lies about 200 feet below the Triassic-Jurassic contact.
3. The shale facies is overlain and underlain by carbonate beds.
4. The deposit is probably of Upper Triassic age.
5. The shale facies is present for several miles northwest of the deposit on both sides of Deer Creek, but no gypsum was seen north of latitude 53° 30' north.
6. The southeastern limit of the deposit was not determined but presumably it does not extend far to the southeast."

Although Irish's description suggests that the gypsum is a local development, Allan and Stelck (1940) have reported Upper Triassic gypsum in a well in the Pouce Coupe area, and Allan (1932) reported that Triassic gypsum occurs along Snake Indian River in Jasper Park, about 15 miles south of the Mowitch Creek deposit.

The occurrence of carbonates above and below the gypsum-bearing shale facies indicates that the gypsum probably occurs in the Whitehorse member of the Spray River formation. The Whitehorse member thins eastward due to either non-deposition or erosion, so that the shale facies is probably confined to the western outcrops of Triassic beds.

Featherstonehaugh Creek

G. G. L. Henderson (personal communication) recently discovered a large deposit of gypsum on the British Columbia-Alberta boundary at the headwaters of Featherstonehaugh Creek in Tp. 55, R. 13, W. 6th Mer. Dr. Henderson described the deposit as follows:

> "This deposit consists mainly of white, fairly massive, sucrose gypsum with lesser amounts of grey, well bedded limy gypsum. A thickness of more than 50 feet of gypsum is exposed in several of the many sinkholes which are associated with the deposits. The gypsum appears to be overlain by a sequence consisting of dolomite breccia interbedded with greater thicknesses of light-grey, thinly bedded, cherty dolomite.
>
> "The very poor fossil collection that I obtained from the associated rocks proved to be worthless except that it suggested a Paleozoic age, rather than Mesozoic. From the lithology of the associated rocks and the regional geology of this area, I believe the deposits are probably Silurian or Devonian in age. My examination was limited to an hour or so on the ground, hence I am sure much more information could be obtained by a more detailed examination."

Conclusions

The gypsum deposit at Peace Point is undoubtedly the most suitable for development in Alberta. Present known reserves are very large and the purity compares favorably with other commercial deposits (which range from 95 to 97 per cent gypsum). The thin overburden should permit ready removal of the gypsum by quarrying and, should the proposed railway from McMurray to Great Slave Lake be built, shipment to marketing centres will be an economic possibility. Because the deposit lies within Wood Buffalo National Park, revised Federal legislation giving adequate protection to the indigenous fauna would be necessary before development could proceed.

Although field relationships in the vicinity of the Mowitch Creek gypsum deposit suggest that it is a local development, further work in the westernmost

Triassic outcrops of the province might show that other Triassic gypsum deposits do occur. Unfortunately, most of the area favorable for the occurrence of Triassic gypsum lies inside National Park boundaries. The most favorable areas outside National Parks are north of Jasper National Park and west of Nordegg. The latter area is more attractive from the point of view of accessibility.

The occurrence of considerable thicknesses of anhydrite in the Devonian and, to a lesser extent, the Mississippian strata underlying the plains of Alberta and the presence of gypsum and anhydrite in the foothills region suggest the possibility of gypsum deposits in the Devonian or Mississippian strata outcropping in the mountains. Gypsum has not been reported from these horizons in the literature and D. J. McLaren (personal communication), who has done intensive work on the Devonian of the Rockies between Banff and Jasper, reported that he had never seen any gypsum in the course of his work. McLaren states that:

> "L. M. Clark of Pacific Petroleumstold me some years ago that he had found anhydrite or gypsum in boulders below the Fairholme section at Whiteman Gap, near Canmore, in Bow Valley. I have not seen them myself, although I am familiar with the section."

An opinion on the possibility of gypsum occurrence in the Devonian strata of the mountains was also obtained from G. G. L. Henderson who has mapped gypsum deposits in British Columbia and worked in a number of areas of the Rocky Mountains of southern Alberta. Dr. Henderson (personal communication) replied,

> "Regarding the possibility of gypsum occurrences in the Rocky Mountains in Alberta, I do not think the chances are good south of the Brazeau River. I have travelled extensively in this area and have not seen any indications of gypsum."

Douglas (1956) reported that collapse breccias occur in the Mississippian Mount Head formation and in the Devonian Southesk and Alexo formations, and suggested that they might indicate the former presence of evaporites in the section. Collapse breccias are also present in the Mount Head area of southern Alberta (Douglas, 1953). If these collapse breccias actually were caused by the removal of gypsum in solution, the depth to which removal has occurred becomes of some interest. The collapse breccias are completely lithified, so that removal of gypsum would not seem to be simply a surface phenomenon that has taken place recently.

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# LIMESTONE

## Introduction

Limestone is an essential raw material of an industrial economy and, because of its low cost and the large bulk required, deposits must be situated comparatively close to manufacturing centres. For these reasons limestone deposits in other provinces do not compete with the supplies of Alberta, and will not be considered.

In Alberta, limestone is used chiefly for the manufacture of cement and lime. Cement production prior to 1948 fluctuated between 200,000 and 800,000 barrels a year (Fig. 1); subsequent to 1948 production has generally increased, being 3,670,000 barrels in 1956, that is, about 12 per cent of the Canadian total. Alberta lime production in 1956 was 39,743 tons and represented 0.3 per cent of the national production.

Limestone beds are present throughout the Paleozoic strata and are also found in Triassic beds; outcrops of Paleozoic deposits are confined to the western and northeastern parts of the province. Only the limestones of the front ranges of the Rockies and those present in Paleozoic outliers in the foothills may be considered as potentially economic at present, and even here close attention must be given to transportation facilities.

The only survey on limestone in Alberta was undertaken by Goudge (1944); most of the following discussion has been abstracted from his report. Goudge's work was confined to the area immediately adjacent to the five railways which pass through or into the Rocky Mountains in Alberta.

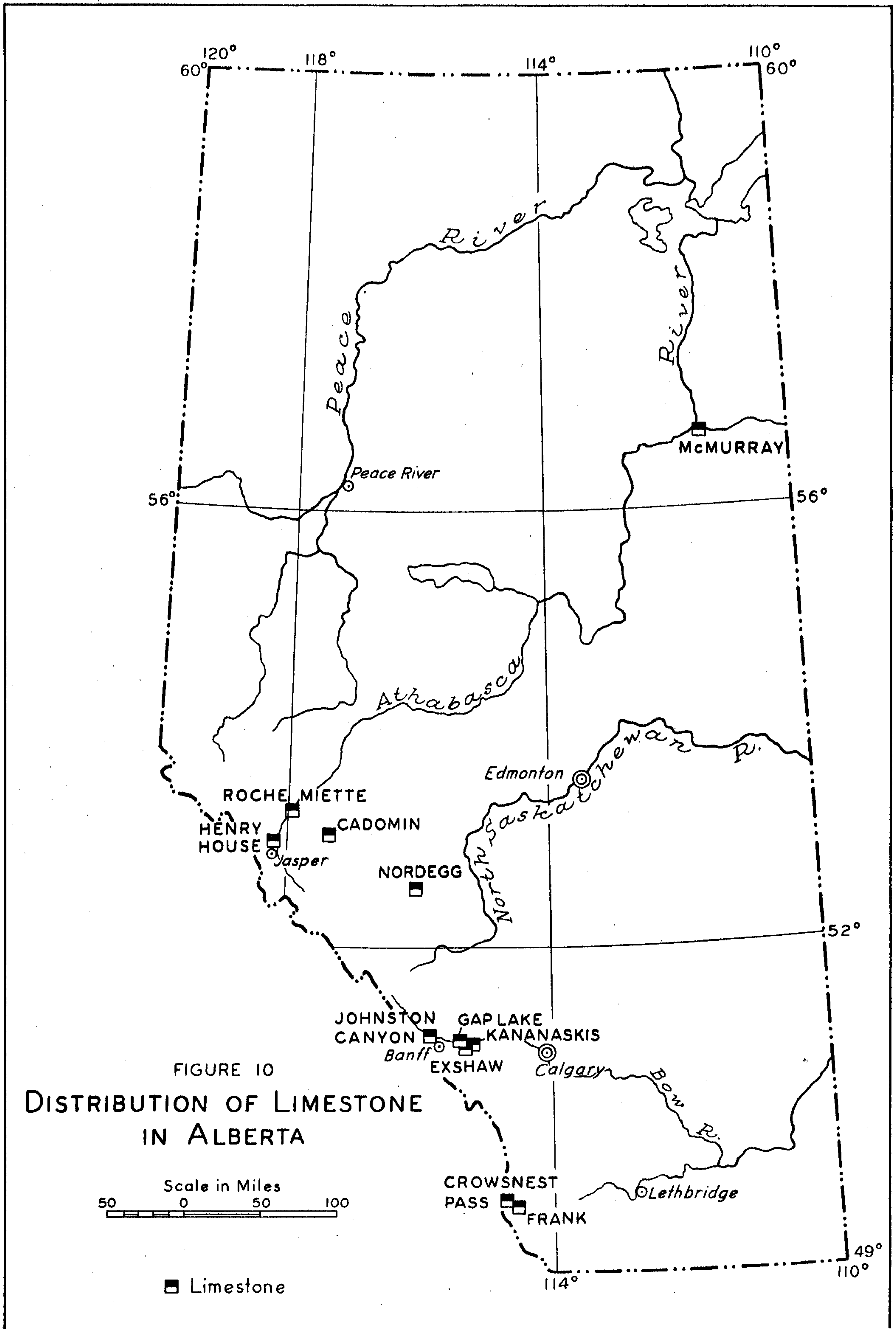


FIGURE 10

DISTRIBUTION OF LIMESTONE IN ALBERTA

Chemical analyses of the various limestone deposits are given in table 4. Unless otherwise stated, all analyses are of channel samples. The location of the deposits discussed below is shown in figure 10.

Kananaskis

Loder's Lime Company Limited is quarrying Cambrian limestone for the manufacture of lime at Kananaskis. Matthews (1956) described the limestone as follows:

> "In this vicinity, the Cambrian consists of a series of thin alternating beds of magnesian limestone and dolomite with a few high-calcium beds. The degree of dolomitization varies both across and along the bedding, even in the high-calcium beds, but to a much lesser extent in these.
>
> "There are at least three bands of dense pale, grey, high-calcium limestone on the property. These vary in width from 40 to 80 feet and are separated from each other by from 75 to 150 feet of magnesium limestone" (p. 39).

Analysis 11 is a weighted average of four analyses given by Goudge (1944) for 63 feet of pure limestone occurring in the most easterly band.

Frank

Periodically, proposals have been made to use blocks of Mississippian limestone that fell into the Crowsnest valley in the Frank slide of 1903. Goudge (1944) reported that:

> "Much of the limestone available in the slide material is cherty, some is highly magnesian and siliceous, and only a relatively small proportion is of the pure high-calcium type" (p. 98).

Since the pure limestone blocks are mixed with the impure blocks, the limestone cannot be used for any purpose for which a uniform chemical composition is required.

Blairmore

Just east of Blairmore at the base of Turtle Mountain and south of the railway, an abandoned quarry exposes Mississippian limestone of variable quality, dipping west at an angle of 65 degrees (Goudge, 1944).

At the eastern edge of the main quarry a 24-foot bed of pure limestone (analysis 1, table 4) is overlain by 18 feet of cherty magnesian limestone which is overlain in turn by 80 feet of limestone, the lower 40 feet of which is represented by analysis 2 in table 4 and the upper 40 feet by analysis 3.

Crowsnest Pass

A considerable thickness of Devonian-Mississippian limestone and dolomite of varying purity is exposed along the north side of the Canadian Pacific Railway line from the east end of Crowsnest Lake to near the British Columbia boundary.

East of a cave opposite Crowsnest Lake, 150 feet of limestone dipping southwest at 32 degrees were sampled by Goudge. The analysis of this sample is given as analysis 4, table 4.

The quarries of Summit Lime Works Limited are located west of Crowsnest Lake. Three quarries have been opened in a 400-foot bed of medium-grained limestone which contains occasional thin interbeds of chert and magnesian limestone. Number 1 quarry, the most easterly, is located just east of the kilns; analysis 5 represents 140 feet of strata being worked in this quarry. Number 2 quarry, 550 feet west of number 1, is a small abandoned quarry which operated in interbedded limestone and magnesian limestone. Number 3 quarry, west of number 2, is operating across a width of 80 feet of limestone which is represented by analysis 6.

Opposite the east end of Island Lake, west of the Summit Lime Works, a spur 600 feet in height consists mainly of high-calcium limestone totalling about 150 feet in thickness; analysis 7 is a representative sample of this limestone. East of the spur, 100 feet of pure limestone is separated from the 150-foot bed described above by a limestone conglomerate or breccia; analysis 8 is representative of this 100-foot bed.

Opposite the island in Island Lake, two bands of limestone, 40 and 30 feet thick respectively, are exposed in an unfavorable location for quarrying. The two bands are about two hundred feet apart. Analysis 9 is representative of the 40-foot band, which is the westernmost, and analysis 10 is representative of the 30-foot bed.

Exshaw

At Exshaw, Canada Cement Company Limited is quarrying approximately 100 feet of limestone from the upper part of the Palliser formation (Devonian). Most of the beds being quarried are high-calcium limestones, but a few thin beds of magnesian limestone are also included. A representative average analysis of the material supplied to the plant is given in analysis 11, table 4.

The Gap

From 1906 to 1914, quarries were operated in two ridges of Mississippian limestone on the southern slope of Grotto Mountain, about 250 feet above the railway. The lower limestone band, 75 feet thick, is separated from an upper band 20 feet thick by 100 feet of cherty limestone and siliceous dolomite. Analysis 12, table 4, is a weighted average of two analyses given by Goudge (1944) for the lower band and analysis 13 is representative of the upper 18 feet of the upper band.

Nordegg

About 4.5 miles east of Nordegg, a thick succession of impure cherty limestones of Devonian-Mississippian age is exposed along the Canadian National Railway and has been described by Goudge (1944). Relatively pure limestone occurs in the sequence in layers up to 50 feet thick. Analysis 14, table 4, is representative of one 50-foot layer described by Goudge as occurring a few hundred yards northeast of Mile 146 on the railway.

One mile east of Nordegg, at Mile 148.5 on the Canadian National Railway, a small quarry has been opened for ballast in a twenty-foot bed of limestone of which the upper 10 feet is pure. West of the quarry, a 40-foot bed of pure limestone is exposed. Analyses 15 and 16 were made by Goudge on the 10- and 40-foot beds respectively.

Cadomin

Devonian-Mississippian limestone is exposed along the Canadian National Railway Mountain Park line for approximately 500 feet immediately north of the 25-mile post (Goudge, 1944). The strata strike east and dip to the south (35 to 60 degrees). Analysis 17, table 4, represents a channel sample, taken by Goudge, of the most northerly 300 feet of the exposures which are from 180 to 250 feet in thickness. Several cherty beds occurring in the sequence were not sampled. Analysis 18 represents the southerly 200 feet of the exposure which is 100 to 175 feet in thickness.

South of the 25-mile post a small ridge of limestone outcrops near the railway, just north of Cadomin Creek. Analysis 19 is representative of this material.

Brule

Massive limestone with occasional beds of mottled magnesian limestone of Devonian-Mississippian age is exposed at Ogre Canyon, approximately three miles southwest of Brule (Goudge, 1944). Analysis 20, table 4, represents a channel sample taken at this point across limestone totalling 200 feet in thickness.

A ridge southwest of Ogre Canyon is composed of pure limestone with occasional partings of magnesian limestone, some of which contains chert nodules. Analysis 21 is representative of a sample taken from the limestone, excluding the bands of magnesian limestone.

Roche Miette

On the north side of Roche Miette, Devonian limestone is exposed along the old railway right of way on the south bank of the Athabasca River. Analysis 22, table 4, represents an average of two samples taken from the northern-most exposures of this limestone. Since no thickness is given by Goudge (1944) for these limestones, it is impossible to arrive at an accurate weighted analysis.

One-quarter of a mile south of the above locality, a quarry was formerly operated by the Fitzhugh Lime and Stone Company. About 15 feet of pure limestone, represented by analysis 23, is present at this quarry.

Henry House

A quarry formerly operated by the Marlboro Cement Company is located on a ridge immediately west of the Canadian National Railway, about 4.5 miles north of Jasper. The limestone strata are of Devonian-Mississippian age and dip southeast at about 25 degrees, being exposed under light overburden for a considerable distance northwest of the quarry. Analysis 24 is representative of a channel sample of 140 feet of strata exposed in the quarry.

One hundred and fifty feet of limestone similar to that described above, but stratigraphically higher, is exposed in a railway cutting just south of the quarry. There is no analysis of this limestone.

The limestone deposits described above are in Jasper National Park, and therefore their exploitation is forbidden by law.

McMurray

Beaverhill Lake limestone of Upper Devonian age is exposed near river level at the junction of the Clearwater and Athabasca Rivers. A grab sample of the limestone was collected by the Research Council of Alberta from the north bank of the Clearwater at its junction with the Athabasca, immediately across the Clearwater River from McMurray. The analysis of this sample is given as analysis 25, table 4.

Hillspring

A bed of fossil oysters, 13 feet thick, in the Upper Cretaceous outcrops near Cardston (Lsd. 5, Sec. 3, Tp. 4, R. 27, W. 4th Mer.). Crockford (1947) carried out a preliminary investigation and reported that the coquina, composed essentially of shells of Ostrea and Corbicula, is pure except for a few thin shale lenses. A chemical analysis of a channel sample collected by Crockford is given as analysis 26 in table 4. Crockford stated that the strata in this area were faulted, and consequently it was impossible to estimate available reserves of material without a detailed examination.

Conclusions

Commercial limestone deposits in Alberta are largely confined to the mountains. Limestone also occurs along the margin of the Precambrian Shield in northeastern Alberta.

Over the remainder of the plains and foothills area coquinas occur sporadically throughout the Cretaceous section, although none of these has yet proved thick enough or extensive enough to be of any value. Fresh-water limestones are reported by Allan and Sanderson (1945) in the Paskapoo formation, but these are thin and discontinuous. Another source of lime in the plains area is provided by marl deposits which are discussed in the chapter on minor minerals.

Since limestones and dolomites frequently exhibit rapid lateral changes in composition, many beds of limestone which were characterized by Goudge as impure may grade into pure limestones within a few hundred feet of the outcrop examined by him. Consequently, the deposits discussed in the preceeding pages are not necessarily the only deposits of pure limestone near railway facilities in Alberta.

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TABLE 4: Chemical Analyses of Limestone Discussed in Report. Analysis 12 after Matthews (1956); analysis 28, Research Council Alberta; analysis 29 after Crockford (1947); remaining analyses after Goudge (1944).

| Analysis No. | Name of Deposit | Thickness (feet) | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $Ca_3(PO_4)_2$ | $CaCO_3$ | $MgCO_3$ | Total | CaO | MgO |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Blairmore | 24 | 0.18 | 0.04 | 0.12 | 0.09 | 98.87 | 1.20 | 100.50 | 55.42 | 6.57 |
| 2 | " | 40 | 0.62 | 0.07 | 0.07 | 0.11 | 96.52 | 2.83 | 100.22 | 54.11 | 1.35 |
| 3 | " | 40 | 1.00 | 0.08 | 0.20 | 0.22 | 88.91 | 10.21 | 100.62 | 49.91 | 4.88 |
| 4 | Crowsnest Pass | 150 | 1.04 | 0.20 | 0.42 | 0.02 | 96.34 | 2.01 | 100.03 | 53.96 | 0.96 |
| 5 | " | 140 | 0.42 | 0.06 | 0.08 | 0.09 | 97.84 | 1.90 | 100.39 | 54.82 | 0.91 |
| 6 | " | 80 | 1.04 | 0.09 | 0.19 | 0.11 | 96.81 | 1.98 | 100.22 | 54.24 | 0.95 |
| 7 | " | 150 | 0.58 | 0.18 | 0.10 | 0.07 | 97.00 | 2.34 | 100.27 | 54.36 | 1.12 |
| 8 | " | 100 | 0.50 | 0.06 | 0.08 | 0.11 | 98.25 | 1.62 | 100.62 | 55.08 | 0.77 |
| 9 | " | 40 | 0.64 | 0.17 | 0.13 | 0.04 | 94.66 | 4.22 | 98.84 | 53.02 | 2.02 |
| 10 | " | 30 | 0.80 | 0.03 | 0.17 | 0.04 | 97.84 | 1.30 | 100.18 | 54.82 | 0.62 |
| 11 | Exshaw | 100 | 1.0 | 0.2 | 0.4 | n.d. | 94.47 | 4.0 | 100.00 | 52.9 | 1.9 |
| 12 | The Gap | 75 | 0.56 | 0.22 | 0.15 | 0.02 | 97.92 | 0.80 | 99.67 | 54.84 | 0.38 |
| 13 | " " | 18 | 1.98 | 0.16 | 0.24 | 0.07 | 95.89 | 1.64 | 99.98 | 53.74 | 0.78 |
| 14 | Nordegg | 50 | 5.26 | 0.49 | 1.73 | 0.13 | 85.62 | 6.56 | 99.79 | 48.02 | 3.14 |
| 15 | " | 10 | 0.42 | 0.06 | 0.17 | 0.02 | 95.25 | 4.20 | 100.12 | 53.37 | 2.01 |
| 16 | " | 40 | 0.24 | 0.04 | 0.21 | 0.02 | 97.96 | 2.00 | 100.47 | 54.87 | 0.95 |
| 17 | Cadomin | 150 | 0.98 | 0.23 | 0.29 | 0.02 | 92.45 | 5.90 | 99.87 | 51.78 | 2.82 |
| 18 | " | 100 | 1.14 | 0.24 | 0.22 | 0.02 | 96.00 | 1.83 | 99.45 | 53.77 | 0.87 |
| 19 | " | Unknown | 0.98 | 0.30 | 0.22 | 0.01 | 95.03 | 3.01 | 99.55 | 53.22 | 1.44 |
| 20 | Brule | 200 | 1.32 | 0.20 | 0.60 | 0.02 | 91.59 | 6.29 | 100.02 | 51.30 | 3.01 |
| 21 | " | Unknown | 1.02 | 0.16 | 0.56 | 0.02 | 96.95 | 1.03 | 99.74 | 54.30 | 0.49 |
| 22 | Roche Miette | Unknown | 0.64 | 0.16 | 0.22 | 0.01 | 96.13 | 2.97 | 100.13 | 50.82 | 3.31 |
| 23 | " " | 15 | 1.44 | 0.18 | 0.28 | 0.02 | 96.78 | 1.51 | 100.20 | 54.21 | 0.72 |
| 24 | Henry House | 140 | 1.82 | 0.25 | 0.43 | 0.04 | 95.00 | 2.34 | 99.88 | 53.22 | 1.12 |
| 25 | McMurray | Unknown | 1.66 | 0.21 | 1.28 | n.d. | 95.18 | 1.11 | 99.44 | 53.33 | 0.53 |
| 26 | Hillspring | 13 | 3.65 | 1.03 | 0.70 | tr | 93.95 | 0.59 | 98.92 | 52.08 | 0.28 |

# PHOSPHATE

## Introduction

The chief use of phosphate is in the manufacture of fertilizers, although it is also used in small quantities in several other industries, such as ceramic products, sugar refining, and in rodent poisons.

There has been no significant production of phosphate in Canada for over 60 years, but phosphates in Quebec and Ontario were mined prior to the development of deposits in the United States. The deposits in the United States are from 20 to 200 feet thick and contain 20 to 40 percent $P_2O_5$. Beds of low-grade phosphate rock are widespread in the Rocky Mountains, but none of the deposits in Alberta so far investigated have proved to be economic. The various occurrences of phosphate are discussed below, and the location of the various outcrops shown in figure 11.

## Perdrix Formation (Devonian)

McLaren (1955) reported that at Wapiabi Gap and Deception Creek strata of the Perdrix formation are overlain by phosphatic and pyritiferous limestones with rolled bone fragments. The phosphate content of these occurrences is unknown, but is believed to be small.

## Exshaw Formation (Devonian)

Black shales underlying Mississippian strata are phosphatic in the Crowsnest, Banff, and Jasper areas. These deposits were described by Telfer (1934) who assigned them to the Banff formation, although present stratigraphic terminology would include the phosphatic horizons in the Exshaw formation.

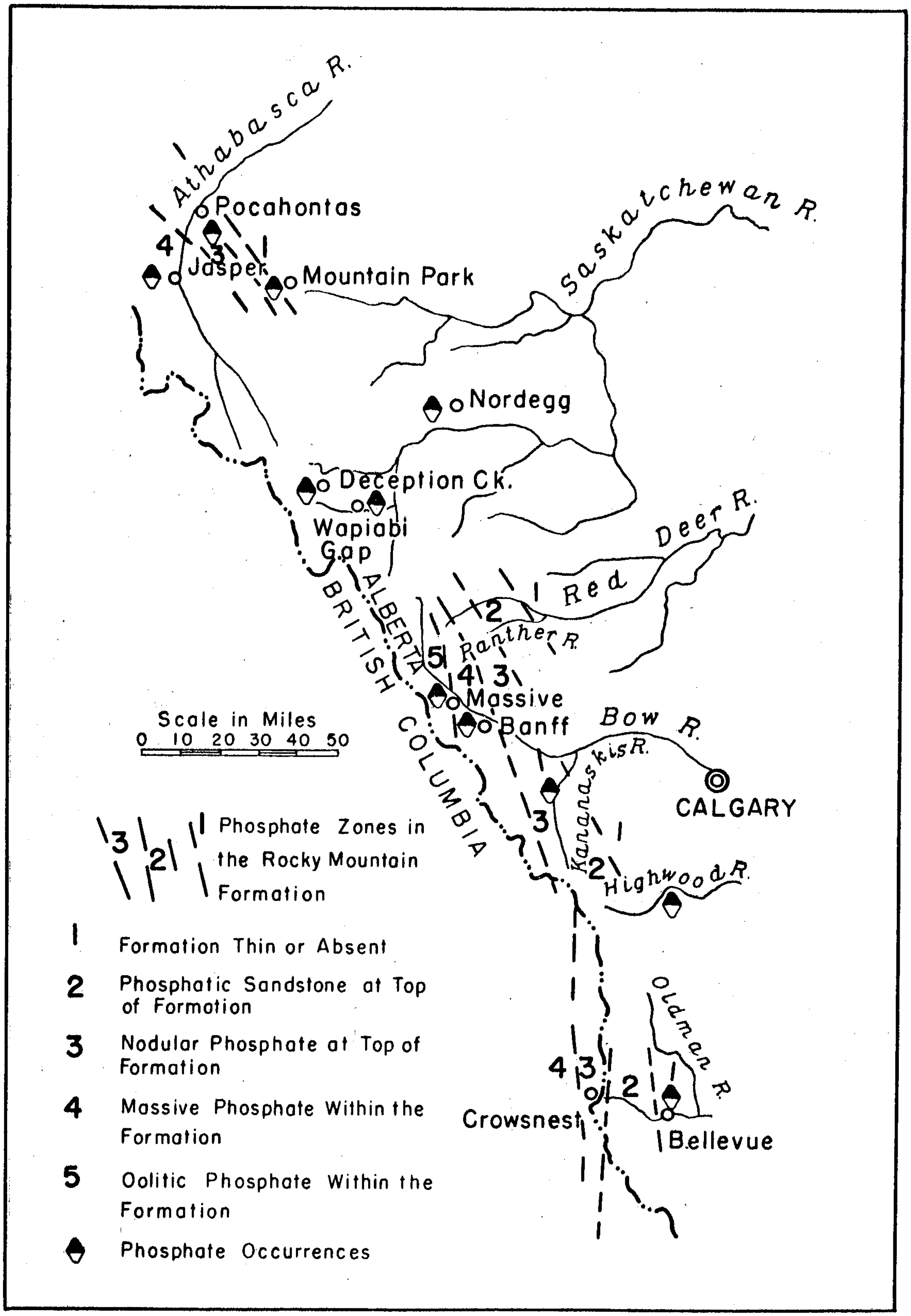


FIGURE 11. DISTRIBUTION OF PHOSPHATE IN ALBERTA
(MODIFIED AFTER TELFER, 1934)

At Crowsnest (British Columbia) there is an upper oolitic phosphate bed 0.6 feet thick, containing 50.8 per cent calcium phosphate, and a lower nodular phosphate bed, 0.6 feet thick, containing 37.4 per cent calcium phosphate. These two beds are separated by 1.7 feet of black shale, containing 6.7 per cent calcium phosphate.

At Banff and Jasper the uppermost Devonian strata are practically non-phosphatic, although in both places there is a six-inch band of rusty phosphatic material at the base of the shales. The thin bed contains 35 per cent calcium phosphate at Banff, and 24 per cent at Jasper.

<u>Rocky Mountain Formation</u> (Pennsylvanian-Permian)

A variable bed of phosphate is developed at or near the top of the Rocky Mountain formation over a considerable area where this formation outcrops. The formation increases in thickness towards the east, and the phosphate content also increases in the same direction. Telfer (1934) distinguished five zones of phosphate occurrence, which are briefly reviewed below and shown in figure 11.

Area 1: The Rocky Mountain formation is thin and contains no phosphate beds as at Bellevue.

Area 2: A phosphatic sandstone occurs at the top of the formation along the Highwood and Kananaskis Rivers. The phosphate content is low, being 8.5 per cent calcium phosphate along the Kananaskis River.

Area 3: At Pocahontas, along the Panther River, and just east of Banff, the highest beds of the Rocky Mountain formation consist of phosphatic sandstone with phosphate nodules. The beds are all less than one foot thick, and contain about 27 per cent calcium phosphate at Pocahontas, 52 per cent at the headwaters of the Panther River, and 63 per cent east of Banff.

Area 4: A bed of massive phosphate up to one foot in thickness occurs 60 feet below the top of the Rocky Mountain formation at Banff and Jasper. This bed was examined by de Schmid (1916) and was found to contain 50 to 60 per cent calcium phosphate in the south and about 77 per cent in the north near Jasper.

Area 5: Oolitic phosphate beds occur about 100 feet below the top of the Rocky Mountain formation in the westernmost exposures. For example, at Massive there are two phosphate beds, separated by 13 feet of shale and chert; the upper bed is 3.5 feet thick and contains 30 per cent calcium phosphate, and the lower bed is about eight feet thick and contains about 11 per cent calcium phosphate.

Spray River Formation (Triassic)

The basal beds of Spray River formation in the Highwood-Elbow area consist of phosphatic limestone or chert breccia, about two feet thick and containing up to 10 per cent calcium phosphate (Allan and Carr, 1947).

Basal Fernie Formation (Jurassic)

The basal bed of the Fernie formation is generally phosphatic. Near Bankhead in the Banff area, an oolitic phosphate bed two feet thick contains 40 per cent calcium phosphate. In another section five miles south of the Panther River, northeast of Banff, an oolitic phosphate bed 0.6 feet thick contains 37 per cent calcium phosphate, and is underlain by 0.4 feet of phosphatic limestone containing 13 per cent calcium phosphate (Telfer, 1934).

In other areas the basal Fernie beds consist of black phosphatic shale containing several per cent calcium phosphate, and in places contain a thin phosphatic conglomerate averaging about 25 per cent calcium phosphate (Allan, 1926; Telfer, 1934; Crockford, 1949; Clow and Crockford, 1951). These areas where the phosphatic beds are thin and low in phosphate content are in the easternmost ranges of the Rocky Mountains. It is possible that the phosphate bed in the basal Fernie formation thickens and becomes richer towards the west because at Crowsnest (British Columbia) the bed is nearly five feet thick and contains 45 per cent calcium phosphate.

Fernie Belemnite Bed

About 150 to 250 feet above the base of the Fernie formation a calcareous sandstone, characterized by the presence of numerous belemnites, contains nodules or oolites of phosphate (Telfer, 1934). Although this bed appears to be widespread, the phosphate content is erratic:

Pocahontas - 15 feet of belemnitic sandstone, 26 per cent calcium phosphate;

Oldman River - 1.2 feet of belemnitic sandstone, 9.5 per cent calcium phosphate;

Nordegg - 0.8 feet rusty-weathering phosphate containing 58 per cent calcium phosphate, underlain by 0.1 feet of phosphate and chert pebbles containing 29 per cent calcium phosphate.

Conclusions

The richest beds of phosphate so far discovered in Alberta occur near the top of the Rocky Mountain formation and at the base of the Fernie formation. Both of these beds appear to become richer and thicker towards the west, and thus many of the more favorable areas for phosphate lie within National Park boundaries. Therefore, whilst prospecting and mining development in National

Parks remain unlawful, further prospecting for phosphate should be concentrated in the area immediately south of Banff National Park, west of Nordegg, and north of Jasper National Park.

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# SALT

## Introduction

Common salt has a wide range of industrial and domestic usage, such as in the chemical industry, refrigerator cars, water softeners, the tanning industry, and for dust and ice control on roads. Salt deposits have been noted in the Provinces of Nova Scotia, Ontario, Manitoba, Saskatchewan, and Alberta. In 1954 Ontario accounted for 76 per cent of the total Canadian production, whilst Alberta and neighboring Saskatchewan each contributed three per cent.

A considerable area of east-central Alberta is underlain by deposits of common salt which occur as beds of varying thicknesses and continuity within strata of Devonian age. The more important deposits lie within the Elk Point group (Middle Devonian), though lesser deposits have been recorded in the Stettler formation (Upper Devonian) in the Stettler area.

The extent of the salt basin and approximate thicknesses are shown in figure 12. The salt beds have a general southwesterly dip, being 600 to 800 feet below surface near McMurray, and 5,000 to 6,000 feet below the surface near Edmonton. The deposits thin out in the south near Patricia, on the west a few miles west of Edmonton, and in the north beyond McMurray, although it is possible that an attenuated evaporite sequence may outcrop beneath drift northeast of McMurray. The basin extends in a southeasterly direction through Saskatchewan into Manitoba and the United States.

Continuous production of salt in Alberta began in 1938 with the opening of the Industrial Minerals Limited plant at McMurray. This plant was closed in 1950, and at present salt is produced by wells at Lindbergh for domestic and industrial consumption and at Duvernay for the manufacture of caustic soda and chlorine. The Alberta salt deposits are described below.

Salt Deposits in the Elk Point Group

The Elk Point group forms a predominantly evaporitic sequence of dolomite, anhydrite and salt which shows a lateral transition to shales and sandstones towards the margins of the basin. Three main salt beds have been found, although this sequence is not generally complete except in the central part of the basin. Detailed stratigraphical and geochemical correlation of the various salt beds encountered in drill holes is incomplete and, therefore, it would be unwise to assume continuity of the beds throughout the basin.

The earliest subsurface salt discoveries were made in the McMurray area, where between 1907 and 1912 two wells drilled by the Northern Alberta Exploration Company (figure 12 and table 6) passed through two salt beds, 100 feet and 90 feet thick respectively, separated by 75 feet of limestone (Allan, 1921). A number of wells put down in this area by Industrial Minerals Ltd. encountered a salt bed up to 200 feet thick, and one of these wells — Industrial Minerals No. 2 (table 6) — was operated for the commercial extraction of salt from this bed. Although none of the Industrial Minerals wells was taken down to the Precambrian, it is unlikely that there are further salt beds of significance at depth since another borehole, Bear Rodeo No. 1, in the same general area passed through two salt beds at 625 and 748 feet respectively and penetrated Precambrian at 1,125 feet. The eastern margin of the salt basin in this area is apparently in the vicinity of the Alberta Government Salt Well No. 2 (table 6) where only thin lenses of salt were encountered above the Precambrian granite which was penetrated at 785 feet.

Thick and extensive deposits of salt were discovered in 1944 about 150 miles due east of Edmonton when the Vermilion Consolidated Oils No. 15 well passed through 442 feet of salt (table 6), commencing at a depth of 3,481 feet (chemical analyses for the salt core of this well are given in table 5). In 1946 the Anglo-Home - C. and E. Elk Point No. 1 borehole (table 6) near Lindbergh passed through three salt beds having an aggregate thickness of over 700 feet of salt. Three other wells in the vicinity encountered salt beds with an aggregate thickness of 500 to nearly 1,000 feet (table 6).

Imperial Ardrossan No. 1 well, just east of Edmonton (table 1), drilled through two salt beds at depths of 5,785 to 5,850 feet and 6,440 to 6,540 feet, respectively. The salt has minor partings of silt and dolomite and is one of the most westerly occurrences of thick salt beds. The Socony Vacuum Craigmyle number 1 (table 6) passed through two thin salt beds totalling 44 feet, and this thinning of the salt deposits towards the south is confirmed by the presence of only one foot of salt (between 5,232 and 5,233 feet) in the Princess Canadian Pacific Railway No. 1 well near Patricia (table 6), which presumably marks the southern margin of the salt basin.

Salt Deposits in the Upper Devonian

In the Stettler area the lower part of the Wabamun group (Upper Devonian) has been described and defined as the Stettler formation (Wonfor and Andrichuk, 1953 and 1956). The Stettler formation is predominantly an evaporitic sequence consisting of anhydrite, primary dolomite and salt, and is correlated with the Potlatch facies of other areas.

TABLE 5: Chemical Analyses of Salt Cores from Vermilion Consolidated Oils Well No. 15 (after Petroleum and Natural Gas Conservation Board, 1945). Salt bed occurs at depths from 3481 to 3903 feet.

| Depth (feet) | Sample Description | Moisture | Insoluble | $Fe_2O_3$ | $CaSO_4$ | $CaCl_2$ | $MgCl_2$ | KCl | NaCl |
|---|---|---|---|---|---|---|---|---|---|
| 3483 | Reddish-brown | 0.18 | 4.58 | 0.05 | 0.84 | 0.09 | 0.16 | 0.38 | 93.77 |
| 3490 | Clear with pink patches | 0.05 | 0.05 | 0.03 | 1.28 | 0.07 | 0.07 | 0.07 | 98.38 |
| 3502 | Pinkish-brown some shales | 0.48 | 9.37 | 0.08 | 0.81 | 0.34 | 0.33 | 0.30 | 88.29 |
| 3519 | Clear, 1-1/2" band, impurities | 0.14 | 0.35 | 0.01 | 0.72 | 0.26 | 0.19 | 0.57 | 97.76 |
| 3522 | Clear, pink splotches | 0.18 | 0.11 | 0.03 | 1.14 | 0.08 | 0.24 | 0.21 | 98.01 |
| 3543 | Clear | 0.16 | 0.07 | 0.04 | 0.38 | 0.09 | 0.22 | 0.15 | 98.89 |
| 3572 | Clear, part grey | 0.01 | 0.32 | 0.01 | 1.21 | 0.18 | 0.09 | 0.42 | 97.76 |
| 3618 | Clear, grey band | 0.17 | 0.59 | 0.04 | 0.23 | 0.19 | 0.18 | 0.76 | 97.84 |
| 3734 | Clear | 0.11 | 0.67 | 0.11 | 0.36 | 0.19 | 0.03 | 0.92 | 97.61 |
| 3780 | Pink and grey stained | 0.11 | 1.13 | 0.12 | 0.84 | 0.20 | 0.03 | 0.88 | 96.69 |
| 3797 | Clear | 0.02 | 0.51 | 0.00 | 0.87 | 0.22 | 0.04 | 0.76 | 97.58 |
| 3825 | Clear, few stringers impurities | 0.01 | 0.34 | 0.01 | 0.37 | 0.63 | 0.05 | 0.80 | 97.79 |
| 3850 | Clear, one parting | 0.09 | 7.09 | 0.02 | 3.23 | 0.34 | 0.10 | 0.75 | 88.38 |
| 3867 | Clear | 0.01 | 0.10 | 0.01 | 0.84 | 0.06 | 0.01 | 0.76 | 98.21 |
| 3887 | Clear, few partings | 0.01 | 0.55 | 0.02 | 1.06 | 0.16 | 0.02 | 0.80 | 97.38 |
| 3902 | Clear | 0.01 | 0.34 | 0.01 | 0.31 | 0.13 | 0.04 | 0.80 | 98.36 |

The maximum concentration of evaporites occurs east of Drumheller, and decreases to the west, north, and east. Salt beds so far recorded are thin, generally ranging from 35 to 90 feet, although 100 feet of salt has been recorded in the Gulf Canadian Pacific Railway Collins No. 7 Well (Lsd. 7, Sec. 19, Tp. 36, R. 19, W. 4th Mer.), situated between Stettler and Big Valley.

## Saline Springs

Saline springs are associated with the gypsum along the Salt River, south of the northern boundary of Alberta (Allan, 1930). The water is almost saturated with sodium chloride, and as a result fairly pure salt has been deposited around the springs. The salt has been used on a small scale to supply the needs of the northern settlements.

Saline springs with a low concentration of salt are also present at La Saline, 26 miles north of McMurray (Allan, 1930), where Elk Point group strata are near the surface, and the salt is presumably derived from salt deposits within the group.

## Conclusions

The growth of the salt industry in Alberta since its inception in 1938 is clearly shown in figure 1, and with a continuing expansion of the chemical industry the production of salt will probably become increasingly important. Although there are abundant reserves of salt in Alberta and the general limits of the deposit are known, much work remains to be done on the detailed stratigraphy and geochemistry of the salt and adjacent strata.

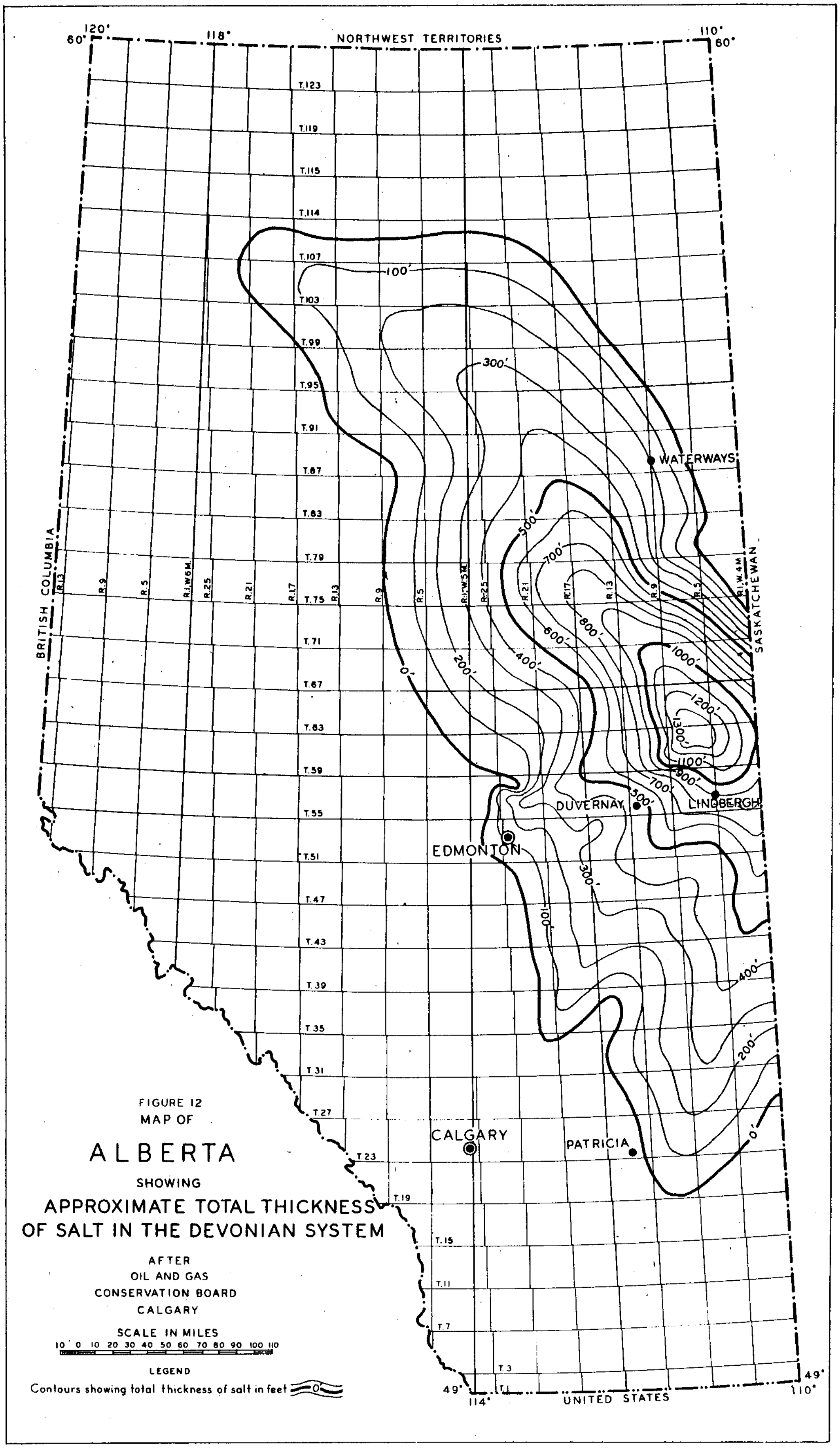
NORTHWEST TERRITORIES
BRITISH COLUMBIA
SASKATCHEWAN
UNITED STATES
120°
118°
110°
60°
49°
114°
WATERWAYS
DUVERNAY
LINDBERGH
EDMONTON
CALGARY
PATRICIA
T.123
T.119
T.115
T.114
T.107
T.103
T.99
T.95
T.91
T.87
T.83
T.79
T.75
T.71
T.67
T.63
T.59
T.55
T.51
T.47
T.43
T.39
T.35
T.31
T.27
T.23
T.19
T.15
T.11
T.7
T.3
T.1
R.13
R.9
R.5
R.1, W.6 M.
R.25
R.21
R.17
R.13
R.9
R.5
R.1, W.5 M.
R.25
R.21
R.17
R.13
R.9
R.5
R.1, W.4 M.
0'
100'
200'
300'
400'
500'
600'
700'
800'
1000'
1100'
1200'
1300'
FIGURE 12
MAP OF
ALBERTA
SHOWING
APPROXIMATE TOTAL THICKNESS
OF SALT IN THE DEVONIAN SYSTEM
AFTER
OIL AND GAS
CONSERVATION BOARD
CALGARY
SCALE IN MILES
10 0 10 20 30 40 50 60 70 80 90 100 110
LEGEND
Contours showing total thickness of salt in feet

TABLE 6: Summary of Drill-log Data for some Wells Penetrating Devonian Salt Beds (modified after Crockford, 1949)

| Name of Well | Lsd. | Location<br>Sec. | Tp. | R. | Mer. | Elevation (feet) | Total depth (feet) | Salt beds (feet) | Total thickness of Salt (feet) |
|---|---|---|---|---|---|---|---|---|---|
| Northern Alberta Exploration No. 1 | | 17 | 89 | 9 | W.4 | | 1475 | 520 - 620<br>735 - 740 | 204 |
| Northern Alberta Exploration No. 2 | | 18 | 89 | 9 | W.4 | | 1405 | 605 - 704<br>779 - 869 | 190 |
| Industrial Minerals No. 2 | 2 | 10 | 89 | 9 | W.4 | 820 | 875 | 696 - 875 | |
| Alberta Government salt well No. 2 | 5 | 32 | 88 | 8 | W.4 | 810 | 789 | --- | |
| Bear Rodeo No. 1 | 8 | 20 | 89 | 9 | W.4 | 792 | 834 | 625 - 682<br>748 - 834 | 120 |
| Anglo-Home - C. & E. Elk Point No. 1 | 7 | 26 | 56 | 5 | W.4 | 1840 | 3929 | 2775 - 3180<br>3480 - 3605<br>3702 - 3929 | 757 |
| Anglo-Home - C. & E. Elk Point No.2 | 3 | 14 | 57 | 6 | W.4 | 1858 | 4359 | 2806 - 3257<br>3554 - 3672<br>3770 - 4173 | 972 |
| Anglo-Home - C. &E. Elk Point No.3 | 15 | 35 | 57 | 5 | W.4 | 2111 | 5007 | 2894 - 3301<br>3659 - 3787<br>3860 - 4293 | 968 |
| Anglo-Home - C & E. Elk Point No.4 | 3 | 26 | 56 | 5 | W.4 | 1724 | 3483 | 2617 - 3063<br>3364 - 3481 | 563 |
| Vermilion Consolidated Oils No. 15 | 6 | 12 | 49 | 6 | W.4 | 1983 | 4632 | 3481 - 3903 | 422 |
| Imperial Ardrossan No. 1 | 8 | 17 | 53 | 21 | W.4 | 2380 | 5775 | 5785 - 5850<br>6440 - 6540 | 165 |
| Socony-Vacuum Craigmyle No. 1 | 12 | 32 | 32 | 16 | W.4 | 1724 | | 4724 - 4727<br>6567 - 6584<br>6588 - 6612 | 41 |
| Princess C.P.R. No. 1 | 13 | 22 | 20 | 12 | W.4 | 2442 | 6155 | 5232 - 5233 | 1 |

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# SILICA SAND

## Introduction

Silica sand is used in the manufacture of glass and silicates, for sand-blasting purposes, and in the hydraulic fracturing of oil formations. Silica flour, obtained by grinding sand to a fine powder, is used in the ceramic industry and as a filler in the rubber industry. Sand is also used extensively for moulding purposes in foundry work.

The production of silica minerals in Canada in 1954 was 1,742,951 short tons, valued at 1,589,254 dollars, most of which was derived from the Provinces of Nova Scotia, Quebec and Ontario.

A number of potential sources of silica sand have been discovered in Alberta, although none are situated ideally with respect to transportation. However, the Peace River Glass Company of Edmonton is developing the Peace River sand deposit (described below) for the manufacture of glass fibre products.

## Peace River

A deposit of silica sand, described by Crockford (1949), is present in the upper 40 to 60 feet of the Peace River formation (Lower Cretaceous). This deposit is located along the Peace River about seven miles downstream from the town of Peace River (Fig. 13) and appears to be a lens of locally unconsolidated clean, fine- to coarse-grained quartz sand. The stratigraphic equivalents elsewhere in the area are hard, fine-grained sandstones.

The individual beds in the deposit are lenticular in form and are up to 19 feet thick. Size analyses and chemical analyses of samples collected by Crockford show that $SiO_2$ varies from 91 to 98 per cent, and $Fe_2O_3$ from 0.1 to 0.2 per cent (tables 7, 8, 9).

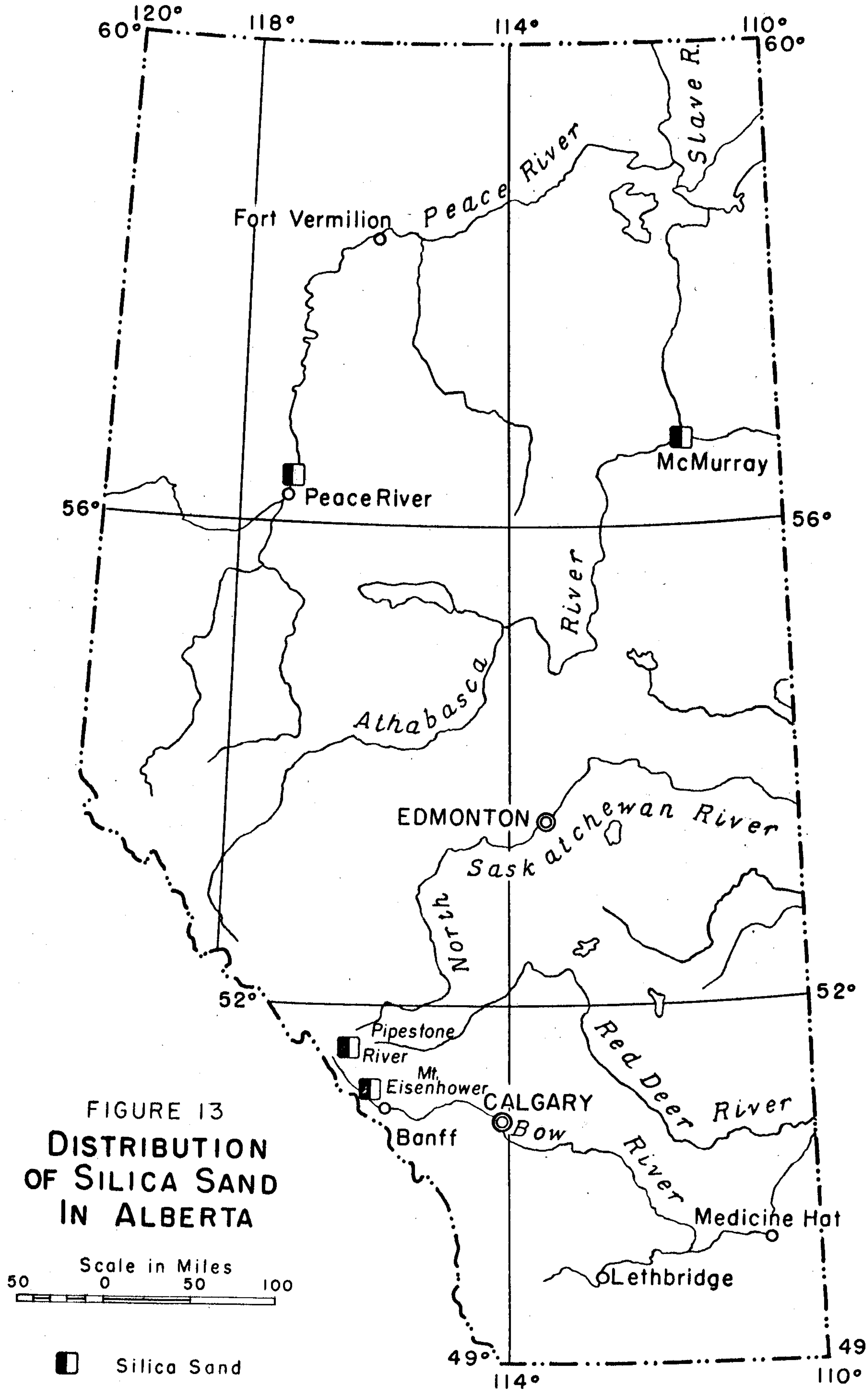


FIGURE 13
**DISTRIBUTION OF SILICA SAND IN ALBERTA**

TABLE 7: Size Analyses of Minus 20 Mesh of Original Feed, Peace River Glass Sand (after Crockford, 1949)

| Sample | 1 | 2A | 2B | 3 |
|---|---|---|---|---|
| % of total | 88.0 | 76.1 | 82.4 | 52 |
| Mesh | Weight % | Weight % | Weight % | Weight % |
| + 28 | 5.0 | 10.2 | 14.2 | 12.4 |
| + 35 | 13.6 | 13.6 | 18.1 | 25.9 |
| + 48 | 34.8 | 22.4 | 40.5 | 34.0 |
| + 65 | 17.9 | 31.4 | 18.5 | 18.6 |
| + 100 | 18.3 | 15.3 | 5.3 | 6.3 |
| + 150 | 8.9 | 6.6 | 2.4 | 2.3 |
| + 200 | 0.9 | 0.3 | 0.7 | 0.3 |
| - 200 | 0.6 | 0.2 | 0.3 | 0.2 |
| | 100.0 | 100.0 | 100.0 | 100.0 |

TABLE 8: Assay of Original Minus 20 Mesh Feed, Peace River Glass, (after Crockford, 1949)

| Sample | % Assay | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $TiO_2$ | CaO | MgO | $Na_2O$ | $K_2O$ | Total |
| 1 | 98.50 | 0.252 | 0.65 | 0.047 | 0.06 | Tr. | 0.17 | 0.14 | 99.819 |
| 2A | 91.11 | 0.111 | 0.97 | 0.036 | 0.05 | Tr. | 0.15 | 0.34 | 99.767 |
| 2B | 98.39 | 0.147 | 0.69 | 0.110 | 0.03 | Tr. | 0.15 | 0.22 | 99.737 |
| 3 | 98.47 | 0.103 | 0.82 | 0.064 | 0.02 | Tr. | 0.18 | 0.22 | 99.877 |

TABLE 9: Wilfley Table Products from Various Tests, Peace River Glass Sand (after Crockford, 1949)

| Sample No. | Wt. % of - 20 mesh | Wt. % of total feed | % Assay | |
|---|---|---|---|---|
| | | | $Fe_2O_3$ | $TiO_2$ |
| 1 | 69.0 | 60.6 | 0.123 | 0.029 |
| 2A | 64.4 | 49.0 | 0.077 | 0.025 |
| 2B | 73.7 | 60.7 | 0.048 | 0.028 |
| 3 | 52.2 | 27.2 | 0.062 | 0.038 |

Pipestone River

A sandstone of high silica content outcrops near the headwaters of the Pipestone River, approximately 22 miles north of Lake Louise station (Cole, 1928). The location, in the SE. 1/4 Sec. 29 and N. 1/2 Sec. 28, Tp. 31, R. 16, W. 5th Mer., is inside the boundaries of Banff National Park (Fig. 13).

Cole described the sandstone as being 1,000 feet thick and showing considerable variation in degree of cementation, although the more loosely-cemented material makes up most of the deposit. Cole suggested that it is probably late Ordovician in age, and that it may be a poorly-cemented facies of the Mount Wilson quartzite.

The sand contains about 98 per cent $SiO_2$ and 0.2 per cent $Fe_2O_3$ (table 10). The size distribution of the material depends upon the crushing treatment (table 11), but at least 60 per cent of the particles are within the size range minus 30- to plus 100-mesh.

TABLE 10: Chemical Analyses of Pipestone River Silica Sand (after Cole, 1928)

| | No. 1 per cent | No. 2 per cent | No. 3 per cent |
|---|---|---|---|
| $SiO_2$ | 98.42 | 98.70 | 98.71 |
| $Fe_2O_3$ | 0.197 | 0.064 | 0.053 |
| $Al_2O_3$ | 0.50 | 0.41 | 0.63 |
| CaO | 0.12 | 0.23 | 0.13 |
| MgO | 0.29 | 0.37 | 0.30 |
| Loss in ignition | 0.38 | 0.25 | 0.22 |

No. 1, crude rock submitted by Lake Louise Silica Co. (unwashed)
No. 2, " " taken from talus pile (unwashed)
No. 3, " " " " " " (washed)

TABLE 11: Sieve Analyses of Pipestone River Silica Sand (after Cole, 1928)

| Mesh | No. 1 Weight per cent | No. 2 Weight per cent | No. 3 Weight per cent |
|---|---|---|---|
| + 10 | -- | -- | -- |
| + 14 | 4.75 | 6.22 | -- |
| + 20 | 6.56 | 9.30 | -- |
| + 28 | 7.07 | 9.82 | -- |
| + 35 | 21.50 | 28.88 | 2.92 |
| + 48 | 21.79 | 24.94 | 32.66 |
| + 65 | 15.25 | 13.20 | 37.69 |
| + 100 | 9.28 | 2.12 | 16.17 |
| + 150 | 5.25 | 5.00 | 5.11 |
| + 200 | 2.15 | 0.24 | 2.81 |
| - 200 | 6.40 | 0.28 | 2.64 |

No. 1, crude material crushed to -10 mesh
No. 2, " " " " -10 mesh and washed
No. 3, " " " " natural grain and washed

McMurray

Sand obtained from oil sands in the McMurray formation (Fig. 13) consists essentially of quartz with mica as the chief impurity. Removal of mica and a slight reduction in $Fe_2O_3$ and $TiO_2$ should produce a sand suitable for glass manufacture, although sieve analyses on the McMurray sands by Ells (1926) and the Research Council of Alberta indicate a wide variation in grain-size distribution. Lilge (1945) performed beneficiation experiments on two sand samples, one taken near Bitumount, and the other from McMurray. The latter proved too fine-grained and too high in $TiO_2$ to respond favorably to beneficiation. The Bitumount sample, after tabling and passing through a magnetic separator, was found to be free of mica and low in $Fe_2O_3$ and $TiO_2$, although the final product was somewhat finer-grained than is desirable for glass manufacture.

Conclusions

The Peace River silica sand deposit is nearing the production stage, and future prospecting in this area may reveal other deposits in the same stratigraphic position.

The Mount Wilson quartzite may provide a source of silica sand, and investigations outside National Park boundaries should probably be confined to those areas most favorably situated with respect to transportation facilities, for example, west of Nordegg.

In general, the McMurray oil sands are too fine to rank as a silica sand suitable for glass manufacture. If the process ultimately chosen for exploitation of the McMurray oil sands should yield a clean sand as a by-product, it may be economical to remove the finer fraction by screening and to beneficiate the screened sand.

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# SODIUM SULFATE

## Introduction

Sodium sulfate is used chiefly in the manufacture of kraft pulp for brown paper and, to a lesser extent, in the manufacture of chemicals and synthetic detergents. In 1954 the entire Canadian production (165,521 tons) was derived from Saskatchewan. Reserves exist in Saskatchewan, Alberta and British Columbia.

"Alkali lakes" are common in eastern Alberta, the major salt present being sodium sulfate but, unfortunately, little work has been done on them since Cole (1926) published a report on sodium sulfate in Western Canada. A typical commercial sodium sulfate deposit consists of a lake containing saturated brine from which crystallization of sodium sulfate takes place when the temperature is lowered. The material crystallized from the lake is usually pure, and is referred to by Cole as the intermittent crystal. The lake-bottom usually consists of sodium sulfate, commonly admixed with impurities, and this forms a bed of varying thickness which is referred to by Cole as the permanent crystal. Only those lakes which have a thick permanent crystal bed overlain by nearly saturated brine are of possible commercial importance, and Tomkins (1954) has estimated that 500,000 tons of sodium sulfate should be present before a deposit may be considered economic.

Cole (1926) described two alkali lakes in Alberta, and this information is summarized briefly below (see Fig. 18).

Minburn Deposit

Two small lakes at Minburn, situated in the S. 1/2, Sec. 12, Tp. 50, R. 11, W. 4th Mer., cover about 25 acres and for part of the year are brine covered. The extent and thickness of the permanent crystal bed are not known, but the brine contains about 10 per cent sodium sulfate.

Metiskow Lake Deposit

Metiskow Lake, located in Secs. 11, 12, 13, 14 and 24, Tp. 39, R. 6, W. 4th Mer., was estimated by Cole (1926) to contain 5,150,000 tons of sodium sulfate mixed with equal quantities of mud. The brine contains about 11 per cent sodium sulfate, and also about 12 per cent sodium carbonate.

The permanent crystal bed is 20 to 30 feet thick over most of the deposit, but in the southern part of the lake is over 50 feet thick. Analyses of the permanent crystal bed at different depths are given in table 12.

Conclusions

Alberta's requirements of sodium sulfate are at present supplied by Saskatchewan, and development of deposits in Alberta would have to meet strong competition from this source. However, the possible extra cost due to the high mud content of extracting sodium sulfate from, for instance, the Metiskow deposit should be more than offset by production of high-value soda-ash as a by-product.

TABLE 12: Averages of all Analyses of Samples from Sodium Sulfate Deposit at Metiskow (after Cole, 1926)

| Depth sampled (feet) | | 0-5 | 5-10 | 10-15 | 15-20 | 20-25 | 25-30 | 30-35 | 35-40 | 40-45 | 45-50 | 50-55 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Insoluble . . . . . | per cent | 13.91 | 22.03 | 21.77 | 23.79 | 25.72 | 7.99 | 12.85 | 6.83 | 11.88 | 5.96 | 3.46 |
| NaCl . . . . . . . | " | 0.78 | 0.77 | 1.05 | 0.78 | 0.67 | 0.37 | 0.14 | 0.18 | 0.34 | 0.08 | 0.50 |
| $NaHCO_3$ . . . . . | " | 4.60 | 3.72 | 4.19 | 2.90 | 2.75 | 2.29 | 3.06 | 1.77 | 2.44 | 1.40 | 1.16 |
| $Na_2CO_3$ . . . . . | " | 4.69 | 3.24 | 3.80 | 2.21 | 2.18 | 1.90 | 3.10 | 1.00 | 1.05 | 1.80 | 0.60 |
| $CaSO_4$ . . . . . . | " | 0.11 | 0.08 | 0.15 | 0.19 | 0.13 | 0.07 | -- | -- | 0.22 | 0.21 | 0.46 |
| $MgSO_4$ . . . . . . | " | 0.27 | 0.30 | 0.33 | 0.45 | 0.29 | 0.29 | 0.24 | 0.27 | 0.23 | 0.17 | 0.18 |
| $Na_2SO_4$ . . . . . . | " | 74.63 | 69.71 | 5.37 | 67.48 | 65.80 | 86.96 | 80.74 | 89.86 | 83.69 | 90.75 | 94.23 |
| Totals | " | 98.99 | 99.85 | 96.66 | 97.80 | 97.54 | 99.87 | 100.13 | 99.91 | 99.85 | 100.37 | 100.59 |

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# INDUSTRIAL MINERALS AS BY-PRODUCTS OF PETROLEUM AND NATURAL GAS DEVELOPMENT

## Introduction

Formation-waters (or "brines") accompany the oil produced in most oil fields, and these waters are commonly rich in various salts of such elements as bromine, iodine, magnesium, sodium and calcium. Certain natural gases in addition to their organic constituents, carry inorganic gases such as hydrogen sulfide and helium. Thus, both oil-field waters and gases offer potential sources of important industrial chemicals which, if the concentration is sufficiently high and production of the parent material large enough, may be economically extracted.

In Alberta only the sulfur of natural gas is at present exploited. Sulfur production and the possibilities of extracting other elements from natural gas and formation waters is reviewed briefly below.

## Sulfur in Natural Gas

Sulfur is used in the manufacture of pulp and paper, and of heavy chemicals including sulfuric acid. It is also used in rubber goods, explosives, and in petroleum and sugar refining.

There are no known deposits of elemental sulfur in Canada. Sulfur, usually as one of its compounds, is derived from copper and zinc smelter-stack gases and pyrite in Newfoundland, Quebec, Ontario, Saskatchewan, and British Columbia. Elemental sulfur is produced from "sour" natural gas in Alberta where the sulfur is present as hydrogen sulfide which is removed before the gas is marketed. Considering only fields with gas reserves greater than 10 billion

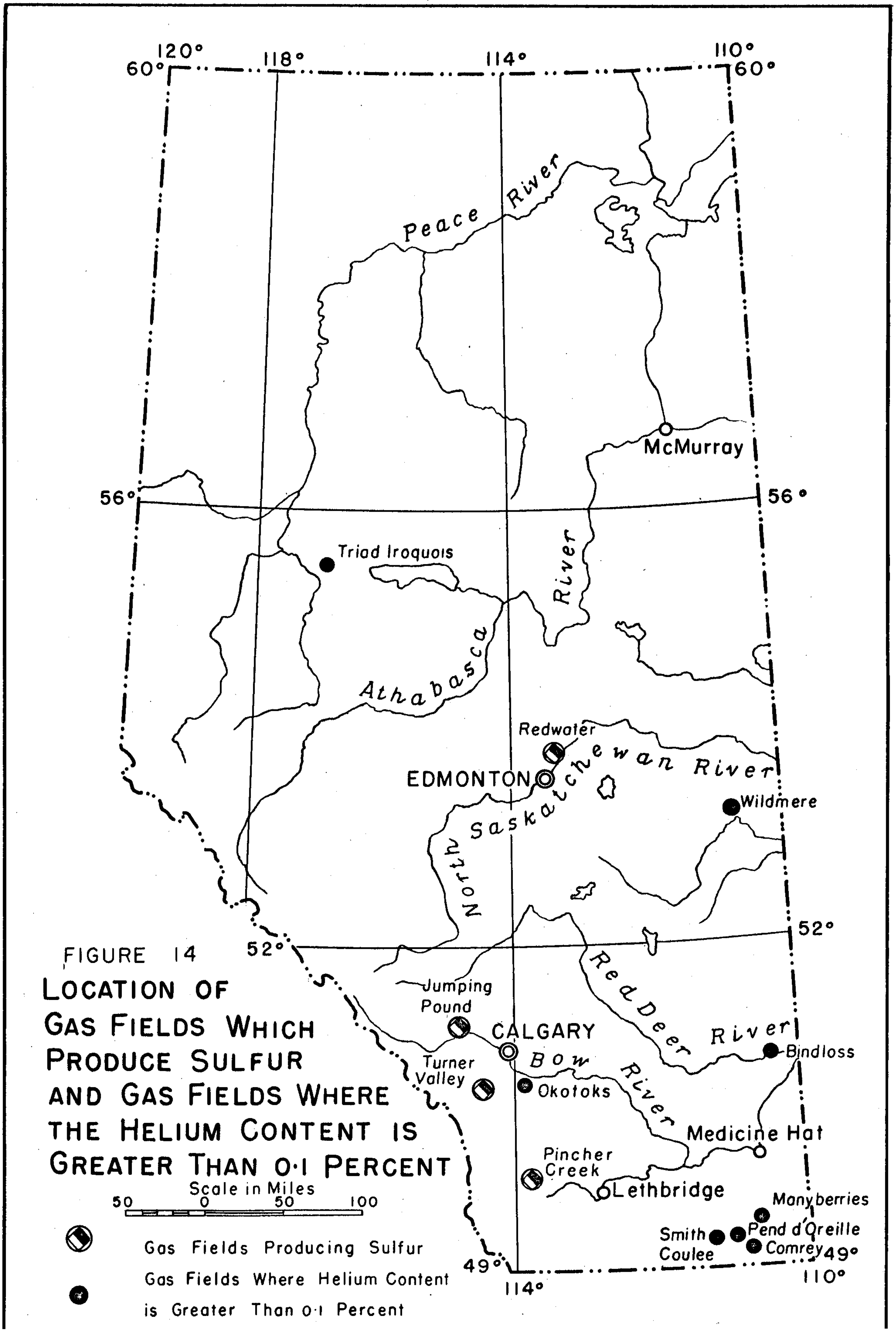


FIGURE 14

LOCATION OF GAS FIELDS WHICH PRODUCE SULFUR AND GAS FIELDS WHERE THE HELIUM CONTENT IS GREATER THAN 0·1 PERCENT

TABLE 13: Approximate Sulfur reserves of gas fields having reserves of more than 10 billion cubic feet of gas and over 2% $H_2S$

| Name of field | Producing horizon | No. of analyses available | $\%H_2S$ | Recoverable gas reserves, B.C.F. | Approx. recoverable sulfur reserves, thousands of tons |
|---|---|---|---|---|---|
| Calgary | Wabamun | 2 | 34.7 | 45 | 640 |
| Crossfield | Elkton | none | ? | 85 | ? |
| Fairydell-Bon Accord | Nisku | 2 | 3.8 | 70 | 100 |
| Fenn-Big Valley | Nisku | 18 | 2.6 | 70 | 65 |
| Homeglen-Rimbey | Leduc-gas cap | | | 800 | 1130± |
| " " | " solution | 9 | 4.0± | 50 | 70± |
| Jumping Pound | Rundle | 24 | 3.6 | 538 | 700 |
| Kathryn | Wabamun | 1 | 12.0 | 30 | 115 |
| Leduc-Woodbend | Nisku-gas cap | | very | 32.5 | ? |
| " " | " solution | | variable | 58 | ? |
| Little Smoky River | Leduc | 1 | 12.0 | 10 | 40 |
| Nevis | Nisku and Leduc | 6 | 6.8 | 480 | 1200 |
| Okotoks | Wabamun | 9 | 33.2 | 135 | 2100 |
| Olds | Wabamun | 4 | 7.2 | 70 | 190 |
| Pincher Creek | Rundle | 8 | 10.2 | 1800 | 7150 |
| Redwater | Leduc | 34 | 2.7 | 62.5 | 60 |
| Samson Lake | Basal Quartz | 1 | 7.5 | 70 | 180 |
| Savanna Creek | Rundle | 11 | 12.0+ | 250 | 1100+ |
| Stettler | Nisku | 4 | 3.6 | 11 | 14 |
| " | Leduc | 4 | 3.2 | 4 | 5 |
| Sturgeon Lake | Leduc | 3 | 9.0 | 18 | 55 |
| " " South | Leduc | 5 | 9.7 | 105 | 380 |
| Sundre | Elkton-gas cap | | | 15 | 25 |
| " | " solution | 4 | 4.5 | 30 | 50 |
| Turner Valley | Rundle-gas cap | | | 205 | 100 |
| " " | " solution | 10 | 1.4 | 150 | 75 |
| West Drumheller | Nisku-gas cap | | | 7 | 5 |
| " " | " solution | 11 | 2.0 | 11 | 8 |
| Wimborne | Leduc | 2 | 35.0 | 65 | 825 |
| Windfall | Leduc | 2 | 16.0 | 600 | 4000 |

Approximate recoverable sulfur reserves: over 20,000,000 tons cubic feet and containing not less than two per cent hydrogen sulfide the sulfur reserves of Alberta * total at least 20 million tons.

Despite these considerable reserves the production of sulfur is limited, being controlled by the markets for gas and by the markets for sulfur itself. In 1956 Alberta produced about 33,000 tons of sulfur, which represented four per cent of the Canadian total; in 1957 the output in Alberta had risen to slightly more than 100,000 tons, chiefly derived from Jumping Pound, Pincher Creek and Turner Valley gas fields (Fig. 14).

## Helium in Natural Gas

Helium is used as a lifting gas in airships, helium-shielded arc-welding, production of titanium and zirconium, fuel expellent in rockets and guided missiles, and in medicine. Helium is produced from natural gases in the United States, where the helium content may be as high as eight per cent. Analyses of natural gas in Alberta (Oil and Gas Conservation Board) show that helium content is generally less than 0.5 per cent. Those gas fields where the natural gas contains more than 0.1 per cent helium are listed in table 3, their locations being shown in figure 14.

It is observed that helium occurs in concentrations of about 0.25 per cent in gas from the southeast corner of the province. However, at Okotoks gas field 4 per cent helium has been recorded, and a single analysis of a well producing from "granite wash" in northern Alberta showed 0.51 per cent helium.

* An additional potential source is provided by the oil of McMurray oil sands which contain about five per cent sulfur (Blair, 1950).

TABLE 14: Helium Analyses Showing more than 0.1% He in Alberta Natural Gases

| Name of Well | Location | Field | Zone | %He |
|---|---|---|---|---|
| Bagsel Bindloss No. 6-29 | 6-29 23-3 W.4 | Bindloss Valley | Bow Island | 0.1208 |
| Canadian Montana Gas No. 6036 - 1.7 | 6-36 1-7 W.4 | Comrey | " " | 0.1334 |
| McColl-Union No. 6D-2-6-6 | 6- 2 6-6 W.4 | Manyberries | " " 2nd sand | 0.18 |
| " " " " | " " | " | " " "K" sand | 0.21 |
| Med. Hat gas well No. 63 | 6-23 3-5 W.4 | Medicine Hat | Medicine Hat | 0.112 |
| Shell Blackwood and Morris 1 | 10-13 21-29 W.4 | Okotoks | Wabamun | 4.0 |
| McColl-Union 4B-16-3-8 | 4-16 3-8 W.4 | Pend. d'Orielle | 2nd Bow Island | 0.249 |
| " " " | 4-16 3-8 W.4 | " " | 1st Bow Island | 0.280 |
| " " 6D-20-3-10 | 6-20 3-10 W.4 | Smith Coulee | Bow Island | 0.257 |
| Dragon Oil & Gas McQuid No. 1 | 16-19 48- 5 W.4 | Wildmere | Colony | 0.1073 |
| U.C.O. No.22 | 12-13 49- 6 W.4 | " | Stray lower Bl. sand | 0.1031 |
| Triad Iroquois No. 15-16 | 15-16 75-19 W.5 | Wildcat | Granite wash | 0.51 |

## Magnesium, Bromine and Iodine in Oil-field Waters

The formation waters of some oil fields in Alberta carry high concentrations of soluble materials (Fig. 15); for example, waters from the D-3 zone of the Wizard Lake field contain approximately 18,000 milligrams per litre of magnesium, 1,400 of bromine, 18 of iodine, 20,000 of calcium, 46,000 of sodium, 195,000 of chloride, and less than 200 each of bicarbonate and sulfate. The analyses have been made by the Oil and Gas Conservation Board, and these results, together with information on quantity and availability of water produced, are presently being studied by the Research Council with the intention of reviewing the possibilities of commercial extraction of certain elements.

The following is a brief summary of some selected data on magnesium, bromine, and iodine.

### Magnesium

Magnesium metal or one of its compounds is used in high-strength and light-weight structural alloys, in the production of titanium, as a cathodic protecting agent for iron and steel equipment (e.g. pipelines) in corroding environments, refractories in the steel and copper industries, and also in the cement, fertilizer, textile and chemical industries.

Canadian production of magnesium is confined to Quebec and Ontario, the raw materials being brucitic limestone and dolomite, respectively. In other regions such as California and Texas and in Great Britain, magnesium is extracted from sea water, which contains about 1,400 milligrams of magnesium per litre.

The magnesium concentration in some formation waters in wells (Figs. 15 and 16) reaches 17,000 milligrams per litre (5.95 pounds per barrel), or over 12 times that of sea water (Figs. 15 and 16). The amount theoretically recoverable depends not only upon the concentration but, of course, upon the amount of water available. The amount of magnesium theoretically recoverable may be as high as 210,000 kilograms (462,000 pounds) per month (Fig. 16).

Bromine

The primary use for bromine is as ethylene dibromide in gasoline antiknock compounds. It is also used in medicine and photography, and recently as a fumigating agent.

Canada does not produce any bromine, the bulk of the world supply being produced in the United States where it is extracted from sea water and well brines. The concentration of bromine in sea water is 60 to 70 milligrams per litre which is considerably less than the concentration in the well water in some oil fields of Alberta (Figs. 15 and 17) where it is present in concentrations of up to 1,400 milligrams per litre (0.49 pounds per barrel). The theoretically recoverable amount is as high as 22,000 kilograms (48,400 pounds) per month.

Iodine

Iodine has a vast range of uses in small quantities, for example in medicine, photography, foodstuffs, metallurgy, dyes, and in the chemical industry.

Most of the world's iodine is produced by Chile (from nitrate deposits) and the United States. Iodine in the United States is derived from oil-well brines which contain an average of 70 milligrams per litre.

The iodine content of well waters for the fields considered for magnesium and bromine ranges from 11 to 23 milligrams per litre. This is

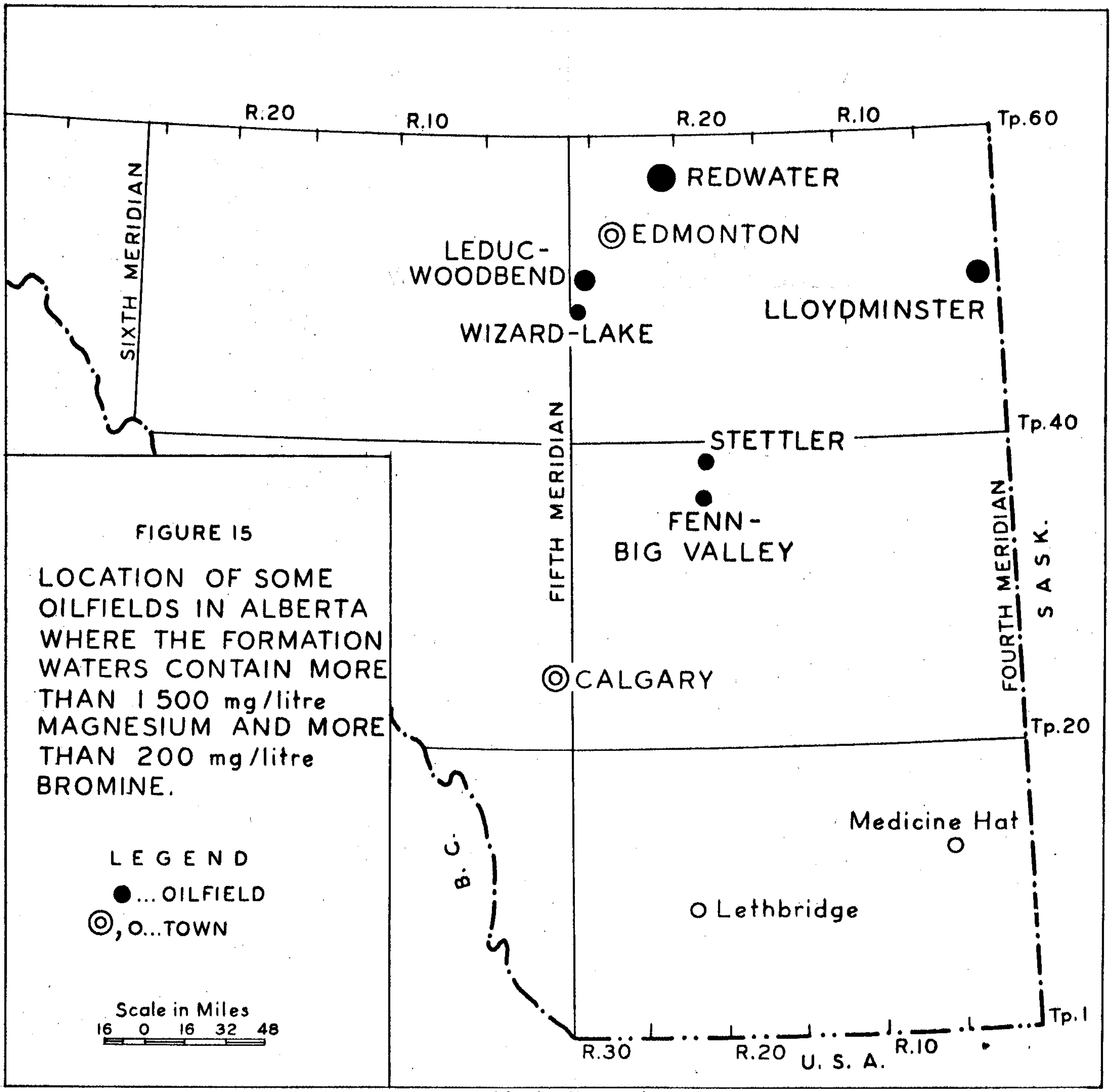


FIGURE 15

LOCATION OF SOME OILFIELDS IN ALBERTA WHERE THE FORMATION WATERS CONTAIN MORE THAN 1 500 mg/litre MAGNESIUM AND MORE THAN 200 mg/litre BROMINE.

Modified after Oil and Gas Conservation Board, 1957.

one-third to one-quarter of the concentration in the well brines of the United States, and the extraction of iodine from Alberta oil-well waters would probably not be economic, except perhaps as a by-product in the extraction of other elements.

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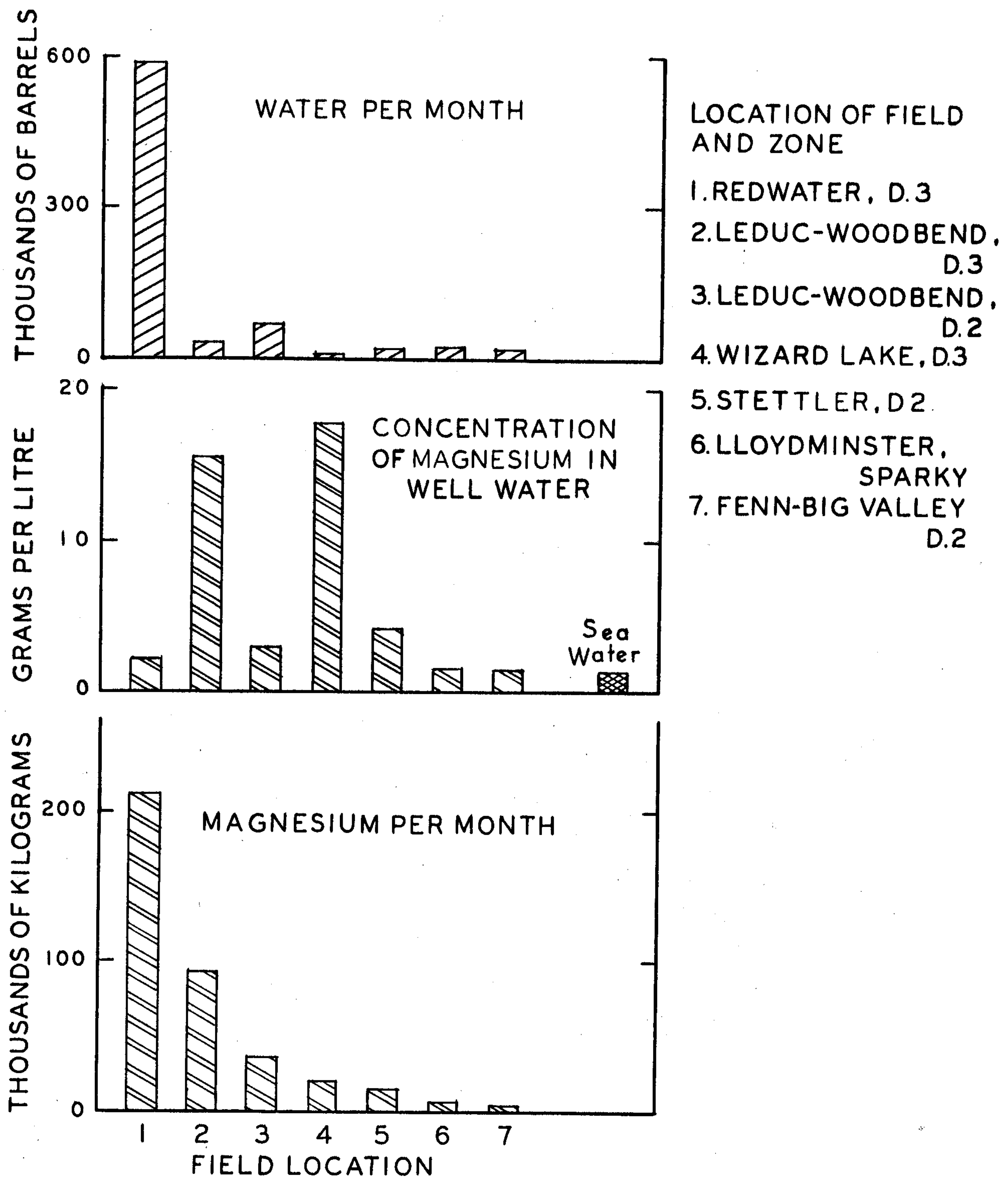


FIGURE 16. MAGNESIUM CONTENT OF SOME OIL-WELL WATERS, ANALYSES BY OIL AND GAS CONSERVATION BOARD LABORATORIES, CALGARY.

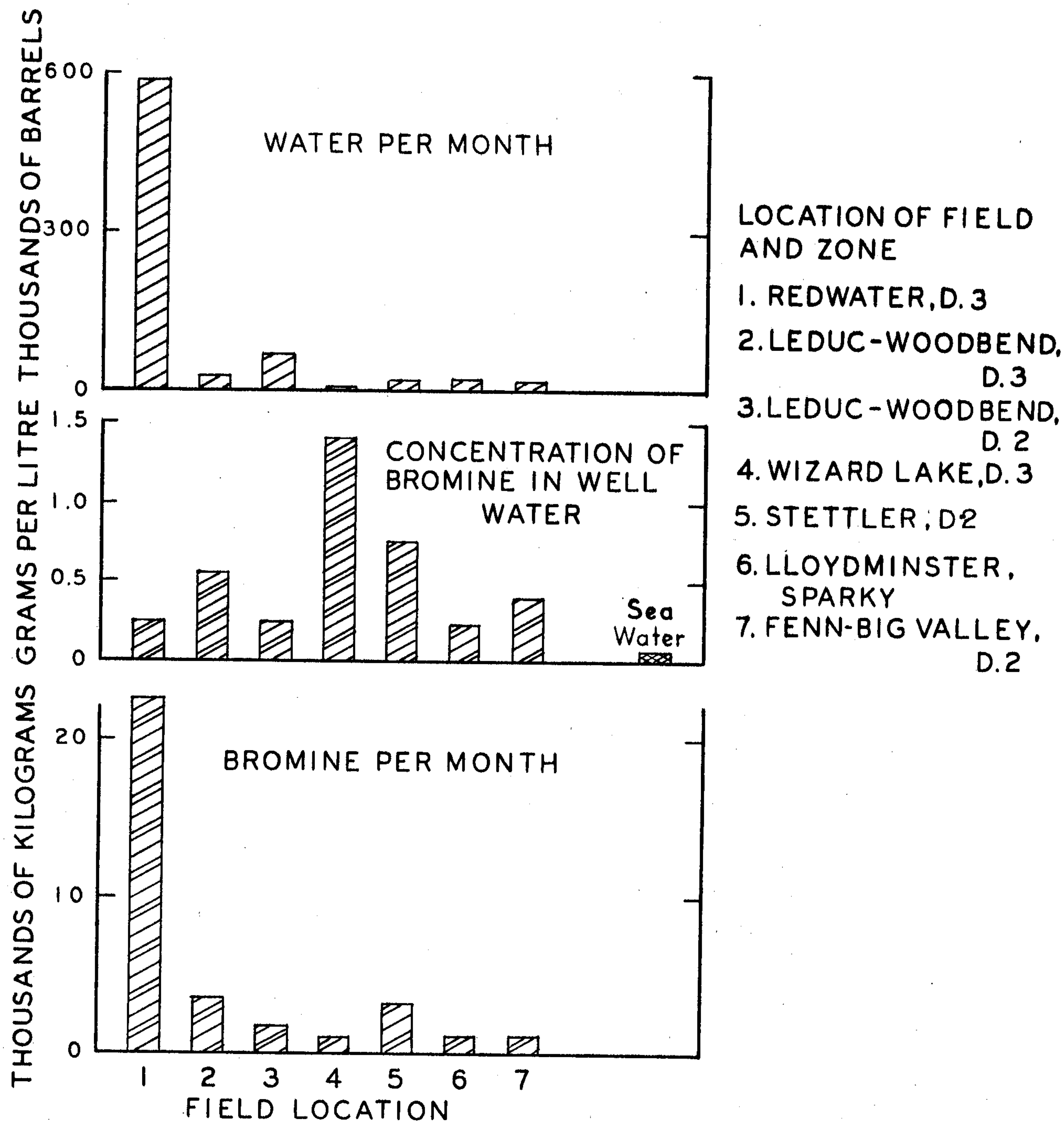


FIGURE 17. BROMINE CONTENT OF SOME OIL-WELL WATERS, ANALYSES BY OIL AND GAS CONSERVATION BOARD LABORATORIES, CALGARY.

# MINOR INDUSTRIAL MINERALS

The minerals grouped in this section are those which, in Alberta, either occur as small deposits or about which little is known. No implication is intended that these minerals have little commercial use or value if present in sufficient quantities. The distribution of the deposits described is shown in figure 18.

## Aluminum Sulfate

The majority of alum salts are now prepared chemically, although a small amount of natural alum is mined in some countries.

Allan (1925) stated that white incrustations of aluminum sulfate are developed at surface outcrops of the lower shale member of the Smoky River formation in the vicinity of the Smoky and Little Smoky Rivers in Tp. 77, R. 24, W. 5th Mer. This deposit rarely has more than two inches of pure salt, and contains 10 to 20 per cent $Al_2O_3$. Rutherford (1932) suggested that the major mineral present is pickeringite.

## Building Stone

Various rock-types from numerous formations have been used in the past for building stone in Alberta, but the industry has no importance at the present time. A reconnaissance survey to assess the potentialities of various geological formations in Alberta as sources of building stone was carried out by Parks (1916). Since this date little specific work has been done, and the following account is derived largely from the paper by Parks.

Many of the Cambrian, Devonian, and Carboniferous limestones in the Rocky Mountains are suitable for building stones, although severe fracturing,

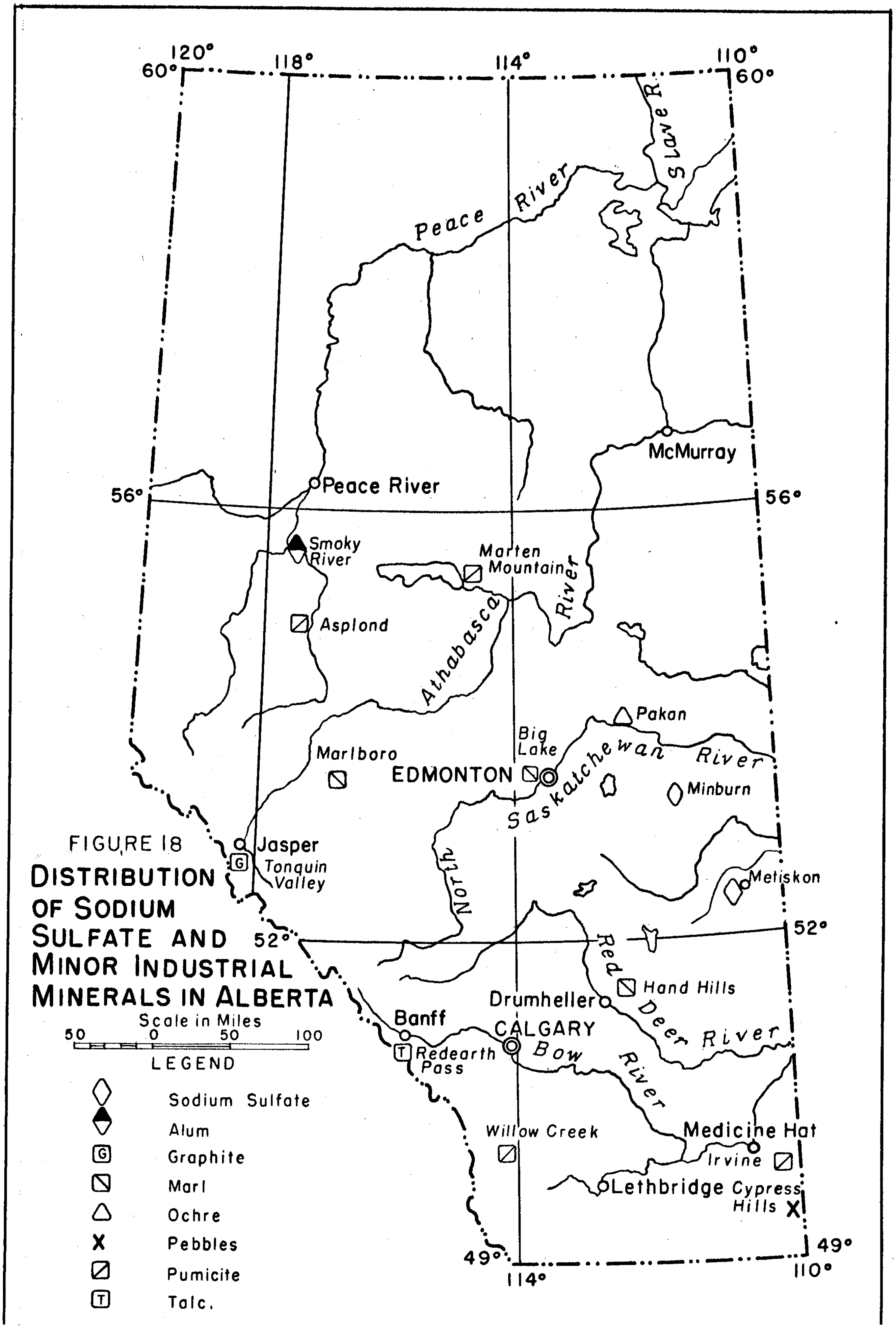


FIGURE 18

DISTRIBUTION OF SODIUM SULFATE AND MINOR INDUSTRIAL MINERALS IN ALBERTA high and variable dips, and excessive hardness of the rocks detract from their value at some localities.

Cretaceous and Tertiary sandstones are, on the whole, unsuitable because of their unattractive color, softness, and poor weathering properties. However, sandstone from the Oldman formation (Cretaceous) has been used, for example, in building Assiniboia Hall on the University of Alberta Campus, Edmonton; and prior to World War I considerable quantities of Paskapoo sandstone (Tertiary) were quarried for general building purposes.

Suitable igneous rocks are rare in Alberta, but Clow and Crockford (1951) described Precambrian sills of the Kinsella formation (Precambrian) in the north Kootenay Pass which they suggested may have some use as ornamental stones. These authors were also of the opinion that certain porphyries of the Crowsnest volcanic sequence (Cretaceous) near Coleman would make an attractive ornamental stone.

Tufa deposits have been recorded at various localities in Alberta, as at Big Hill Creek and Radnor. Though both these deposits have been considered too soft and porous for use (Allan, 1936; Matthews, 1956), small amounts have been used for decorative purposes, for example Big Hill tufa was used in the Government Administration Building at Edmonton, and the Radnor tufa in the Civic Utilities Building at Calgary.

## Graphite

No natural graphite has been produced in Canada since 1954, when a total of 2,463 short tons was mined at a single mine in Ontario.

No commercial deposits of graphite have been found in Alberta, the only known occurrence (described by Allan, 1932) is in Tonquin Valley, Jasper National Park (Fig. 18). The graphitic bed is in Precambrian strata, the outcrop occurring at an elevation of 7,000 feet in a creek in the southwest corner of Tp. 44, R. 2, W. 6th Mer. The Precambrian rocks here consist of slates, phyllites, schists, quartzites, and pebbles conglomerates. The slates are carbonaceous and intensely metamorphosed, graphite being developed where the carbon content is highest. The graphite zone is 20 feet thick, but the carbon content is very low (Allan, 1932).

## Marl

Data concerning marl deposits in Alberta are scanty, although samples submitted to the Research Council for identification suggest that marl deposits may be widespread in the province. The information available is summarized below, the locations of the deposits being shown in figure 18.

Hand Hills: Allan and Sanderson (1945) report that a large deposit of marl underlies the conglomerate capping the Hand Hills. The marl is exposed in the southwest corner Tp. 30, R. 17, W. 4th Mer.

Big Lake: It is understood (Research Council of Alberta files) that preliminary development work is being undertaken by private interests on a marl deposit near Big Lake, north of Stony Plain and northwest of Edmonton. No information is available on the extent or purity of the deposit.

Marlboro: A deposit of marl near Marlboro, west of Edson, has been used in the past for the manufacture of cement. This deposit has recently been examined (by Byrne), and it appears that the marl remaining in the deposit is of small extent and thickness, but a few shallow boreholes would establish the extent of the deposit more definitely.

## Ochre

Allan (1921) reported that ochre deposits occur at many springs in Alberta, and that although the quality is high, the quantity is small. The only deposit which has been described (Allan, 1921) occurs in Sec. 36, Tp. 58, R. 15, W. 4th Mer., near Pakan, where high quality ochre covers about one acre to a depth of eight inches.

## Pebbles

Quartzite pebbles derived from the Cypress Hills conglomerate and washed into stream beds along the northern flank of the Cypress Hills are used for ball-mills in British Columbia (Crockford, 1951). Cole (1928) carried out tests of the Cypress Hills pebbles and reported them to be comparable in quality to commercially used Danish pebbles. The area from which these pebbles are obtained is indicated in figure 18.

## Potash

The salt deposits of Saskatchewan, equivalent to the upper salt in Alberta, contain 6.4 billion tons reserves of potash. This figure includes only deposits containing 25 per cent or more potash. Although no systematic search has yet been made for potash in Alberta, investigations in Saskatchewan along the Alberta boundary have shown only traces of potash (Tomkins, 1955). The few analyses available (Cole, 1948) suggest that commercial quantities of potash are unlikely to be found in Alberta, the highest concentration encountered being three to four per cent potash in the vicinity of Neutral Hills (Imperial Provost No. 2 well, Lsd. 1, Sec. 33, Tp. 37, R. 3, W. 4th Mer.). However, it would be unwise to discount entirely the possibility of economic potash deposits in Alberta before examining drill-cores from wells which have penetrated the salt deposits.

## Pumicite

Pumicite is mainly used as a concrete aggregate and as an abrasive. It is used in minor amounts in acoustic and insulation products and as an absorbent.

Although deposits of pumicite are widespread in Saskatchewan, Alberta and British Columbia, there has been no recent production due to the thinness of beds and lack of nearby markets.

No detailed investigations have been undertaken on pumicite in Alberta. The following is a brief review of data available on the more important occurrences, the location of the deposits being shown in figure 18.

Irvine: A thick bed of bentonite and pumicite occurring 100 feet above the base of the Bearpaw formation in southeastern Alberta was described briefly in the chapter on bentonite. In the northern and eastern outcrops of the Bearpaw formation surrounding the Cypress Hills, the greater part of this bed appears to consist of pumicite varying from pure material to fairly bentonitic. The pumicite shows rapid lateral changes in purity, and sometimes grades laterally into bentonite (Byrne, 1955).

The pumicite-bentonite bed outcrops extensively one mile south of the town of Irvine in the southwest quarter of Sec. 30, Tp. 11, R. 2, W. 4th Mer. Numerous other exposures are present in the general area where the lower Bearpaw formation outcrops in southeastern Alberta, although south of the Cypress Hills the bed is thinner and consists entirely of bentonite.

Marten Mountain: Pumicite is poorly exposed at the west end of Marten Mountain on the east end of Lesser Slave Lake. Rutherford (1931) examined the deposit, but due to lack of good outcrops he was unable to determine the thickness, other than to establish that it is in excess of one foot.

Calgary: Allan (1932) reported that a bed of pumicite from a fraction of an inch to 10 inches thick is exposed in alluvial deposits a short distance above the bed-rock just downstream from the Glenmore Dam in Calgary. The deposit is of some academic interest, since it indicates that volcanoes were active in Western Canada a relatively short time ago.

Willow Creek: A small tonnage of pumicite has been mined from a deposit of cream-colored to black pumicite in the southeast quarter of Sec. 36, Tp. 13, R. 2, W. 5th Mer. The pumicite occurs under about two feet of overburden and is 10 to 15 inches in thickness. Eighty per cent of the pumicite is finer than 200-mesh.

Asplund: A sample of indurated pumicite, partially altered to bentonite, was submitted to the Research Council of Alberta in 1942 by Mr. W. W. Caldwell* of Asplund, Alberta, who stated that he dug through 1.5 feet of this material without reaching the base of the bed while he was digging a cellar in the north-east quarter of Sec. 27, Tp. 69, R. 22, W. 5th Mer.

### Conclusions

Although several occurrences of pumicite are known to exist in Alberta, data concerning its purity and composition are not available. Pumicite is a rather drab-looking material that could easily be overlooked in reconnaissance geological mapping, so it is reasonable to suppose that a number of occurrences have not yet been discovered.

## Talc

The national production of talc in 1954 was 25,691 short tons, derived from Quebec and Ontario. This was used chiefly in the rubber and paint industries.

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* Personal Communication to J. A. Allan, Research Council of Alberta.

Talc deposits have been noted on both sides of the Alberta-British Columbia boundary in the vicinity of Redearth Pass (Spence, 1940). In Alberta, the talc occurs as beds within grey dolomite of the Cathedral formation (Lower Cambrian), as irregular stringers one to five feet thick, and also within the formation as small "pods" up to two feet thick. The talc is white in color and appears to be of good quality **.

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