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MEMOIR 196

GEOLOGY OF LAKE ATHABASKA REGION, SASKATCHEWAN

BY

F. J. ALCOCK

GEOLOGICAL SURVEY
DEPARTMENT OF MINES
OTTAWA
1936

CANADA
DEPARTMENT OF MINES
HON. T. A. CRERAR, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

BUREAU OF ECONOMIC GEOLOGY
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CONTENTS

CHAPTER I

PAGE

Introduction.. 1

CHAPTER II

General character of the region.. 7

CHAPTER III

General geology.. 10

CHAPTER IV

Economic geology.. 25

Index.. 39

Illustrations

Map 339A. Goldfields area, northern Saskatchewan.. .. .. In pocket
363A. Tazin Lake sheet, northern Saskatchewan.. .. .. " "
364A. Fond-du-Lac sheet, northern Saskatchewan.. .. .. " "
365A. Stony Rapids sheet (west half), northern Saskatchewan.. .. .. .. " "

Plate I. A. Goldfields, Saskatchewan.. 4
B. Cannery bay, lake Athabaska.. 4

II. A. Fond-du-Lac, near the east end of lake Athabaska.. 4
B. Rapid on Crackingstone river. Typical of the streams entering lake Athabaska from the north.. 4

III. A. Dead Man bay, north shore of lake Athabaska.. 6
B. Murmac bay, Beaverlodge lake, typical of the country north of lake Athabaska.. 6

IV. A. Esker west of Oman lake.. 8
B. Sand-plain country along north branch of Grease river.. 8

V. A. Banded Tazin sediments, Beaver River area.. 14
B. Hybrid gneiss near Fon-du-lac.. 14

VI. A. Contorted schistose band in hybrid gneiss south of Train lake.. 16
B. Folding in injection gneiss, Grease River region.. 16

VII. A. Contorted injection gneiss, Robillard river.. 16
B. Crossbedding in Athabaska sandstone, south of Fond-du-Lac river.. 16

VIII. A. Camp of Consolidated Mining and Smelting Company of Canada, Limited, June 1935.. 28
B. Camp of Athona Mines, Limited, September 1935.. 28

Figure 1. Showing location and access.. 2
2. Showing principal mineral properties.. 26

Geology of Lake Athabaska Region, Saskatchewan

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

The discovery of gold in the summer of 1934 at Lodge bay on the north shore of lake Athabaska led to considerable staking in this region. The area lies in the northwestern corner of Saskatchewan about 50 miles east of the Alberta boundary. At different times in the past considerable prospecting was carried out along the north shore of the lake, but though occurrences of sulphides and of iron oxide were known no gold discoveries had been reported. Since the discovery of gold the area has attracted widespread attention and there has been a great demand for maps and for information concerning the geology of the region. Much of the season of 1935 was spent by the writer in mapping geologically an area of some 400 square miles, including most of the staked territory. In addition to this somewhat detailed work reconnaissance geological mapping was carried out over a wider field, from the Alberta boundary eastward for a distance of 160 miles to Stony Rapids and from the lake northward to latitude 60 degrees, the northern limit of the province.

For this work the party was divided into groups, each consisting of four men with two canoes. E. A. Hart, assisted by B. A. Valde, S. L. Tallman, and G. Munthe, covered the area from the Alberta boundary eastward to Cannery bay and northward to Tazin lake. J. A. Thomson, with F. E. Hogg, E. G. Tallman, and Earl Till, mapped the region drained by Charlot and Crackingstone rivers. E. S. Carpenter, with W. G. Robinson, W. N. Mulock, and W. G. Cameron, worked eastward from Tazin lake up Tazin river and down through the country drained by the upper Oldman waters to Beaverlodge lake. D. T. Willis, assisted by W. B. Gallup, J. G. Thibault, and J. R. Talbot, covered the area drained by Bulyea river north of Fond-du-Lac.. A. E. Moss, with B. Sigurdson, T. J. Boyle, and J. D. Cardy, covered the region drained by the north branch of Grease river. L. S. Trenholm, with K. Barnard, A. Agnew, and G. D. Campbell, mapped the region surrounding Scott, Premier, Dodge, and Grollier lakes in the section between the two branches of Grease river; and C. A. L. Hogg, assisted by E. W. Greig, R. S. Campbell, and B. Sutherland, explored the country lying between the east branch of Grease river and Fond-du-Lac river. In order to save time these seven parties with their outfits and provisions were placed by airplane at convenient places in their respective areas, the first three being flown from Cannery bay, where they had been brought by lake boat, and the remaining four flown from Fond-du-Lac. Bi-weekly visits were made by plane by the writer to all the parties in order to supervise the work, ascertain progress, correlate results, and to take in more supplies as these were required. In his work in the region around Lodge bay the writer was assisted by B. C. Elsley, J. W. Lehman, G. M. Godfrey, and S. Sutherland.

The writer acknowledges the many courtesies shown to him by the mining officials in charge of the numerous properties on which exploration work was being carried out during the past summer.

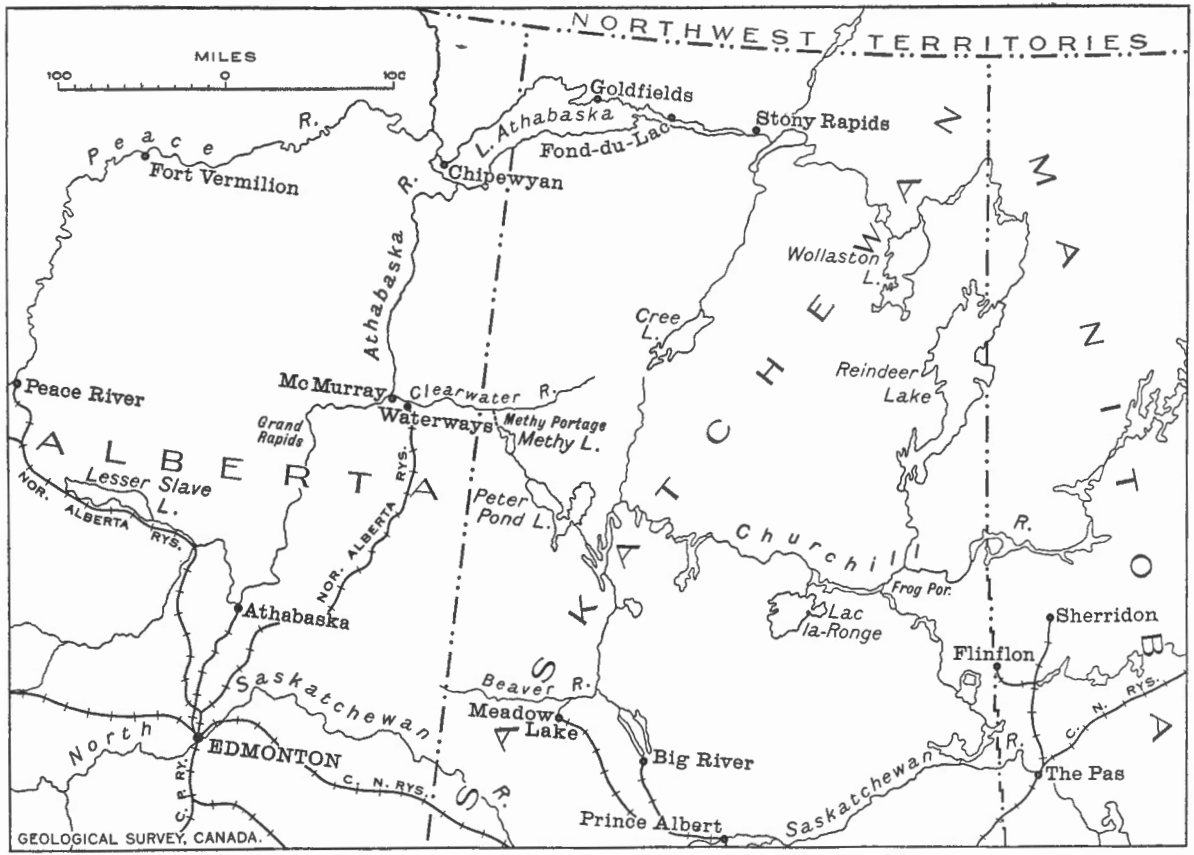

Figure 1. Showing location and access.

ACCESS

For over one hundred years the route to lake Athabaska was by way of Churchhill, Clearwater, and Athabaska rivers. From Cumberland House, on Saskatchewan river, Sturgeon-weir river was ascended to Frog portage and from there the Churchill to Methy lake: from the latter the route led across Methy portage to the Clearwater and down that stream to the Athabaska. The great obstacle in using the route for freight transportation was Methy portage (or portage la Loche), 12¼ miles in length, and when, about 1885, it was found that scows could be successfully run down the rapids of the Athabaska above the mouth of the Clearwater the route was abandoned for one by way of Edmonton and Athabaska Landing on the upper Athabaska.

From the abandoning of the Methy Portage route until 1914, Athabaska Landing was the rendezvous for the northern trade. Here, annually, were built scores of scows in which supplies for the Athabaska-Mackenzie trading posts were carried down to lake Athabaska. These scows could be run loaded through all the numerous rapids of the river with the exception of the Grand, where in a distance of about half a mile the river drops 60 feet. In the middle of the rapid is an island over which the freight was portaged on flat cars along a primitive tramway and the scows were run down empty through the right hand channel. Sometimes when the water was low cargoes had to be portaged also at two other rapids farther down, the Little Cascade and the Big Cascade.

In 1915 the railway reached Peace river and for several years the Peace displaced the Athabaska as the main highway to lake Athabaska. This was due to the fact that it is a much better stream for navigation, there being but a single interruption, that at Vermilion chutes, about half-way between Peace River Crossing, where the railway reaches the river, and lake Athabaska. River steamers plied on the two parts of the river above and below the chutes and a wagon portage 4 miles long led around the swift water.

In 1919 a railway line from Edmonton reached Waterways near McMurray where the Clearwater joins the Athabaska and once again the latter stream became the chief route to the Athabaska-Mackenzie region. From McMurray to the lake the Athabaska flows smoothly, offering a good route for river steamers. A train operated by the Northern Alberta Railways runs once a week from Edmonton to Waterways and in the summer boats make connexion with it for the journey to lake Athabaska and on to Fitzgerald on Slave river. Boat service along the lake is also maintained by the Hudson's Bay Company and by the McInnes Products Corporation, Limited. The distance from Edmonton to Waterways is 300 miles; from Waterways to Chipewyan at the west end of lake Athabaska is 236 miles by river, and from Chipewyan to Lodge bay is about 110 miles. Regular air service is maintained between Waterways and Lodge bay and still more rapid access to the region can be had by flying from Edmonton or from Prince Albert. The distance by air from Prince Albert to Goldfields is 465 miles.

HISTORY AND EXPLORATION

Exploration of the Athabaska country may be said to have begun in 1770 when Samuel Hearne, a young employee of the Hudson's Bay Company, left Fort Prince of Wales at the mouth of Churchill river on Hudson bay in an endeavour to reach a stream to the northwest reported to abound in copper ore. Two previous overland attempts by him had proved unsuccessful, but on this third venture, under the guidance of an Indian chief named Matonabbee, he found Coppermine river. On his return journey he saw Great Slave lake, then known as lake Athapuskow, and proceeding southward he reached Slave river and ascended it probably as far as the place where Fort Smith now stands. From here he proceeded eastward and eventually arrived at Fort Prince of Wales in June 1772.

Though Hearne had crossed the entire region immediately north of lake Athabaska he had probably never been closer than 70 miles to the lake itself. This was first actually reached by a Montreal trader of American birth named Peter Pond. In 1778 Pond entered the Athabaska country by way of Methy portage and Clearwater river and established a fort, which became known as the Fur Emporium, on Athabaska river some 40 miles above its mouth. From here he made excursions to lake Athabaska and in 1787 explored as far as Great Slake lake. Rivalry between him and another trader by the name of Ross culminated in the murder of the latter by Pond. This event alarmed the various Montreal traders, with the result that in 1787 they united into a single organization known as the North West Company. Pond became a partner in the company but he was not allowed to remain in charge of the Athabaska district, Alexander Mackenzie being sent out to replace him. Before he left the region in 1788, however, he gave Mackenzie all the information he possessed about the country and fired the latter's enthusiasm regarding the possibilities of discovery down the river that drains Great Slave lake.

Mackenzie immediately began to make preparations for this exploration. To take his place while he should be away, he had his cousin, Roderick Mackenzie, appointed to his department. When Roderick arrived at lake Athabaska he selected a place on the south shore about 8 miles east of the mouth of Athabaska river and on it built Fort Chipewyan in 1788, naming it after the tribe of Indians found there. It was from this fort that Alexander Mackenzie started on his famous expedition in 1789, in which he discovered the outlet of Great Slave lake and followed to the Arctic ocean the river that now bears his name.

A few years later the Hudson's Bay Company entered the territory and to secure a better location the North West Company moved their fort to a promontory on the north side of the lake. In 1815 the Hudson's Bay Company built a post which they called Fort Wedderborne on an island about one mile distant from the North West Company's fort. In 1821 the two rival companies became successfully united. At present there are trading posts at Chipewyan at the west end of the lake, at Fond-du-Lac near the east end, at Stony Rapids on Fond-du-Lac river, and at Goldfields townsite on Lodge bay, the centre of the new mining camp.

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A. Goldfields, Saskatchewan.

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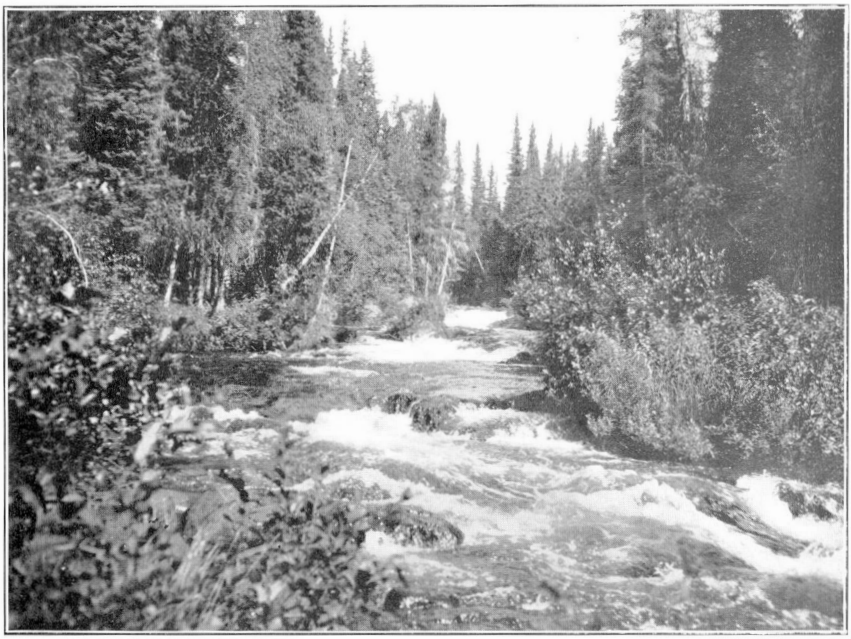
B. Cannery bay, lake Athabaska.

A. Fond-du-Lac, near the east end of lake Athabaska.



B. Rapid on Crackingstone river. Typical of the streams entering lake Athabaska from the north.

SURVEYS AND PREVIOUS WORK

The earliest known survey of lake Athabaska was made by Philip Turner who, in 1790, was sent by the British Government to Fort Chipewyan to determine the truth of certain reports about the proximity of that port to the Pacific ocean. After determining the latitude and longitude of the fort he made a survey of the north shore from there as far eastward as the mouth of Fond-du-Lac river.

In 1796 the work of Turner was enlarged by David Thomson. Thomson left Churchill river, ascended Reindeer river to Reindeer lake, followed and surveyed the west side of that body of water to Canoe river. From there he proceeded along a route by way of Wollaston lake to Fond-du-Lac river and ended his survey where Turner had left off, where that stream empties into lake Athabaska.

In 1880 and 1881 A. S. Cochrane, a topographical assistant on the Geological Survey, made a survey beginning at Cumberland House on Saskatchewan river. He followed along Reindeer lake and continued north and west up Cochrane river to Fond-du-Lac river; he then descended the latter stream, traversed lake Athabaska to Fort Chipewyan and went out by way of Athabaska and Clearwater rivers.

In 1892 and 1893 a survey of lake Athabaska was made for the Geological Survey by J. B. Tyrrell. In the former year, D. B. Dowling, acting as Mr. Tyrrell's assistant, surveyed the south shore of the lake, while in the following summer, Mr. Tyrrell, with the assistance of James W. Tyrrell, surveyed the north shore from Chipewyan to Fond-du-Lac. Bearings were taken with prismatic or solar compass, distances were measured by means of a floating boat-log, and observations were made with sextant for latitude and for magnetic variation.

In 1914 a survey of the lake by transit and stadia checked with astronomic readings was begun for the Geological Survey by A. G. Haultain and was completed the following year by B. R. MacKay. This survey was tied to the fourth meridian, forming the boundary between the provinces of Alberta and Saskatchewan, which had been surveyed as far north as the south shore of the lake.

From oblique photographs of the region surrounding the lake, taken by the Royal Canadian Air Force, a series of topographic sheets were prepared for publication on a scale of 4 miles to 1 inch by the Topographical Survey of the Department of the Interior. The Chipewyan and Fitzgerald sheets, covering the portion of the lake that lies in the province of Alberta, were issued in 1929 and 1930, respectively. Provisional editions of the Tazin Lake, Fond-du-Lac, and Stony Rapids sheets, covering the Saskatchewan part of the lake, were issued in 1935. Copies of these last three sheets on a scale of 1 mile to 1 inch were used as base maps for the assembling of the geological information in connexion with the field work described in the present report. For the more detailed work around Lodge bay copies of a part of the Tazin Lake sheet on a scale of 2 inches to 1 mile were used.

Geological investigation of the region may be said to have been begun by Cochrane, but no report of his results was published. In 1888 R. G. McConnell made a traverse along the south shore of lake Athabaska from the mouth of Athabaska river as far eastward as point William. At several places he observed outcrops of a clastic formation to which he gave the name Athabaska sandstone. The work of Tyrrell and Dowling

resulted in the publication of a report that gives the first description of the general geology of the region. In 1914 Charles Camsell explored a route between Black bay on lake Athabaska and Great Slave lake, following Tazin and Taltson rivers. His report outlines the geology of the region. In 1915 he made another visit to lake Athabaska to investigate a reported discovery of silver near the eastern end of the lake. The writer spent the season of 1914, under the direction of C. Camsell, in investigating the geology of the north shore of the lake and in 1916 this work was continued. In 1922 J. A. Allan and A. E. Cameron investigated the occurrence of iron on the north shore of lake Athabaska east of Lodge bay.

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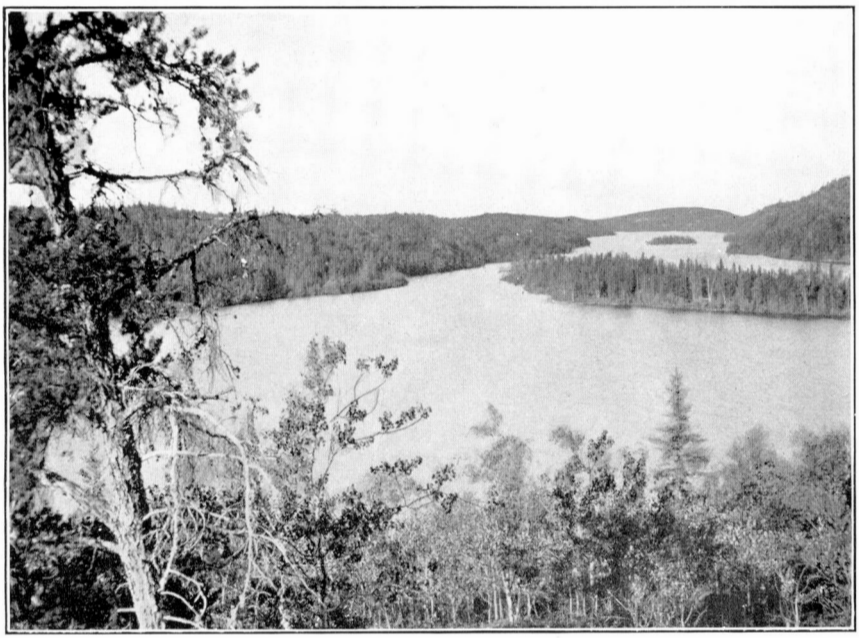

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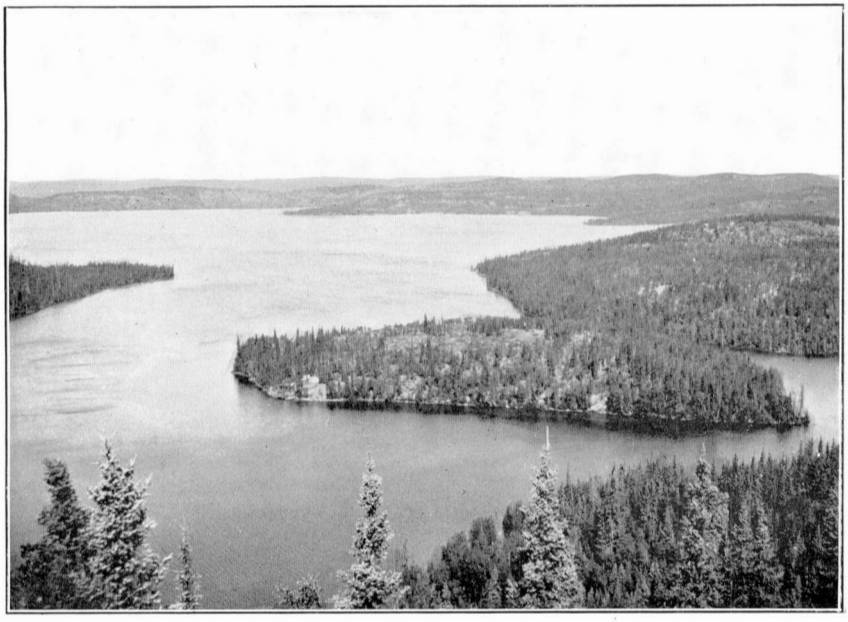
A. Dead Man bay, north shore of lake Athabaska.



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B. Murmac bay, Beaverlodge lake, typical of the country north of lake Athabaska.

CHAPTER II

GENERAL CHARACTER OF THE REGION

TOPOGRAPHY

The region lies within the Canadian Shield and its topography is fairly typical of that found nearly everywhere over that wide geological province. The two chief characteristics are low relief and disorganized drainage. In general the shield is a hummocky country of ridges and hills separated by depressions that are commonly occupied by lakes or muskeg swamps. There are wide areas where the ridges are rarely more than 100 feet above the level of the adjacent lakes; in other places the local differences of relief amount to several hundred feet. The lakes, which are nearly everywhere abundant, are of all sizes and are marked by very irregular outlines and by numerous islands. Many of the water-courses are mere successions of lake expansions with the intervening stream sections broken by rapids and waterfalls.

Lake Athabaska has an elevation of 699 feet above sea-level at average water conditions. During the past season (1935) the difference in level between low-water level in early spring and that of high water during the summer when Athabaska and Peace rivers were in flood was 10 feet. North of the lake the country rises to elevations of over 1,400 feet within short distances of the lake, particularly in Black Bay region, so that seen from the lake the topography is more rugged than that over much of the shield. The prominent ridge northwest of Goldfields townsite rises to an elevation of 1,300 feet above the sea. It stands over 500 feet above the level of the adjacent Beaverlodge lake. In detail the country shows irregular ridges, most of which trend in a northeast direction. Many of these ridges have steep and locally precipitous sides. In Black Bay region the divide between the waters that flow to lake Athabaska and those that flow northward to Great Slave lake is close to the former body of water.

The region north of lake Athabaska shows a maze of lakes. In places, as northeast of Fond-du-Lac, the country presents the appearance of a drowned topography with only the ridge summits projecting above the water. In many places the lake outlines show curving patterns. These are the result of structural control and represent old valleys carved out along the lines of strike of softer bands of rocks.

Rock exposures are abundant nearly everywhere in the region. Locally, morainal deposits of gravel and sand, however, cover minor areas. Sand-plains and ridges cover local patches and in places form lake beaches. Terraced beaches of gravel at various places along the lake mark levels at which the lake formerly stood.

CLIMATE

The climate of Athabaska Lake region is typically continental, being cold in winter and relatively warm in summer. Temperature and precipitation records have been kept at Chipewyan since 1884 and at Fond-du-Lac since 1905. Temperatures have ranged from 90° F. in late June to —61° in January. The following table for the year 1930 gives a general idea of the monthly ranges.

The annual rainfall is low, averaging between 8 and 10 inches. The snowfall averages between 30 and 50 inches. If 10 inches of snow be taken as the equivalent of 1 inch of rain the total average annual precipitation is about 13 inches.

Lake Athabaska, Saskatchewan, 1930

—	Temperature (F.)						Precipitation		
	Mean daily	Mean daily maximum	Mean daily minimum	Mean daily range	Extreme highest	Extreme lowest	Total in inches	Number of days	Greatest fall
January	−20	−13	−27	14	17	−50	.....	.....	.....
February	−11	− 4	−17	13	13	−44	.....	.....	.....
March	4	16	− 8	24	40	−40	.....	.....	.....
April	23	32	14	18	48	−15	.....	.....	.....
May	42	53	31	22	72	15	1·80	7	0·57
June	55	66	44	22	84	31	1·00	5	0·59
July	62	73	52	21	83	41	4·75	11	1·22
August	60	69	52	17	85	42	1·30	8	0·30
September	44	51	37	14	61	22	1·10	3	0·77
October	29	35	23	12	61	1	.....	.....	.....
November	11	17	6	11	37	−26	.....	.....	.....
December	3	10	− 4	14	36	−29	.....	.....	.....

At the western end of the lake the water is shallow and the lake commonly freezes over about the middle of October; at Fond-du-Lac it is usually the middle of November before the ice extends all the way across the lake, whereas at Black bay where the lake is widest and deepest the lake does not ordinarily freeze over before the middle of December. In the spring the ice breaks up in May, but floes of ice usually remain until about the middle of June.

Winds are variable; they sweep with equal violence both up and down the lake, producing storms that often last for several days.

A. Esker west of Oman lake.

B. Sand-plain country along north branch of Grease river.

FLORA AND FAUNA

Most of the region is forested, but the trees are small and few can be used for timber. The chief variety is black spruce which in places where there is sufficient moisture grows to heights of 40 to 50 feet and to a diameter of 18 inches. Associated with it locally are patches of white spruce. On the sand-plains there is an abundant growth of Banksian pine forming open park-like areas. In places, too, this pine is found growing on practically bare rock ridges. With their roots fastened in mossy crevices these trees thrive where no other variety could exist. Aspen poplar and white birch are also common, but few are found with a diameter over 8 inches. In the wide areas that have been laid waste by forest fires poplars are the first trees to reappear.

The fur-bearing animals of the region include red, black, and cross foxes, beaver, marten, otter, mink, weasel, wolverine, and skunk. The black bear roams everywhere and muskrats are locally abundant. A few moose and woodland caribou are to be seen. In the summer the barren ground caribou sometimes come south in small bands to the lake. In the winter huge herds migrate south and commonly cross the lake at the east end.

POPULATION AND INDUSTRIES

The largest settlement of the area at present is the new townsite of Goldfields where a post office was established in August 1935. This is the centre of the mining activity, and is in the midst of the principal prospects undergoing development. It includes a radio station, a couple of restaurants, stores, a church, a school, and a growing number of houses. Here in the shelter of a branch of Lodge bay, planes can land in any weather.

Aside from prospecting and mining development the chief occupations of the white people of the area are trapping and fishing. The number of white trappers is few and most of them have to go long distances to secure profitable trap lines. Fishing for export is carried on by the McInnes Products Corporation, Limited, which has its base on an island about 6 miles east of Crackingstone point. The company entered the field in 1926. Operations are carried on only for two months, from July 15 to September 15. The catch is lake trout and whitefish and most of it goes to New York and Chicago.

The native population of the region surrounding the lake belongs to two tribes, the Crees and the Chipewyans. At Chipewyan at the west end of the lake the representatives of the two are in about equal numbers; at Fond-du-Lac, where about five hundred Indians annually assemble for treaty, they are all Chipewyans.

CHAPTER III

GENERAL GEOLOGY

The consolidated rocks of Lake Athabaska region are all of Precambrian age. They include sediments belonging to at least three different series whose periods of deposition were separated by earth movements and the intrusion of igneous rocks. The following table summarizes the succession.

Proterozoic	Athabaska series	Conglomerate, arkose, sandstone, shale. Basalt flows and dykes
	Unconformity	
		Granite
	Intrusive Contact	
		Gabbro, norite, peridotite, amphibolite
	Intrusive Contact	
	Beaverlodge series	Quartzite, conglomerate, iron formation
	Unconformity	
Archæan		Granite, granodiorite, quartz-syenite, pegmatite
	Intrusive Contact	
	Tazin group	Dolomite, limestone, quartzite, argillite, conglomerate; mica schist and gneiss; volcanic flow and fragmental rocks

TAZIN GROUP

The term Tazin series was introduced by Camsell to describe the early Precambrian sediments and volcanics encountered by him in his traverse along Tazin and Taltson rivers. These early rocks present considerable variety in lithology and degree of metamorphism. Since it is possible that more than one series may be represented they are here included as a group.

Volcanic rocks locally ellipsoidal and apparently interbedded with sediments are present in some places. They are, however, greatly subordinate in volume to the sedimentary members in most of the areas where the group is exposed. The sediments consist of carbonate rocks, quartzite, argillite, and conglomerates. Mica schists and gneisses, commonly garnetiferous, apparently represent metamorphosed phases of these sediments. In places the beds have been injected intimately by granite producing "lit-par-lit" injection gneisses. All gradations exist from comparatively fresh-looking sediments through hybrid rocks to gneissic granitoid rocks. As a result many of the geological boundaries shown represent only gradational zones, or zones in which certain varieties of rock predominate, rather than abrupt changes in lithology.

BLACK BAY-TAZIN LAKE AREA

A belt of Tazin sediments extends along the shore of lake Athabaska from near the mouth of Cypress river to Charlot river, and swings north and northwestward through Thluicho and Tsalwor lakes. North of Slate island the dominant rock type is a grey arkose varying over into slaty and cherty quartzites. Certain beds are dense and fine-grained; others contain numerous feldspar fragments, some of which exceed 2 inches in diameter. In one thin section the arkose is seen to be made up of orthoclase, quartz, and albite particles in a fine-grained matrix of quartz and feldspar with zircon and iron oxide in small amounts. Brown biotite is abundant and chlorite is present as an alteration mineral. Another section shows a peculiar interfingering of thin beds consisting of rounded quartz grains with others made up of feldspar and quartz. The composition of the rock suggests its derivation from a granitic terrain and the material was evidently not transported far enough to decompose the feldspar. Some of the dense, slaty zones are marked by the presence of two sets of fractures which with the bedding form three planes that give rise to numerous triangular pits on the outcrop surfaces. These vary in size from 1 to 6 inches across. Interbedded with the grey arkosic rocks are red gneissic zones produced by the injection of granite along the bedding planes. In places granite and pegmatitic dykes also cut across the structure.

The west side of Thluicho lake is composed of light and dark coloured quartzites, quartzose sericite schists, and some thin bands of carbonate rock. The belt continues through the middle of Tsalwor lake. On either side the sediments pass over into granitoid rocks of hybrid origin. In places they are injected by granite. In other places well-bedded sediments develop augens of feldspar and reddish bands in which feldspar is abundant. The resulting complex has locally the appearance of a granite-gneiss and in other places that of a banded paragneiss.

Farther west along Thainka lake and Tazin river volcanic rocks are associated with the sediments. The complex consists of grey and greenish schists, dark green porphyries, and volcanic tuffs. The porphyries contain phenocrysts of feldspar in a fine-grained, greenish groundmass consisting largely of chlorite. The tuffs contain much acid feldspar and some quartz in a fine-grained matrix. Dykes and masses of granite cut these rocks.

BEAVERLODGE AREA

Beaverlodge area includes the district surrounding Beaverlodge lake. It extends from Black bay on the west to Mackintosh bay on the east. The Tazin rocks in this area consist dominantly of sediments, but volcanics are known in at least one locality. The beds are highly altered and no locality was found where the succession could be determined with certainty.

Volcanic rocks occur northeast of Elliot bay underlying the sediments of the Beaverlodge series. The latter form a prominent ridge striking northeast, in which the beds dip to the southeast. The Beaverlodge sediments are dominantly quartzites, but there is a coarse, basal conglomerate resting on volcanics and granite-gneiss. The volcanics are of the dense

greenstone type and show excellent pillow structure. In thin section this material is seen to consist of a dense mass of secondary minerals. The volcanic outcrop belt is narrow, disappearing under drift and muskeg to the northwest.

The sediments of the area consist of carbonate rock, quartzite, dark-banded quartzite, and argillitic rocks and their metamorphosed equivalents. A few patches of granitized conglomerate are included in the group.

A zone of carbonate rock consisting of dolomite and dolomitic limestone with associated quartzite and argillitic members extends from Beaverlodge bay to Fish Hook bay. The rock is crystalline; on its weathered surface it is a dark rusty brown; where freshly broken it is commonly white to bluish grey, but certain zones are stained red throughout by iron oxide. In places the rock is banded, showing original bedding planes; in others it is massive. A common feature is the presence of secondary silicate minerals. The most abundant of these consist of tremolite occurring often as radiating masses and a pale bluish green pyroxene, apparently diopside. In places the weathered surface of the rock shows small ridges composed of those harder minerals, and locally the rock has gone over almost entirely into silicate rock. Between Fish Hook bay and Cornwall bay the carbonate zones are thick and are interbedded with quartzite. To the west around Lodge bay the rock occurs as lenses and thin beds interlaminated with quartzitic argillites. Deformation has locally podded up the dolomite bands into irregular masses. In some localities a characteristic type of occurrence is carbonate containing irregular masses of quartzite and quartzite with rounded masses of carbonate rock.

Quartzites are prominent phases of the group in Beaverlodge area. West of Fish Hook bay a thick zone of white quartzite is interbedded with dolomite. To the east of the same bay occur hills of heavy-bedded grey quartzite, some beds of which carry carbonate. Well-banded, grey, cherty quartzites occur along the east side of Milliken lake. The quartzites grade into dark, banded rocks intermediate between quartzites and argillites. White quartzites interbedded with garnetiferous schists north of the entrance to Mackintosh bay resemble lithologically some of the younger quartzites of the Beaverlodge series.

Along the west side of Nero lake on the portage route from Beaverlodge lake to Crackingstone river is a belt of coarse conglomerate which has been highly granitized. Since it occurs in the granitic complex of pre-Beaverlodge age it has been mapped with the Tazin group. The rock is red. On the glaciated surface the outlines of the boulders are clearly distinguishable. These are rounded to subangular and are of all sizes up to 2 feet in diameter. Most of the boulders are of red granite. The matrix has a granite-like texture and is made up of quartz and red feldspar. The rock is distinguished from the conglomerates of the Beaverlodge and Athabaska series by its texture and by the absence in it of boulders of many types that are present in the two younger series. Certain belts are, however, of doubtful age. Towards the eastern end of Tazin lake some or all of the conglomerates shown as Athabaska may be older, possibly Tazin, and the same applies to conglomerates lying east of Wellington lake.

In the region between Murmac bay, Beaverlodge lake, and Mackintosh bay a common type of sediment is a dark, banded quartzite or quartzitic schist commonly carrying garnets. A prominent hill north of the narrows of Mackintosh bay is made up of biotite schist in which are closely packed, red garnet crystals varying in size up to 2 inches in diameter. Garnet schists are interbanded with rusty quartzites and white to grey quartzites and all are cut by granite and pegmatite dykes and by quartz veins and stringers.

East of Mackintosh bay the sediments become more altered, passing into schists and paragneisses. Locally they are injected by granite and pegmatite producing "lit-par-lit" hybrid gneisses. In other places the sediments themselves are recrystallized and have taken on a granitoid appearance. In Hayter bay the well-banded character of certain rocks leaves little doubt as to their sedimentary origin. Some bands are dark garnetiferous mica schists. Others equally well banded and also containing garnets have a typical granitic texture. In this hybrid complex it is difficult to determine how much of the granitoid rocks are due to the intrusion of igneous material and how much to the recrystallization or replacement of the older sedimentary complex.

North of Mackintosh bay is a belt of high country underlain by granitized or partly granitized sediments. The rocks are banded, giving a gneissoid appearance, and on their weathered surfaces are pink to reddish. Certain bands consist largely of feldspar. Locally, bands of dark mica schist occur with the lighter coloured zones. Basic dykes and granite dykes cut the complex. A thin section of a well-banded phase shows quartz, orthoclase, albite, and considerable carbonate, with minor amounts of chlorite and sericite. To the west of Mackintosh bay similar looking beds occur interbanded with quartzose sediments. The complex evidently is the result of the alteration of Tazin sediments through the addition of material from a granitic magma.

BEAVER RIVER AREA

From Beaver river eastward to beyond Lepus island is an area of altered sediments which are placed with the Tazin group. The rocks consist of quartzites and mica schists, the latter commonly garnetiferous and in places graphitic. An interesting variety of the quartzite is a white, massive rock containing numerous bright red garnets. The series is injected by granite and in places by basic rocks. The belt grades into hybrid and injection gneisses so that it is difficult to draw zonal boundaries.

GREASE RIVER REGION

Stretching east and northeast of Grease bay is a large area of altered sediments whose lithology and relations to the intrusive rocks suggest that they should be assigned to the Tazin group. The sediments consist of quartzites, argillites, paragneisses, mica schists, and local bands of conglomerate. The quartzites vary greatly in appearance. One variety is white and contains garnets; another is dark and locally massive, resembling an igneous rock. The quartzites grade into banded argillitic rocks and into sedimentary gneisses which are commonly garnetiferous and locally

graphitic. Along the southwest arm of Reeve lake a conglomerate is exposed and another outcrop of similar rock occurs on a lake one-half mile to the northwest. The beds are composed largely of pebbles from ½ inch to 2 inches in diameter enclosed in a quartzose, argillitic matrix. One boulder has a diameter of 18 inches. The matrix in places shows crystals of feldspar and hornblende up to half an inch in length.

North of Clut lakes the sedimentary complex is intruded by granite-gneiss. The contact between the sediments and intrusive is not sharp. There is a gradational zone in places a quarter of a mile wide consisting of sedimentary material injected by granite. In places crossing the strike from well-banded sediments to typical granite-gneiss there appears to be a gradational change with no sharp break anywhere. Intruding the sediments, also, are masses of basic rock, most of which are linear bodies showing sill-like relationship to the complex.

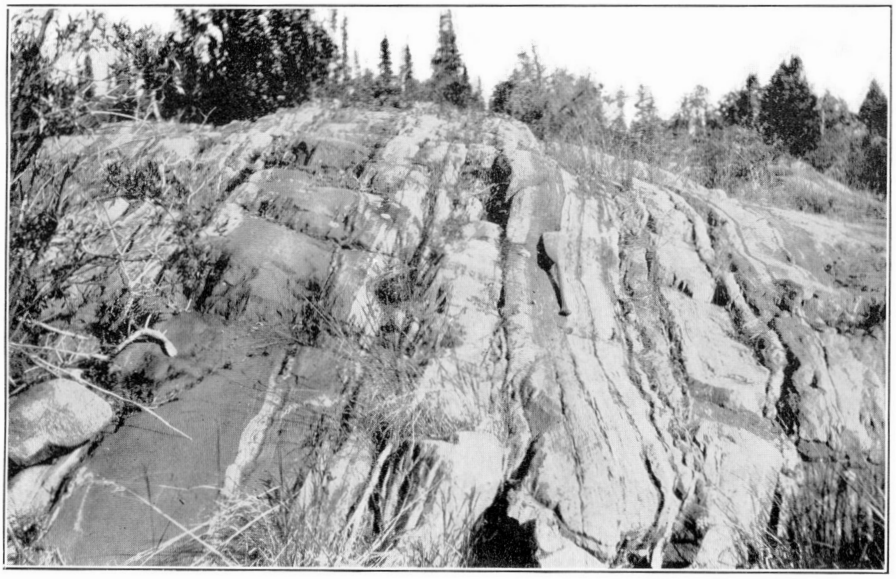
Locally along Grease river and farther northeast along the same strike at Chambeuil lake there are dark, dense rocks that appear to be volcanics interbedded with the sedimentary gneisses. Throughout Grease River region there are local rusty zones in the gneisses that contain weathered pyrite and a few small quartz veins. No mineralization of importance was seen, however.

GRANITE, GRANITE-GNEISS, ETC.

Much of the country north of lake Athabaska is underlain by a complex of granitoid gneisses. They vary in colour from grey to red, in texture from massive granitic rocks to well-banded gneisses, and in composition from granites to granodiorites. Associated with them are pegmatites and aplites and locally lamprophyres. As has already been mentioned in connexion with the description of the Tazin sediments there are wide areas underlain by gneisses of sedimentary origin. These are in places so injected and altered into granitoid rocks that they have been mapped as hybrids. The differentiation of the gneisses into paragneisses, hybrid gneisses, and orthogneisses, however, requires very detailed work, and the results would in many cases have to be expressed on a percentage basis.

The sedimentary gneisses are marked by a well-banded structure and individual bands can be traced for considerable distances. They commonly contain quartzitic bands and are often also marked by minerals suggestive of a sedimentary origin, such as garnet and graphite. Locally certain well-banded rocks of this type have developed a granitic texture and composition, and in hand specimen would be classed as granite. That they are interbedded with garnetiferous mica schists and are well banded themselves indicate, however, their sedimentary origin. The granitic composition and texture have been produced by recrystallization, with the probable addition of material from an adjacent intrusive magma.

Proof of the addition of material was furnished by the study of a thin section of garnetiferous gneiss. The garnets of this particular rock are broken into irregular-shaped fragments and in the intervening fractures and spaces a pale mica is extensively developed. Its intimate association with the garnet is strongly suggestive that it is an alteration product of



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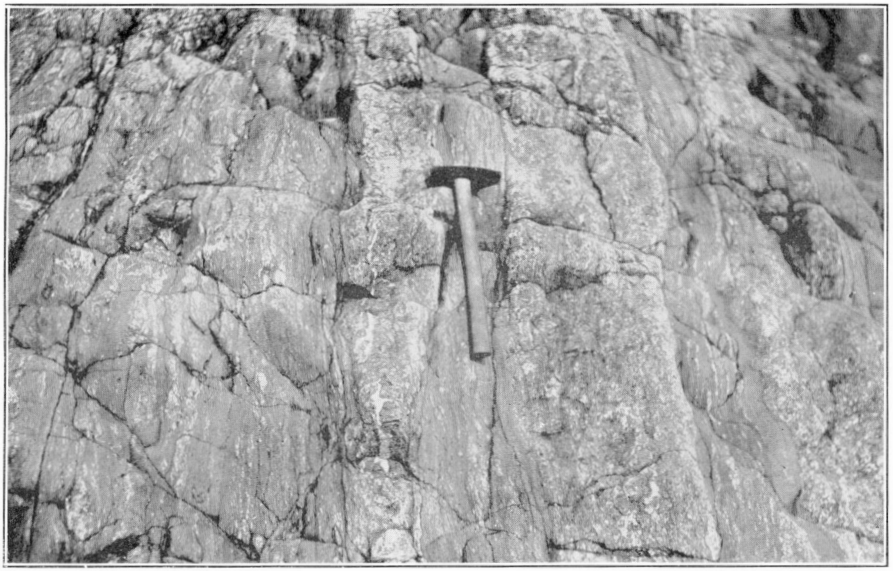
A. Banded Tazin sediments, Beaver River area.



B. Hybrid gneiss near Fond-du-Lac.

it. A qualitative analysis of the garnet shows that it contains iron and alumina with a small amount of calcium but no magnesium. It is accordingly of the andradite variety. Quartz and feldspar inclusions are present. A band of the mica separates some quartz inclusions from the surrounding garnet, a feature that strongly suggests that the mica is an alteration product of the latter. Since mica contains some potassium and garnet does not there must have been an addition of potassium to effect the change.

The hybrid rocks are commonly well banded as a result of the injection of igneous material along the bedding planes of the sediments. The injected material is granitic, pegmatitic, and aplitic. Granitic bands produced by injection can in many cases be differentiated from those produced by recrystallization by the fact that in places the injected material in addition to following the bedding planes locally crosscuts them. An example of the complexity of the gneisses is seen 9 miles west of Fond-du-Lac, where a small exposure shows four distinct rock types. The oldest is the regional gneiss dominantly red in colour and containing abundant garnets. It apparently represents a highly altered sediment. Intrusive into it is a grey granite-gneiss which cuts with sharp contacts across the structures of the first. Cutting both types is a pegmatite, and traversing all three is a lamprophyre. Some of the hybrid gneisses show folded structures much like sedimentary rocks. In places there are drag-folded and contorted structures that evidently originated at the time the composite character of the rock was produced.

Locally the gneisses present beaded and augen structures with rounded feldspars surrounded by crushed material. In places the augens appear to be formed from original feldspar phenocrysts developed in an igneous rock; in others they appear to be of secondary origin developed during the metamorphism of early sediments. Some of the banded gneisses consist of dense, reddish, and occasional greenish bands separated by coarser, red, pegmatitic zones. Many of the banded rocks evidently crystallized from a liquid state for they contain inclusions of older rocks some of which show absorption borders. The banding in the gneisses is due in places to the parallel arrangement of the constituent minerals and in others, as has already been indicated, to the alternation of bands of rock of slightly different composition. Certain zones simulate the banded appearance that is sometimes produced when two different slightly viscous liquids are mixed.

Numerous thin sections of massive and gneissic rocks from various parts of the region show a range in composition from granite to granodiorite. In most there is abundant quartz and the feldspars are chiefly orthoclase, microcline, and albite or oligoclase. In some, quartz is less abundant and the rock approaches a syenite. In others, the feldspar is oligoclase or andesine and the rock is a granodiorite. The ferromagnesian minerals are biotite and to a less extent hornblende and both are commonly altered to chlorite. Some of the granites carry muscovite. Iron oxide, apatite, and zircon are present as accessory minerals. A feature of some zones is the presence of hornblendic masses which may represent included greenstone or sedimentary rocks altered by the intrusive.

As has already been mentioned, the contacts of the granite-gneisses with the rocks of the Tazin group are not sharp. They are rather zones

of altered and injected rocks of hybrid origin. It would appear that the intrusion of these ancient granites combined a number of processes. There was a granitization of Tazin rocks due to solutions and mineralizers supplied by an underlying magma. There was the intimate injection of the older beds by magmatic material, giving combinations of hybrid and igneous masses in all proportions, and there may have been also an actual melting of older rocks resulting in the production of granitic rocks.

Pegmatites are common rocks in the gneissic complex. Some are white, but the majority are reddish. They occur as lenses in the gneiss and as dykes cutting across the foliation. The latter are of all sizes up to several hundred feet across. Some of the smaller dykes in places form a network and locally they are offset by faulting. The minerals of the dykes consist of quartz, orthoclase, microcline, and albite, with minor amounts of iron oxide, biotite, muscovite, garnet, titanite, and tourmaline as accessory minerals in various combinations. Graphic intergrowths of quartz and feldspar occur in some. One zone in which pegmatites are particularly abundant is near the south end of Bulyea lake immediately east of Schlater lake. One persistent dyke strikes northeast between two lakes lying 3 miles north of the head of Hayter bay.

Small lamprophyre dykes locally cut the gneisses. Many of them are less than a foot in width. The rocks are dense and black and commonly show flakes of black, lustrous mica. A thin section of a dyke 9 miles east of Fond-du-Lac consists largely of biotite with orthoclase, secondary chlorite, and apatite. An interesting feature of the rock is the absence of iron oxide which is usually present in this type of rock. The dykes are regarded as late differentiates of the granite.

BEAVERLODGE SERIES

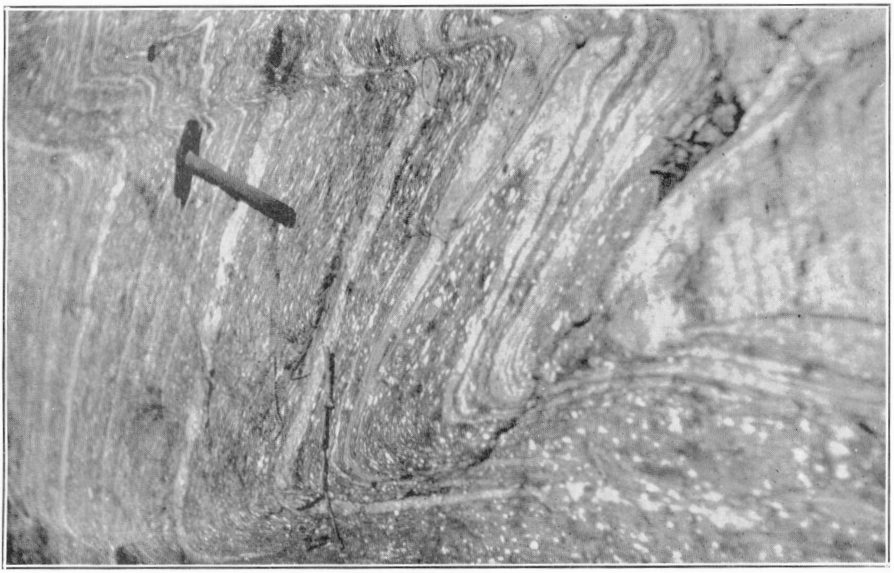
The Beaverlodge series occurs mainly in the region stretching southwest from Beaverlodge lake and Lodge bay to Elliot bay and on the islands south and southwest of Elliot bay. Other islands such as Beaverlodge and Bigfowl are composed of beds also belonging to it. The main zone continues eastward for a short distance from Beaverlodge lake and scattered outcrops occur to the north. In Black Bay region are also exposures of the series.

The dominant rock type is a quartzite that for the most part is white but that locally varies from reddish to deep red. In places, as on Bigfowl island, bedding planes are well marked by colour banding. In others, the rock is even textured and bedding planes cannot readily be determined. The quartzite is nearly everywhere jointed and breaks into small, angular blocks. Beaches of such material occur on many of the islands and along the shore of the mainland southwest of Lodge bay. In places the rock is feldspathic. Nearly everywhere it is cut by quartz veins and stringers.

The base of the series is well exposed along the northwest side of the ridge northeast of the head of Elliot bay. Here a conglomerate rests on a complex of ellipsoidal greenstone and granite-gneiss and grades upward into the white and reddish quartzite typical of the series. At one place the conglomerate has a thickness of 40 feet and forms the actual base of the series. At another place where the contact was observed the basal

A. Contorted schistose band in hybrid gneiss south of Train lake.

B. Folding in injection gneiss, Grease River region.



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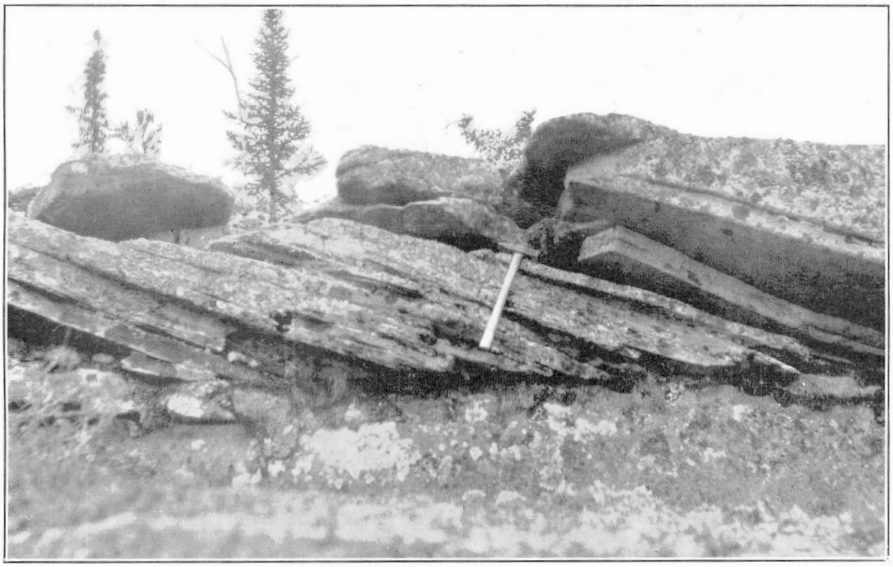
A. Contorted injection gneiss, Robillard river.



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B. Crossbedding in Athabaska sandstone, south of Fond-du-Lac river.

beds are quartzite with a thickness of 20 feet. These grade up into conglomerate which in turn changes over gradually into the typical quartzite. The boulders of the conglomerate are well rounded and are of all sizes up to over a foot in diameter. Though the rock has been sheared the boulders show no effects of the process, the matrix having taken up the movement. The majority of the boulders consist of reddish granite which is fresh and massive. Greenstone boulders are present and there are also numerous, rounded quartz pebbles. A feature of interest is a number of boulders of carbonate rock containing secondary silicate minerals, exactly like certain of the Tazin sediments exposed today in the Lodge Bay and Cornwall Bay regions. This suggests that the Tazin carbonate rocks were metamorphosed to their present condition and were undergoing erosion prior to the deposition of the Beaverlodge sediments. Immediately above the conglomerate zone the quartzose sediments are well bedded; in addition they show coarse crossbedding, in which the oblique fore-set beds are straight and are terminated sharply above and below by the regular bedding planes.

The unconformable relations between the quartzite and the sediments of the Tazin group can readily be observed at two places on the lake shore. One is at the extreme end of the point about a mile southwest of the camp of the Consolidated Mining and Smelting Company of Canada, Limited, on Lodge bay, where a fringe of white quartzite overlies highly tilted beds of older sediments. The divergence in dip and strike between the two series is not great, but it is apparent from the continuous exposures of the older sediments back of the point that the quartzite is not interbedded with them but overlies them unconformably.

The second locality is on the iron-stained point east of the mouth of Fish Hook bay. Here associated with the quartzites are red and bluish beds containing hematite in such considerable amounts that the beds may be termed as iron formation. The beds form a syncline pitching to the southwest and resting on older grey quartzites of the Tazin group. The two series are not seen in actual contact, but at one place they occur with diverging strikes within 40 feet of each other.

Surrounding Langley bay on the southeast side of Black bay is an area of sediments that has been mapped as Beaverlodge. The lower part consists of white quartzite striking northeast and dipping northwest off the granite-gneiss complex. The beds are intruded by amphibolite and cut by quartz veins and stringers. Above the quartzite is a zone of reddish arkose also striking northeast and with high dips to the northwest. Lithologically the arkose resembles phases of the Athabaska series, and may be of that age.

The most westerly exposure of the series in the area examined during the past season lies between Cypress river and Grover lake. Here the rocks consist of the usual white and reddish quartzites. About a mile north of Lobstick island they appear to rest unconformably on granitoid rocks. The beds here as in other areas are cut by numerous small quartz veins.

The Beaverlodge series is everywhere deformed and has dips up to 90 degrees. No reliable estimate of thickness could be made, but it is undoubtedly great, certainly to be measured in hundreds of feet. The strata are broken by faults. In the region between Elliot bay and Beaver-

lodge lake the distribution of the sediments suggests repetition by faulting. The series is extensively invaded by sheets of basic rock. West of Lodge bay a granite stock also intrudes it. Along the contact with this stock the quartzite is locally sheared to a white sericite schist.

In the table of formations the Beaverlodge series has been placed in the Proterozoic. The break between it and the pre-Beaverlodge complex upon which it rests is clearly one of major importance. On the other hand it may be that the Beaverlodge like the Tazin should be assigned to the Archæan, for the interval between its deposition and that of the Proterozoic Athabaska series is also one of the first rank. During this latter interval the Beaverlodge rocks were folded, faulted, intruded by both basic and acidic deep-seated rocks, were metamorphosed to their present condition, and underwent deep erosion. Just which of these two intervals should be selected as the time break most nearly corresponding to that dividing the Proterozoic from the Archæan is, therefore, a matter of opinion.

BASIC INTRUSIVES

Under this head is grouped a series of basic igneous rocks which intrude the sediments of the Beaverlodge series and all the rocks older than that series. Most of these intrusives have been more or less altered and some have been completely recrystallized. In places it is difficult to differentiate certain altered varieties from some of the dark, altered sediments of the Tazin group. It is possible that some of the basic rocks are post-Tazin but pre-Beaverlodge. Most of the intrusives are linear bodies intruded along the foliation planes of the gneisses or along the bedding planes of the Tazin and Beaverlodge sediments. The rocks are intruded by the younger granites of the region and are cut by quartz veins.

GABBRO

In the region between Elliot bay and Beaverlodge lake are several bands of dark igneous rocks that are apparently altered gabbros. They range in texture from fine-grained to coarse. On the freshly broken surface they are dark grey to black, but they commonly weather to a rusty brown. In thin section most of the rocks are seen to consist of hornblende and altered plagioclase feldspar. The hornblende is pleochroic in shades of green and bluish green and is apparently secondary. In some sections remains of diallage crystals can be recognized. Brown biotite and fibrous actinolite shreds are also present in some specimens. Iron oxide and apatite occur as accessory minerals. Many of the rocks have been altered to hornblende schists. Sections of them show secondary hornblende, epidote, zoisite, quartz, and sometimes carbonate.

In the region of Beaver river is a belt of basic rock intrusive into the gneissic complex. The belt runs northward for a distance of 10 miles to Kisiwak lakes and has an average width of about half a mile, widening at one place to over a mile. Smaller dykes of similar rock type also cut the sediments of the region. The rocks weather reddish, but on the fresh surface are black and often lustrous, due to the cleavage surfaces of the pyroxene and hornblende crystals. Some of the smaller dykes consist of dense rock; others are distinctly porphyritic with hornblende crystals over

half an inch across. In thin section the minerals are hornblende, augite, plagioclase, epidote, zoisite, chlorite, iron oxide, and apatite. The pyroxene is monoclinic and pale in colour. The hornblende is dark green and strongly pleochroic, absorption Y>Z>X. Much of it is altered to chlorite. The feldspar is andesine-labradorite.

NORITE

At the eastern end of lake Athabaska the gneissic complex is intruded by dark rocks carrying hypersthene. Most of the intrusions follow the structural planes of the paragneisses, but in places they show crosscutting relationships and contain inclusions near their borders. Some phases are difficult to distinguish in hand specimen from the dark sediments. In mapping, the zones shown as intrusive are merely those in which the norite predominates.

The main variety consists of labradorite, hypersthene, and iron oxide. Pyrite is present in some varieties and one dyke of dark grey rock about 9 miles east of Fond-du-Lac proved to be a quartz-norite. In thin section it is seen to consist of plagioclase, quartz, hypersthene, biotite, hornblende, iron ore, apatite, zircon, garnet, and tourmaline. An interesting feature in connexion with these norite rocks is the occurrence of complementary varieties, some dykes consisting of labradorite with only minor amounts of pyroxene and iron oxide and others being made up almost completely of orthorhombic pyroxenes, hypersthene chiefly, but enstatite also in considerable amounts.

AMPHIBOLITE

Oldman island, situated about 13 miles east of Goldfields, is made up of quartzite and a dense intrusive rock consisting largely of hornblende. The intrusive continues northeast along the east side of Reed bay. The belt has a width of about a mile and a length on the mainland of about 5½ miles. The rock is slightly schistose. On the glaciated surface it is greyish black, but where freshly broken the hornblende cleavage surfaces give it a bright appearance. The rock is fine-grained, individual crystals of hornblende rarely exceeding a millimetre in length. One section of the rock studied consists of brownish hornblende, labradorite feldspar, and a little iron oxide. In another section the hornblende is green, probably secondary. Additional minerals include labradorite, quartz, iron ore, and apatite. The rock probably resulted from the dynamic metamorphism of a gabbro or diorite.

SERPENTINE

On the east side of Cornwall bay dark basic rocks are in places serpentinized. These rocks intrude sediments of the Tazin group, but since they were not found cutting Beaverlodge sediments it is not known whether their age is pre-Beaverlodge or post-Beaverlodge. One section of a basic rock in this area shows an ophitic texture with laths of labradorite penetrating ferromagnesian minerals which are now altered to secondary hornblende and chlorite. Sections of the serpentinized rock show serpentine, small veinlets of asbestos—some of which send branches into the surrounding serpentine—and magnetite.

GRANITE

In the region between Elliot bay and Mackintosh bay occur a number of masses of granite which intrude all the rocks up to and including the sediments of the Beaverlodge series and the younger basic rocks. The granite in these masses shows considerable variation in texture and appearance, so that on lithological grounds it is difficult to say whether other masses of granite in the region should be correlated with it or not. To make a definite correlation it is necessary to show that the intrusive is younger than sediments of Beaverlodge age or cuts basic rocks that intrude such sediments. That older granite very similar in appearance to phases of these intrusives exists is shown by the presence of large rounded boulders of such rock in the conglomerates forming the base of the Beaverlodge series.

The main mass lying between Elliot bay and Beaverlodge lake has a length of 5 miles and a greatest width of 2½ miles. It runs in a northeast direction, in the main parallel to the strike of the sediments on either side. In its northeastern part a few of the higher hills are capped by masses of basic rock which are apparently roof pendants. The granite mass is surrounded chiefly by quartzite which it intrudes, but to the north it is overlain unconformably by conglomerate and arkose of the Athabaska series.

The rock varies in colour from almost white to grey and in places to pink and reddish. As a rule it is even grained, but locally crystals of feldspar larger than the average grain of the rock give it a porphyritic texture. At the contact with the basic igneous rocks the granite is fine-grained, in places showing chilled contacts. The basic rock at the contacts is locally sheared and shot through by small granitic stringers. In thin section the white granite is seen to consist of feldspar, quartz, and a little white mica. The feldspars are orthoclase, microcline, and albite or albite-oligioclase. A darker phase of the granite near the contact with one of the masses of basic rock contains biotite. The granite is locally cut by small veins and stringers of quartz.

A number of smaller masses of similar grey and reddish granite occur between Lodge bay and Mackintosh bay and it is on these that the important mineral claims of the area have been staked. South of Mackintosh bay is a stock about 3 miles in length and averaging about 2 miles in width intruding sediments of the Tazin group. Along the south and east margins the strike of the enclosing sediments parallels the contact with the intrusive. On the north the granite in places shows crosscutting relations to the older rocks. Numerous small masses of the sediments in the granite represent inclusions or roof pendants. In thin section the rock is seen to consist of orthoclase, quartz, microcline, albite, and biotite. In some sections the only ferromagnesian mineral is chlorite, apparently secondary after biotite.

Moose island is composed largely of granite and with the adjacent islands forms another stock separated from the Mackintosh Bay mass by a narrow synclinal zone of older sediments. Cameron island and the other smaller islands immediately to the east of it make up still another stock. The channel to the north of it lies along the contact of the intrusive with

the older, partly granitized sediments. The granite is a red, coarse-grained, biotitic variety, commonly massive, with only locally a suggestion of gneissoid texture. All these masses may be the upper portions or offshoots of a larger batholithic mass below.

Other masses of granite in the region are undoubtedly related to this same period of intrusion. Underlying the quartzite that forms the ridge along the southeast side of Elliot bay is a zone of granite-gneiss which is cut by dykes of fresh, massive, red granite. Similar dykes intrude the granitoid complex northwest of Black bay and Crackingstone river. The granite mass that lies 3 miles northwest of Goldfields and just east of Beaverlodge lake may also be partly or wholly of this age.

Farther east are areas of massive granite that may likewise be post-Beaverlodge. Since, however, no Beaverlodge sediments by means of which they might be dated occur, they have been mapped with the older granite-gneisses. One such area occurs on Fontaine lake. The rock is a massive, pink to red, fine- to medium-grained granite which intrudes gneissic sediments. It is cut locally by numerous pegmatite dykes and at one place by a dark dyke, probably a lamprophyre. Similar granite occurs on Bulyea river north of Fond-du-Lac, on Bulyea lake, and at numerous other localities.

ATHABASKA SERIES

The Athabaska series was first described by R. G. McConnell who in 1888 found along the south shore of lake Athabaska outcrops of a granular siliceous formation to which he gave the name Athabaska sandstone. In 1892 D. B. Dowling found that the formation extends along the entire south side of the lake and forms an escarpment to the south. Outcrops were traced as far eastward as Wollaston lake, but the southern limit of the formation was not determined. This region south and east of lake Athabaska is the type area.

In 1893 and 1894 J. B. Tyrrell found in Dubawnt Lake region many small areas of a red, altered, feldspathic sandstone or arkose which he correlated with the Athabaska sandstone. In places it passes into a coarse conglomerate. With the sediments are associated dykes and masses of both acid and basic eruptives, diabases, and quartz porphyries.

The series outcrops on a number of islands in lake Athabaska immediately east of Black bay and at several places on the north shore of the lake. North of the lake are a number of other areas underlain by conglomerates and arkoses. Some of these have high dips in contrast with the flat or low dips in the type area, but on the basis of lithology they have been correlated with the Athabaska sandstone. The largest of these areas surrounds Beaverlodge lake.

In the type area south of lake Athabaska the dominant rock type is a sandstone consisting almost entirely of quartz. It varies in colour from white to buff and reddish. The grains are well rounded and in places the rock is hard and well cemented; in others it is weak and friable. The texture locally is uniform; in other places larger rounded grains and pebbles of quartz up to several inches in diameter are scattered irregularly throughout the sandstone.

North of lake Athabaska the strata consist largely of buff to reddish arkoses and conglomerates. The conglomerate contains boulders of all the older sedimentary and intrusive rocks. As a rule the boulders are well rounded and are all sizes up to 3 feet in length. Coarse beds are interbedded with finer grained ones and the conglomerate bands commonly show lenses of arkose. A little red shale locally is associated with the coarser clastic material.

Bedding is commonly well marked throughout the series, the beds varying in thickness from less than an inch to a couple of feet. In many places it is marked by colour banding, in other places by bands of different degrees of coarseness. In some places it is difficult to determine the bedding planes. In a bay on the east side of Beaverlodge lake a zone of bright red arkose is so even textured and massive as to closely resemble a granite.

The series shows a great deal of crossbedding. South of lake Athabaska the common type observed consists of diagonal layers banded above and below by horizontal beds. A similar type is to be seen on Beaverlodge lake. Locally a more irregular type is presented showing curved foreset beds irregularly truncated by other curved beds above.

Ripple-markings are fairly common and those observed were of the symmetrical type. Sun-cracks were observed in some fine-grained beds northeast of Beaverlodge lake. The outlines were polygonal, with an average diameter of about 4 inches, and the filling of sandstone standing up as prominent ridges. Rain-prints have been recorded from only one locality, south of Fond-du-Lac river. In the same region a number of round impressions filled with clay were found in the sandstone. These clay-galls vary in size from 1 to 2 inches in diameter.

Jointing is well marked in many places in the series, causing the rock to break into huge, angular blocks. South of Fond-du-Lac river a set of east and west trending joints keep the face of the escarpment vertical, and normal to the direction large crevasses mark a second set. In places large blocks outlined by thin joints stand out as vertical pillars in front of the escarpment.

In the type area south of lake Athabaska the sandstone lies horizontally. Some of the patches on the north shore and on the islands are also either flat-lying or have low dips that are probably depositional. In the region surrounding Beaverlodge lake, however, a series of beds that are correlated with the series are thrown into a syncline that pitches to the northeast. Dips on the limbs average around 35 degrees, but locally they reach as high as 65 degrees. Owing to the fact that the waters of Beaverlodge and other lakes conceal much of the region underlain by these sediments continuous sections are difficult to obtain and estimates of thicknesses are as a result only very approximate. There is no doubt, however, that a very considerable thickness of conglomerate and arkose is represented in this syncline, probably about 1½ miles.

In places the series is faulted, and the slickensided surfaces have been preserved. A few quartz veins and stringers also cut the beds in Beaverlodge Lake region. The large island at the southwest end of the lake is composed of conglomerate with layers and lenses of sandstone and arkose. At one place the rock over a width of 4 feet is fractured and mineralized

with quartz, chiefly white but also showing a little of the amethystine variety. The veins form a network and in their immediate vicinity the rock is more firmly cemented than it is over the rest of the island. On the shore of the mainland about a mile southeast of this island is a much larger showing of quartz which can be traced in a southwest direction for 300 feet and over a width of 50 feet. It forms a stockwork with in places solid quartz over widths of 14 feet. The quartz is chiefly white, but a little amethystine is also present. It appears to contain no other mineral. In places the grey arkose of the shore contains crystals and small masses of pyrite. This mineralization may be related to the volcanic activity that accompanied the deposition of these beds and that will be referred to later, or it may be later, possibly Palæozoic.

The relations of the Athabaska series to the other formations are clear and distinct. Its conglomerates contain boulders of granites, gneisses, quartz, basic intrusions, quartzite, iron formation, and various types of altered sedimentary and volcanic rocks. At a number of places the contact at the base of the series is exposed. On the mainland about a mile east of the McInnes Products Corporation camp, a flat-lying conglomerate belonging to the series rests on an uneven surface of Beaverlodge quartzite dipping at angles averaging 50 degrees. Other contacts between these two formations are to be seen on the islands in this region and on at least two islands in Beaverlodge lake. An interesting feature seen in at least two places is the presence of sandstone and conglomerate dykes of Athabaska age cutting quartzites of the Beaverlodge series. One on the top of the ridge behind the McInnes fish camp has a width up to 3 inches and a length of 10 feet. The second occurrence is on the top of the ridge between the head of Elliot bay and the main body of the lake. There a sandstone-conglomerate dyke with a width up to 7 inches can be traced for 50 feet. These so-called dykes clearly represent fractures in the quartzite floor upon which the Athabaska beds were here deposited.

The relation between the Athabaska beds and the granite that cuts the Beaverlodge series can be seen on the south side of Beaverlodge lake about 1½ miles west of Beaverlodge portage. On the shore of the lake the granite passes from fresh, massive rock to weathered material consisting of broken up granite with quartz fragments, clearly an old regolith. This material has a thickness of about 15 feet and above it bedded Athabaska arkose with conglomerate layers begins.

In Beaverlodge Lake area volcanic flows are interbedded with the sediments. They are best exposed on Martin lake, which lies along the axis of the Beaverlodge syncline. There are five bands of volcanics swinging around the southern part of the lake and pinching out to the north. The rocks are dense, dark basalts which are commonly amygdaloidal The amygdules consist largely of calcite and vary in size up to an inch in diameter. In thin section the rock is seen to be very fine-grained, with small labradorite crystals and pyroxene that has largely altered to chlorite. A thin section across one part of an amygdule shows a well-banded structure. The outer layer consists of silica containing much fresh chlorite. Bordering this band is a zone consisting of chlorite which, under crossed nicols, is seen to consist of radiating bundles of fibres. This zone is sharply marked off from calcite which fills the remainder of the space.

Diabase dykes belonging to the same period of igneous activity are found here and there throughout the region. They are usually small and cut across the structure of the older rocks. In hand specimen they are fine-grained and black and show sharp contacts against the intruded rock. The borders as a rule show chilled phases with a dense, slate-lake appearance.

The Athabaska series was placed by McConnell in the Cambrian, but it is now generally regarded as more probably of late Precambrian age. Nowhere has it yielded any fossils. That it is older than the Ordovician is suggested by the fact that the Ordovician limestones that cap the Precambrian rocks along the west side of Hudson bay and form outliers to the west have nowhere been found to be cut by diabase dykes as have its strata. The lithological similarities of the series to the late Precambrian sandstones of Lake Superior region, the association of its sediments with basic volcanics and intrusives as in that region, suggest that it too should most probably be assigned to the Keweenawan.

The lithology and structural features displayed by the series suggest a continental rather than a marine origin for it. It is probable that it was deposited in broad, subsiding basins between mountains of considerable relief under conditions of a semi-arid climate in which erosion and disintegration proceeded rapidly. Late Precambrian time in North America was apparently marked by wide areal extent and conditions favourable for the accumulation of subaerial deposits.

STRUCTURE

Over the greater part of the region under discussion the main structural features are along northeast-southwest lines. This is particularly striking in the eastern section north of Stony rapids which is underlain by the early sedimentary gneissic complex. In certain areas, however, other trends are to be noted as, for example, in Beaver River and Tsalwor Lake regions where the strikes are northwest. It would appear, however, that in such cases the structural lines swing around large intrusive masses of granite and granite-gneiss. The rocks of the chief areas underlain by Beaverlodge sediments also strike northeast. This is particularly well shown in the region stretching eastward from Johnston island to Lodge bay, in Langley Bay area, and in the small syncline east of Fish Hook bay. Even the Athabaska sediments where folded, as in the area around Beaverlodge lake, follow the same general trend.

The main faults and shear zones appear also to follow northeast lines. As has already been mentioned the repetition of quartzite bands northeast of Elliot bay suggests faulting accompanying folding. This zone of weakness was apparently the channel of access for an intrusive mass of granite. The faults and zones of brecciation in the Athabaska rocks also, for the most part at least, follow northeast lines. It would appear that at widely separated intervals in the Precambrian thrusts acted along northwest-southeast lines producing folding and faulting.

The metamorphosed character of the rocks and the lack of distinctive horizons render the working out of detailed structure in the Tazin and Beaverlodge rocks most difficult. To properly elucidate all the structures much more detailed work would be necessary than was found possible during the carrying out of the past season's mapping.

CHAPTER IV

ECONOMIC GEOLOGY

Lake Athabaska region is known to carry mineralization of a number of types. The chief interest, however, lies in the possibility of developing workable deposits of gold.

GOLD

The centre of activity at present is Goldfields where extensive development work is being carried out on a number of properties surrounding Lodge bay. The deposits occur in the granite, which intrudes all the rocks up to and including the sediments of the Beaverlodge series, and the basic rocks which also intrude that group. The granite is commonly fresh and massive, but in places shows a gneissoid structure. It varies in colour from grey to red and in places this transition can be traced in a single slab. In texture the rock varies from fine-grained to coarse and locally the presence of feldspar crystals larger than the average grain of the rock gives it a porphyritic appearance. The rock in many places is cut by numerous small quartz veins, few of which, however, exceed 6 inches in width, and in addition small quartz stringers are commonly abundant, most of which run at angles to these veins. Free gold occurs in the quartz of the veins and stringers and in places visible gold has been found in the granite itself away from the vein quartz. Assays also show its presence in the granite. Sulphides, particularly galena, in the quartz stringers, usually indicate gold values. The granite in places carries disseminated sulphides, chiefly pyrite, and where such minerals are present the gold assays are commonly much higher than where none occurs. Tests were made at the University of Alberta on a shipment of 100 pounds of pink granite ore from the Hazel group owned by the North West Minerals, Limited. The results supplied through the courtesy of Mr. C. W. McKee, General Manager of that company, indicate: (1) that the greater part of the gold occurs as particles finer than 200 mesh (0·074 mm.); and (2) that most of the gold of the shipment, probably at least 90 per cent of it, is directly associated with the sulphides and can be recovered by fine grinding and flotation.

The granite forms a number of stock-like masses near the shore of the lake. One begins 2½ miles northeast of the head of Elliot bay and runs to Beaverlodge lake, a distance of 5 miles. It has a greatest width of about 1½ miles. A considerable amount of staking has been done on this mass, but the gold values over it have as yet been found to be low. On the northwestern side of Lodge bay a sill-like mass of the red granite is the ore-bearing zone which is being developed by the Consolidated Mining and Smelting Company of Canada, Limited. To the east, on the opposite side of the bay, a peninsula 2 miles long and less than a mile wide, consisting of granite intrusive into sedimentary and basic igneous rocks, contains the claims of Athona, Greenlee, Athabaska Portal, and parts of Murmac and Athabaska Beaverlodge holdings. North of Fish Hook bay a mass, three-quarters of a mile long and between one-quarter and one-half

mile wide, is occupied by the Bearcat group. Northwest of Moose island is a stock 3 miles long and 2 miles wide, known as the Mackintosh Bay mass. Most of the holdings of North West Minerals lie in it. It would appear from what is known at present that the higher values occur in the smaller masses. A possible explanation of this may be that these are all cupolas forming the upward prolongations of a granite batholith whose upper surface is irregular. During the cooling of the magma, ore-bearing solutions ascended to these cupolas where they were trapped. Movements after the crystallization of the border zone resulted in fracturing and afforded an opportunity for further mineralization. Where these cupolas have been merely uncovered is probably the most favourable zone to look for mineralization; where they have been dissected and their upper parts removed by erosion, the best ore-bearing zone has probably disappeared too. If this interpretation be correct the favourable places to search for ore are within and around the borders of small masses of this gold-bearing granite.

CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA, LIMITED

The chief holdings of this company in Lake Athabaska region comprise what is known as the Box property. It was the discovery of gold here by two prospectors, Box and Nyman, which led to the rush to take up claims in the region. Seventeen claims, Vic 1 to Vic 17, covering about 900 acres, were staked by the company in August 1934. They lie along the northwest side of the arm of Lodge bay leading to Goldfields. Little surface work was done, but an extensive diamond drill program was carried out and underground work is at present being prosecuted.

The rocks on the property comprise sediments belonging to the Tazin and Beaverlodge series, gabbro intrusions into both of these, and younger granite. The ore zone is a sill-like belt of grey to reddish granite striking northeast intruded into the older sediments. The granite contains numerous quartz stringers and in places inclusions of dark schist. Near the contact with these the grey granite commonly becomes reddish or even very red. Pyrite and to a less extent chalcopyrite are present in the granite.

Free gold occurs in the quartz stringers and in the granite itself. The quartz stringers in places carry galena and sphalerite. Gold is commonly associated with these sulphides. A little marmatite was found at shaft No. 2 and in places tourmaline occurs in the quartz.

Development work is progressing from two shafts. The No. 1, which is a two-compartment shaft, was begun in July 1935, near the southeast shore of Vic lake. It is an incline at an angle of 42 degrees to the southeast following the contact of quartzite below and granite above. The dip of the sediments and the contact is from 37 degrees to 45 degrees. At the time of the writer's visit in September the incline was down to the 100-foot level and drifting was proceeding on that level both to the northeast and to the southwest. In addition a crosscut to the southeast had been driven a distance of 70 feet. The direction of the drift is north 60 degrees east. In the working numerous small quartz veins were being encountered, many of which strike south 15 degrees east with dips of 50 to 70 degrees west. The main gold values, however, appear to be in the granite itself.

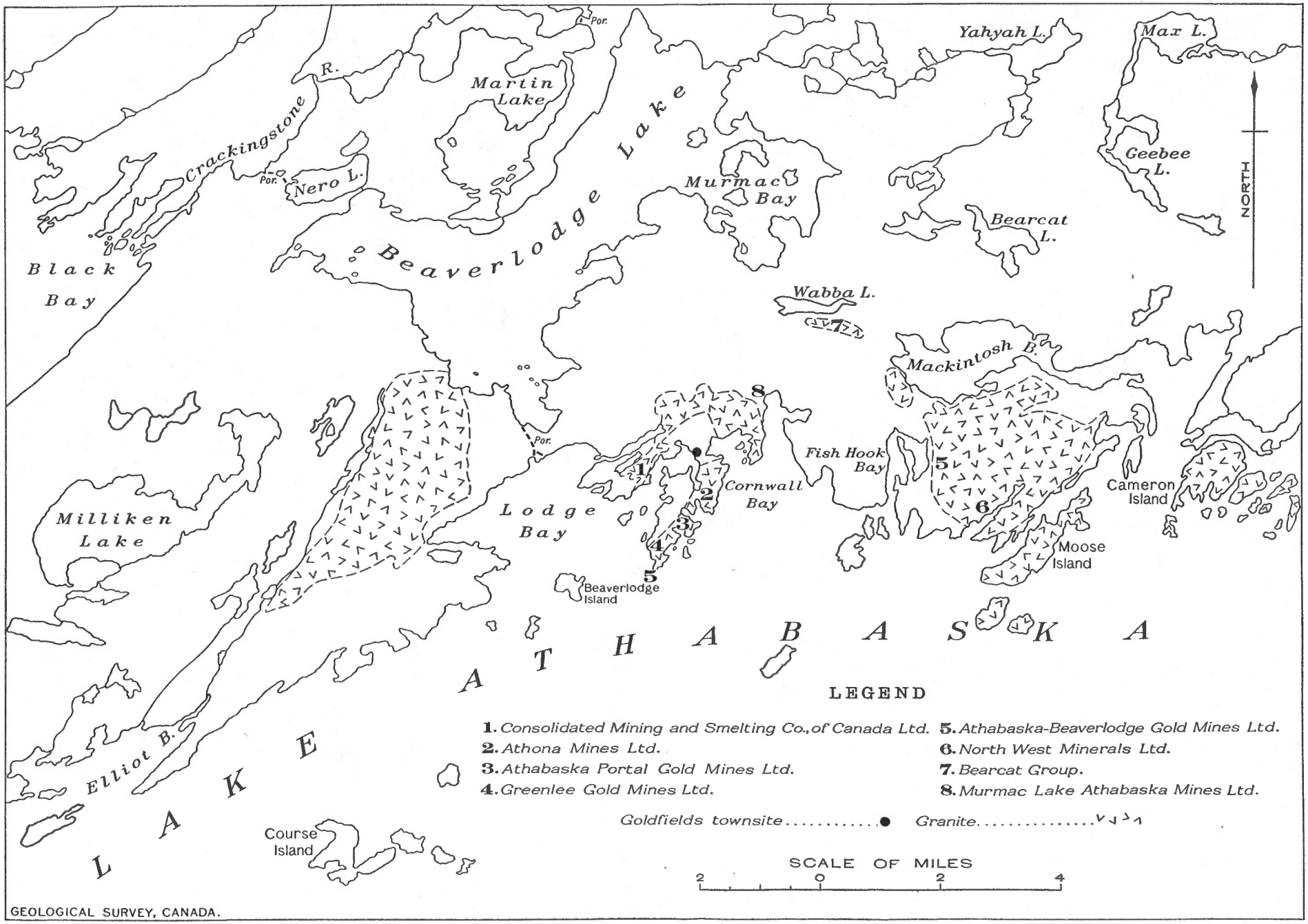


Figure 2. Showing principal mineral properties.

No. 2 shaft was started in September. It is a three-compartment shaft located 1,270 feet northeast of No. 1. It, too, is an incline at an angle of 45 degrees to the southeast. It was begun in granite 30 feet southeast from its contact with quartzite. Like No. 1 it will, therefore, closely follow the foot-wall of the granite.

The underground work will furnish large bulk samples over a wide zone. The company at present is depending on numerous assays to determine the average run of the zone being thus explored. The future of the property depends upon the average gold content of the zone.

ATHONA MINES, LIMITED

The property of Athona Mines is situated on the peninsula between Lodge bay and the main lake. The camp is about a mile south of Goldfields townsite. The company was formerly Great Bear Lake Mines, Limited.

The property is known as the Lucky Willy group. The Willy claims, of which there are two, were staked in September 1934; the Lucky group, consisting of eleven claims and three fractions, was staked around the Willy claims in the autumn of 1934 and the spring of 1935.

The rocks in the property are chiefly granite. A few masses of black hornblende schist apparently represent roof pendants of altered gabbro rock. The granite varies from grey to red and locally is gneissoid. In one place it contains an inclusion of quartzite about 70 feet long and 30 feet wide. Near the shore on the east side of the property a basalt dyke strikes northeast cutting the granite. It has vertical walls, a length of 540 feet, and varies in width up to 5 feet. It cuts quartz veins as well as the granite and is clearly related to the basic igneous activity that accompanied the deposition of the Athabaska sediments.

A certain amount of trenching was done in 1934, but the first real work on the property was begun in March 1935. Diamond drilling commenced March 31. A single drill was used up to July 30 and from that date two were employed until August 30 when drilling ceased. In all thirty-two holes were put down, with a total length of 10,750 feet. Surface work was begun about the middle of May and for the most part was completed by the end of July. Present work consists of sinking a three-compartment shaft, from which horizontal work both drifting and cross-cutting will be carried out on the 125-foot and 225-foot levels. A 15-ton mill is being installed which will serve for bulk sampling.

There are two ore zones, known respectively as the Main Vein system and the East Vein system. The Main Vein system has been opened up on the surface by eight trenches spaced at 50-foot intervals. The trenches vary in length from 70 to 120 feet and run north 82 degrees west. They are in grey granite varying in places over into pink. The rock is locally sheared. Cutting the granite are a series of parallel veins trending north 13 degrees east. They are five main veins varying in width up to 7½ inches. The most easterly is the longest and can be traced for 400 feet. Small quartz stringers branch off from the veins. These usually are less than an inch in width and are rather irregular in direction. In some places the main veins are offset by faulting, but never more than a foot.

The ore zone lies along a contact of hornblende schist and granite, the former occupying the top of a ridge to the west of the contact. The contact dips to the west at an angle of about 45 degrees at the surface, flattening as it goes down. The trenches run right up to the contact. At the contact the basic rock is fine-grained and contains rounded quartz masses. Away from the contact it is fresh and coarse-grained. The granite is locally somewhat finer grained at the contact, but not appreciably so. It sends small, red granite stringers across into the hornblende schist and the latter rock is also cut by quartz stringers.

The granite of the ore zone contains pyrite, but only rarely is this mineral found in the quartz stringers and veins. The free gold is chiefly in the quartz, usually along the sides of the veins. In places the quartz also contains galena and black sphalerite and in some cases chalcopyrite. A little molybdenite occurs in the granite and along slip planes in the older basic rock. In one specimen visible gold was found in red orthoclase of the granite.

To test this zone at depth twenty-one diamond drill holes were put down. Under each of the eight trenches a hole was drilled to the west at an angle of 45 degrees. Two extra holes were put down in the trenched portion and south of this eleven other holes, also to the west. The angles for these were 45, 50, and 60 degrees. The longest hole was 580 feet and the average length 322 feet. The total length of the schist-granite contact explored by drilling was 1,500 feet. The average width of the zone carrying values at the surface is about 80 feet.

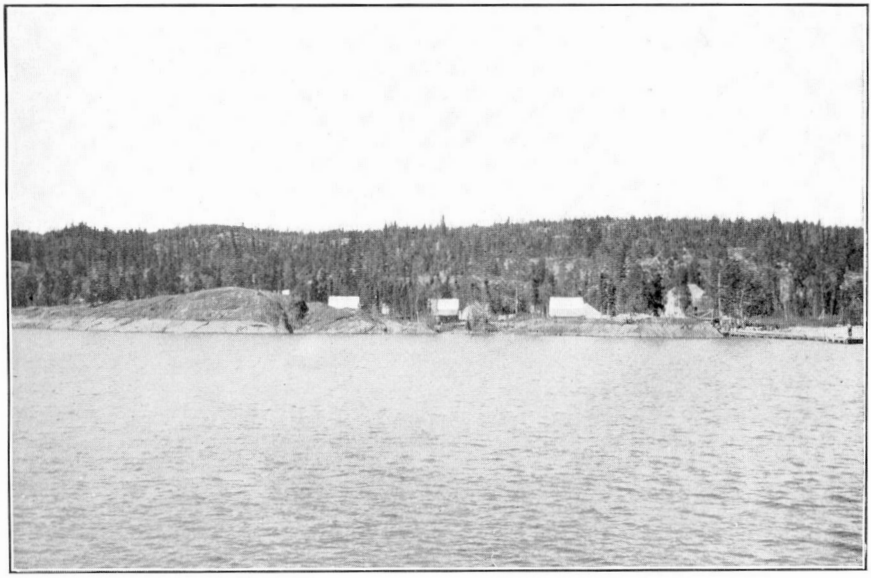
The East Vein system also lies along a granite-gabbro contact. Here the gabbro mass lies to the east and most of it is under the lake. The contact dips at an angle of 55 degrees to the southwest with the granite overlying the gabbro. Six holes, with an average length each of 395 feet, were put down at angles of 45 or 55 degrees to the east, starting in the granite. Values occur at places along the zone for a distance of 1,500 feet.

Altogether over 1,000 feet of sampling was carried out during the 1935 operations on the two ore zones. On both the values vary greatly. On the main zone they range from very high to almost nothing. Some sludge assays gave as high as 10 to 12 ounces. Bulk sampling by means of the mill will determine whether this zone as a whole averages sufficiently high to mine at a profit.

MURMAC LAKE, ATHABASKA MINES, LIMITED

This company holds fifteen claims and eleven fractions, or approximately 700 acres, at the head of Cornwall bay. The property adjoins that of the Consolidated Mining and Smelting Company on the west and that of Athona Mines on the southwest. The townsite of Goldfields is on Murmac claim No. 12. The claims were staked in August 1934 by two prospectors working for James E. Day, the present president of the company.

The rocks on the property consist of altered sediments of the Tazin series, and granitic and basic intrusives. The sediments include limestone partly altered to secondary silicate rock, quartzite, and mica schists. The basic intrusives include gabbro and altered forms which are now horn-



A. Camp of Consolidated Mining and Smelting Company of Canada, Limited, June 1935.

B. Camp of Athona Mines, Limited, September 1935.

blende schist. Acidic intrusives include grey gneiss, grey granite, and red granite. It is possible that both the pre-Beaverlodge granite and the younger granite are represented.

The first discovery of free gold in the property was made on claim No. 2 on June 27 in a quartz vein in grey granite. The vein has a width of about 4 inches and has been traced in a northerly direction for a distance of 200 feet. It dips 75 degrees to the east and pinches and swells. The vein parallels the contact of the granite with a basic inclusion. In addition to this vein there are a series of others parallel to it.

Discovery No. 2 was on the southwest corner of Murmac fraction No. 6 near the line between it and the property of the Consolidated Mining and Smelting Company. This is a small vein in grey granite near the contact of the latter with altered gabbro. The vein strikes about north and south and shows visible gold.

Discovery No. 3 is a series of parallel quartz stringers 250 feet north of No. 2 on Fraction 6. Free gold was found in several of these stringers.

A considerable area of the property still remains to be prospected and in the spring this work will be continued.

NORTH WEST MINERALS, LIMITED

The North West Minerals, Limited, hold seven groups of claims on lake Athabaska. The Hazel group consisting of eleven claims, the Juca eleven claims, the Max four claims, and the Bear two claims, were all staked in September 1934. The Sam group consisting of four claims, the Harris of three claims, and the G.I.M. fraction of two claims, were staked in January 1935.

Field operations were begun in April 1935, and up to date work has been concentrated on the Hazel group, lying about three-quarters of a mile north of the southwest end of Moose island. These claims lie along the southwest border of the Mackintosh Bay mass of biotite granite near its contact with quartzite of the Tazin group. Visible gold was discovered during trenching operations at three places. The first of these was made in what is known as the centre zone, which consists of a fractured zone in the red and grey granite containing numerous cross and parallel quartz stringers. Pyrite with some pyrrhotite and galena is finely disseminated throughout the rock mass. The mineralization is much heavier in and close to the quartz stringers. Visible gold has been found as fine flakes and as coarse kernels both in the quartz and adjacent granitic rock. An interesting feature is that the gold appears to be concentrated in the many small shearing and slip planes which, like the fracturing, occur with a great variety of strikes and dips. In September one trench showed visible gold across a width of 14 feet.

The second discovery was made in a 12-inch quartz stringer in the south zone 240 feet from the above discovery. This parallels the contact zone and like it is in a fractured belt in the granite, containing a number of parallel and cross quartz stringers varying in width up to 12 inches. The mineralization is similar except for the fact that no galena has yet been found.

The third discovery was made in what is known as the galena vein about 1,000 feet west of the centre zone. It is a well-defined quartz vein,

varying in width from 12 to 30 inches, and has been opened up by trenching for a length of 230 feet. The country rock is red porphyritic granite. A number of smaller quartz stringers strike obliquely to the main vein. The vein is marked by the presence of flakes of galena.

A considerable amount of trenching has also been done on a fourth area known as the contact zone. Here numerous quartz stringers occur in the red granite. The fracturing seems to be more pronounced and the mineralization more concentrated as the contact of the granite with the quartzite and schists is approached. Pyrite and small flakes of galena are present.

Enough surface trenching was carried out during the past season for the laying out of a program of diamond drilling, and holes were planned to intersect at depth the gold-bearing zones opened up at the surface.

In view of the finds made in the Hazel group the 1935 development work was concentrated on these claims, just enough work being carried out on the remaining groups to meet assessment work requirements. The Max, the Juca, and the Sam groups lie south of Mackintosh bay, along the north border of the same granite stock in which the Hazel lies. On claim Juca No. 3 a zone of quartz stringers was found in grey granite. Small amounts of pyrite, chalcopyrite, and galena were found, but no visible gold. The Harris group lies west of the west end of Mackintosh bay and the Bear group along the east side of Cornwall bay. The G.I.M. fraction group lies between the holdings of Murmac and Athabaska Portal.

ATHABASKA PORTAL GOLD MINES, LIMITED

The property of this company consists of the Melma group of six claims, staked August 17, 1934. It changed hands a number of times and was acquired by the present owners in February 1935. The property is located immediately west of that of Athona Mines, Limited. Work during the summer consisted in surface prospecting, trenching, and in putting up camps. Diamond drilling was begun in October.

The rocks on the property consist of old sediments, in places partly or wholly granitized, intrusive gabbro, and young granite. The latter varies from grey to red and is the ore carrier.

On claim No. 5 visible gold was found over a width of 40 feet and a length of 300 feet. The zone is of red granite and is situated on the north side of the bay in front of the camp not far from the Athona property. The granite here dips under a mass of hornblende schist which caps a hill. The granite is cut by stringers of quartz. Pyrite occurs in the quartz and in the granite itself; galena is present in the quartz which locally also carries a few needles of arsenopyrite and a little chalcopyrite. Gold has been found both in the quartz stringers and in the granite itself.

On claim No. 3 surface work has been done in red granite. The rock is cut by quartz stringers, but only low values had been obtained here in September.

On claim No. 6 trenching has been done near the camp and on the shore of the bay on the east side of the peninsula. Encouraging gold values are reported to have been encountered.

On claim No. 4 a vein carrying heavy galena mineralization has been traced for a distance of 400 feet. High values in silver and commercial values in gold are reported to have been indicated in samples taken from it.

GREENLEE GOLD MINES, LIMITED

The main holdings of this company (formerly Lee-Greenlaw) consist of the Star group of fourteen claims and fractions situated immediately south of the Athabaska Portal property. The claims were staked by J. C. Byrne in February 1935.

The rocks of the property consist of altered sediments, basic igneous rock, and granite. Most of the work done as yet is towards the south margin of the property near the end of the peninsula on which the claims are located. In September 1935, there had been opened up seven large trenches averaging about 100 feet in length. They lie in granite near its contact with a mass of hornblende schist. In No. 1 trench, excavated in the spring at low water and flooded during the high water of midsummer, gold was observed over a width of 22 feet. Trench No. 2 shows gold over a length of 41 feet. No. 3 has visible gold over a width of 30 feet. Altogether a zone some 250 feet long has been trenched over a width of about 88 feet. The granite of this zone has been shattered and is cut by quartz veins. These appear to have no regularity, in places forming a stockwork. The largest vein has a width of about 10 inches, at one place swelling to 14 inches. The gold occurs both in the quartz stringers and veins and in the granite itself. It is most abundant where pyrite or galena is present.

ATHABASKA-BEAVERLODGE GOLD MINES, LIMITED

The holdings of this company in 1934 consisted of two groups of claims. The first is the Yah group of ten claims located east of Fish Hook bay; the second is the Chuck group consisting of five claims and two fractions situated south of the Greenlee holding.

The Yah group was staked September 10, 1934. The claims are most readily reached by a trail beginning from the head of the bay immediately east of Fish Hook bay. They lie in granite near its contact with quartzite and hornblende schist. Surface work only has been carried out. It consists of thirty-five trenches located on six of the ten claims. The longest trench is 98 feet long. The granite contains pyrite and numerous quartz stringers. In places the quartz carries a little pyrite and galena. Visible gold was found at three different places, but on the whole the zones investigated proved to be all of too low grade to be mined.

The Chuck group lies on the tip of the peninsula occupied by the Athabaska Portal and Greenlee holdings and on an island 1,500 feet to the south of the point. The rocks consist of hornblende schist intruded by granite dykes. Quartz stringers are found in both rocks. A series of fracture planes in basic rock dips to the southeast.

BEARCAT GROUP

The Bearcat group of claims was staked on an intrusion of the younger granite lying west of Mackintosh bay. The mass runs east for a distance of about 1 mile and has a width of less than ¼ mile. The claims may be reached by a trail from the western extremity of Mackintosh bay or by a

longer, poorer trail beginning at the Murmac camp at the head of Cornwall bay. The granite intrudes Tazin sediments and contains inclusions of them. The intrusive is cut by many quartz veins, most of which are under a foot in width. A number of them strike north 30 degrees east and in places a little sphalerite pyrite is locally present. The granite where the veins occur is mineralized with pyrite. In September, Ventures, Limited, took an option on eight of the claims from the owners, Messrs. E. Cody, O. Knutson, and I. G. Paulsen, and development work, consisting of approximately 1,000 feet of trenching besides numerous small pits at favourable looking places, was carried out. Some two hundred chip and channel samples were taken. Though very few ran nil, none ran higher than 0·02 ounce in gold, much too low to encourage further development.

BOREALIS SYNDICATE

This company holds claims at Neely lake about 14 miles north of Goldfields and also a group to the southwest on Fredette lake.

The claims on Neely lake comprise four groups lying on either side of the southwest half of the lake. The lake runs in a northeast direction and is paralleled on its southeast side by a ridge of red granite-gneiss some 400 feet in height. The northwest side is bordered by a similar ridge, high at the northeast end of the lake, but towards the southwest end approaching Elder lake it breaks up into three ridges which rise less than 100 feet above these lakes. It is the area covered by these lower ridges that contains the best mineralized half of the claims.

Both sides of Neely lake are bordered by quartzite which forms a syncline between the ridges of granite-gneiss. The beds on the northwest limb have a steeper dip than those across the lake. Cutting the quartzite are dykes and masses of red granite. The most striking of these is a dyke near the northwest shore. It averages about 7 feet in width and dips steeply to the southeast. Its northwest border forms an abrupt cliff. The granite is much fractured and cut by numerous quartz veins and stringers. Many of the fractures are filled with pyrite, some in the form of narrow, thread-like stringers and others as veins up to half an inch in width filled with coarsely crystallized pyrite. Quartz veins also cut the surrounding quartzite. A trench across the granite dyke shows a layer of graphite on its northwest side where it lies in contact with the quartzite.

Northwest of this dyke the middle ridge shows an intrusion of red granite wider than the first, but not so well mineralized. At the base of this ridge is a small vein of calcite and immediately to the northeast of this vein is a dyke of dense, dark diabase of apparently Athabaska age. Beyond this ridge and to the western boundary of the property are small exposures of quartzite with much granite-gneiss and small masses of red granite.

On the southeast side of the lake the rocks grade from quartzite to the red granite-gneiss that makes up the ridge. At one place near a small lake an exposure of red granite is mineralized.

The Midas group of claims lies north of the southwest end of Fredette lake. The country here is a series of ridges with red granite cutting through sediments and gneiss. The granite is cut by quartz veins and stringers. Considerable quantities of pyrite occur and locally some galena.

SUCKER BAY

In the autumn of 1935 the country surrounding Sucker bay was prospected and a considerable number of claims were taken up. The staked region stretches from Robillard bay on the north to Camille bay near the Pine Channel narrows on the south. The rocks of the region are quartzites varying from white to black, quartzitic argillites, and altered quartzose sediments that are now garnetiferous gneisses. They are intimately injected in places by norite. Both the intrusive and the intruded rock locally carry sulphides, chiefly pyrrhotite, which in places produce rusty zones. Between Sucker bay and Robillard bay the sediments assume the appearance of granite-gneisses and are cut by granite dykes.

The main mineral showings to date are on the north side of Algold bay, lying between Robillard and Sucker bays, and on an island on the south side of Sucker bay. The showings are quartz stringers which occur in parallel sets cutting across the strike of the sediments. The quartz carries arsenopyrite and free gold. Exploratory work is necessary to see if the quartz-bearing zones are sufficiently large and average high enough in gold to warrant development.

COPPER-NICKEL

Towards the eastern end of lake Athabaska deposits of sulphides, chiefly pyrrhotite and chalcopyrite, are associated with the norite intrusions and sulphide mineralization occurs also locally in the sedimentary gneisses. Prospecting has been carried out here over the period of the last twenty-five years at least and a number of times claims have been taken up. In 1910 a prospector named Piché staked a claim which he called the Athabaska on the shore of the lake 18 miles east of Fond-du-Lac. In 1912 and 1913 he and other prospectors staked a considerable number of claims in the vicinity of the Narrows at the eastern end of the lake. Only those considered the more important were recorded. In 1914 several prospectors were again at work in the district and most of the old claims were examined. In 1915 a sudden new interest in the region was aroused by the report published in many Canadian papers that a sample of silver ore obtained near Fond-du-Lac assayed high in silver and that the ore zone could be traced for several miles. There was a great rush to the region in the early spring and some hundreds of claims were staked and recorded. By summer the majority of the prospectors, many of whom were familiar with the silver field of Cobalt, had left the region without having staked any claims at all.

The chief name in connexion with the activity of 1914 and subsequent years is H. V. Dardier. Dardier, who was financed by English capital and who had prospected in British Columbia, heard of the copper-nickel showings on lake Athabaska and accompanied by a prospector named Dalton, who had already staked claims in the region, went in 1914 to investigate. After a summer spent in the field he returned to England to raise more funds. In the spring of 1915 he set out again for lake Athabaska with a considerable crew and two Calyx shot drills. A hole was

put down near their camp at Dardier point to a depth of 425 feet. This took nearly a year owing to the hard character of the rock and Dardier decided to bring in a diamond drill outfit. This was later brought in from Edmonton and several holes were put down about 12 miles west of Dardier point. Only a few stringers of sulphides were encountered, however, and the drill was shifted to a new site some 12 miles east of Dardier point. No body of ore was encountered here and work was abandoned.

In 1929 interest in the field was once again aroused by the finding of sulphide showings on Axis lake, about 8 miles northwest of Stony rapids. Extensive development work was carried out in 1929 and 1930 on these deposits by Dominion Explorers, Limited.

The rocks of the region consist largely of sediments altered to a large extent to garnetiferous gneisses and intruded by linear masses of norite, most of which have sill relationships to the sediments. In places in the norite are bunches of sulphides weathering red and consisting of pyrrhotite, chalcopyrite, and arsenopyrite. Locally quartz stringers 2 to 6 inches wide crosscut the rocks and in these the principal sulphide is arsenopyrite with occasional specular hematite, pyrite, or galena. At the head of Camille bay sulphides are disseminated through the paragneiss over a considerable area along a well-defined strike, but nowhere appear to be sufficiently concentrated to form ore-bodies.

The deposit on Axis lake is the one on which the greatest amount of work was done. It lies at the eastern end of the lake and can be readily reached by a wagon road 4 miles long leading from lake Athabaska. The country rock is a massive, fine-grained norite, intrusive into sediments consisting of quartzites and garnetiferous gneisses. The ore zone can be traced for over 3,000 feet in a general east and west direction. It dips to the south at angles between 70 and 80 degrees, and shows fairly sharp walls against the unmineralized rock. The zone is marked by two sets of joints which cut it into rough blocks. The sulphide minerals in the zone are pyrite, pyrrhotite, and chalcopyrite. In general the pyrite appears to decrease from west to east along the zone and chalcopyrite and pyrrhotite increase. In places veinlets of solid chalcopyrite one-eighth of an inch wide occur in the zone.

The source of the sulphide was evidently the norite itself. A thin section of the rock shows considerable disseminated sulphides. Fracturing appears to have produced channels where these were concentrated during the late cooling of the mass.

In Black Bay region are local showings of chalcopyrite and bornite. During the past year diamond drilling was carried out by the Sterling Collieries, Limited, at the southeast end of Ellis bay and also farther north on the north side of the east and west trending lake situated immediately east of Thluicho lake. The rocks here are granitized sediments that have been sheared and faulted. The deposits are small veins consisting of calcite and quartz and mineralized with chalcopyrite and bornite. The deposits discovered so far are too small and of too low grade to be of commercial importance.

LEAD-ZINC

As has already been mentioned in the section on gold, galena usually in only small amounts is present in many of the quartz veins and stringers of the gold-bearing zones. Sphalerite locally occurs in small amounts as well.

Another type of occurrence of these sulphides is also known, namely, contact metamorphic deposits in limestone. Such occurrences are found in the Anchor group near the head of Cornwall bay, but sufficient work has not as yet been done to determine how large the deposits are. They are apparently irregular masses in the limestone. This rock is cut by granite dykes which are probably offshoots of a larger underlying mass. From the few assays that have been made the precious metal content appears to be low. One sample of material gave the following assays: lead, 21 per cent; zinc, 3·5 per cent; and silver, 4·7 ounces to the ton.

An occurrence of mineralogical interest is the presence in a small quartz vein cutting gneiss in the vicinity of Fond-du-Lac of a mass of subfibrous material of which jamesonite, a sulphantimonide of lead, proved to be the principal mineral; stibnite and sphalerite were also found to be present with chalcopyrite and arsenopyrite in minor quantities.

IRON

The presence of iron-bearing rocks on the north shore of lake Athabaska has been known from at least 1893 when J. B. Tyrrell noted their occurrence at several places. The main locality is around Fish Hook bay and on a point to the east of it. In 1921 a number of claims were staked in this region by Messrs. E. A. and N. C. Butterfield and considerable prominence was given to the area through reports that large masses of iron ore were available here. The deposits were examined in 1922 by Professors J. A. Allan and A. E. Cameron of the University of Alberta who came to the same conclusion as that reached by the writer in 1916, that the deposits are not of commercial value as a source of iron.

The rocks of the area surrounding Fish Hook bay consist of sediments of the Tazin series, sediments of the Beaverlodge series, and granite younger than both of these. The Tazin sediments are dominantly dolomite and quartzite. These two rocks are interbedded. In places beds of quartzite occur where the dolomite predominates and in other places dolomite bands occur in dominantly quartzitic strata. The dolomite weathers a dark brown, and commonly shows a pitted surface. Where freshly broken it is light grey. In places it shows the presence of secondary silicate material, usually light-coloured pyroxene. The quartzite shows considerable variation. In places it is grey and massive, in some cases containing a few small red garnets. Some beds are white. In other places the quartzite becomes darker and passes over into a fine-grained paragneiss. In several places thin beds of flaggy bluish iron slate and narrow bands of blue hematite also occur in the series. The rocks are cut by quartz veins and granitic dykes.

The Beaverlodge series is represented by iron-bearing quartzites and slates forming the point east of Fish Hook bay. The rocks here form a syncline pitching southwest standing in front of a high ridge of grey

quartzite of the Tazin group. The strike of the younger beds swings completely round in front of the older rocks. The beds consist of quartzite stained with red iron oxide, banded quartzite and blue hematite, and blue iron-slate. The iron appears to have been deposited with the silica, giving what may be called an iron formation. Locally the hematite has been concentrated in pockets and along fractures by the leaching of silica, and by the redeposition of iron by surface solutions. Evidence of leaching is seen in the porous nature of the rock in places. Nowhere, however, has the concentration proceeded far enough to produce any quantities of commercial ore.

The Tazin sediments are intruded by the Mackintosh Bay granite stock. In Fish Hook Bay area this intrusive does not come in contact with the Beaverlodge sediments, but from information obtained elsewhere it is known that the granite is younger than that series also.

In addition to the iron-bearing rocks of the Beaverlodge series there are zones in the Tazin rocks that carry appreciable quantities of iron. One such zone follows the west side of Fish Hook bay and two others occur in the peninsula separating the two parts of that bay. The iron occurs in both of the two main rock types, the quartzitic sediments, and the dolomite. The iron-bearing zones are very irregular both across and along the strike. The thickest band is less than 50 feet in width and this is made up of iron-stained quartzite, quartz-schist, slate, and thin bands of bluish hematite. At a number of places the dolomite is stained a deep red, giving the appearance of a rock high in iron. In thin section such rock is shown to have had the iron introduced by solutions, the red iron oxide having been deposited around the carbonate grains and along their cleavage planes. Though a certain amount of iron was evidently deposited with the Tazin sediments the source of the iron for this secondary concentration was evidently to a large extent at least the sediments of the Beaverlodge series. These nearly everywhere carry a certain amount of iron. The concentration evidently followed lines of movements. In places the rock is a breccia made up of angular fragments of rock cemented by iron oxide.

A considerable number of samples were taken by Allan across parts of the main iron-bearing zones, and in addition hand-picked specimens of the best material were selected from the richest portions. The amount of metallic iron in the average samples ranged from 4·22 to 34·02 per cent and in the picked specimen from 6·86 to 38·22 per cent. The grade is, therefore, much too low to call any of the material an iron ore.

PITCHBLENDE

In July 1935, pitchblende was discovered in the area between Cornwall bay and Fish Hook bay on the property of Mineral Belt Locators Syndicate, Jos. Errington, manager. The rocks consist of dolomite, or dolomitic limestone and quartzite of the Tazin group, intruded by gabbro and peridotite. The carbonate rock has been partly altered into a light-coloured pyroxenite and in other places into tremolite rock. Earlier work had been done here in 1930 on a copper showing by J. D. Nicholson, field manager of the syndicate.

Pitchblende has been found in two places on the property. The first is on the Jim claim immediately west of the small lake lying to the west of the mouth of Fish Hook bay. The rocks are quartzite and dolomite striking north 73 degrees east and dipping 55 degrees to the southeast. The mineral deposit is a vein cutting the quartzite. It strikes north 64 degrees west and dips 45 degrees to the northeast. In the one trench in which it is exposed it has a maximum width of 10 inches. The vein material consists of carbonate, pitchblende, and sulphides, and shows green, blue, yellow, and cobalt bloom stains.

Two specimens from this exposure were submitted to H. V. Ellsworth for mineral determination. He reports that "the first is a much altered complex mixture consisting mainly of niccolite and botryoidal pitchblende with minor amounts of greyish nickel-cobalt arsenides, nickel and cobalt arsenates—but mainly the former—annabergite, small grains of thucholite, and granular crystalline magnesian limestone or dolomite. On one side of the specimen there is a crust of impure botryoidal calcite carrying considerable nickel with some cobalt. The dolomite also carries a little nickel. The pitchblende masses are not pure, but carry numerous minute inclusions of grey nickel-cobalt arsenides.

The second specimen consists of a nodular mass of black to brownish material without definite cleavage, carrying thin brownish to pale yellowish coatings on outer surfaces and fractures.

On a broken surface the material is seen to carry a few small grains of more or less altered chalcopyrite with associated limonite. It would appear that the whole mass has resulted from the alteration involving hydration and silication of an original mixture of pitchblende, chalcopyrite, and probably other sulphides and arsenides that are now completely decomposed. On detailed examination some of the pure black, lustrous areas with conchoidal fracture were found to consist mainly of a black, altered, silicated pitchblende containing UO_2 and easily soluble in hydrochloric acid, along with a few enclosed grains of original less altered pitchblende that is practically insoluble in hydrochloric acid. Under the microscope this altered pitchblende is greenish brown, translucent, isotropic, with index between 1·75 and 1·85.

Other compounds are also present in the mixture of alteration products. A sample believed to be representative of the whole mass on partial quantitative, qualitative analysis gave the following results: silicate silica 15+ per cent; U_3O_8, 49+ per cent; Fe_2O_3, 16 per cent; rare earths, 2 per cent. The remainder is chiefly H_2O with smaller amounts of Pb, Al, Ca, Cu, As, Ni, V, etc. The material is evidently a mixture of hydrous silicates of uranium and iron, chiefly, though some of the iron comes from chalcopyrite and limonite resulting from the alteration of chalcopyrite. There is very little original pitchblende left.

The second showing is on a hillside northwest of the camp at the head of Halfmoon bay. It is a narrow vein striking south 32 degrees east and dipping northeast at 70 degrees. It follows the strike of carbonate rock and quartzite belonging to the Tazin group of sediments. It shows pitchblende, niccolite, smaltite, and abundant cobalt bloom stain.

GRAPHITE

Graphite occurs disseminated in certain rusty sedimentary gneisses towards the eastern end of lake Athabaska. It was found along Sucker creek near the narrows east of Fond-du-Lac and at a number of places west of Fond-du-Lac. The rock in which it occurs is a garnet-biotite-gneiss in places iron-stained due to the oxidation of pyrite. The graphite is scattered throughout the rock as flakes and as long, narrow shreds that present a fibrous appearance in thin sections. None of the occurrences is sufficiently large or of high enough grade to be of commercial importance.

INDEX

Access to area..... 3
Acknowledgments 1
Agnew, A., field assistant..... 1
Airplanes, use of in mapping..... 1
Algold bay 33
Allan, J. A., investigations by..... 6, 35
Amphibolite 19
Anchor gp..... 35
Antimony ores..... 35
Argillite 10
Arkoses 21
Asbestos 19
Athabaska cl..... 33
Athabaska l., elevation 7
  Navigable periods..... 8
  Surveys on..... 5
Athabaska series, description..... 5, 21
  Relation to other formations..... 23
Athabaska-Beaverlodge Gold Mines, Ltd. 31
Athabaska Landing..... 3
Athabaska Portal Gold Mines, Ltd..25, 30
Athona Mines, Ltd.....25, 27
Axis l., copper ores..... 34
Barnard, K., field assistant..... 1
Basic intrusives 18
Bear gp..... 29
Bearcat gp.....26, 31
Beaver r., rocks 18
Beaverlodge bay..... 12
Beaverlodge is. 16
Beaverlodge lake.....16, 18
  Rocks 20
Beaverlodge series.....16–18
  Iron bearing 35, 36
Beaverlodge Lake area, rocks.....11, 23
Beaver River area, rocks..... 13
Bigfowl is..... 16
Black bay, rocks.....11, 16
Borealis Syndicate..... 32
Bornite 34
Box prop..... 26
Boyle, T. J., field assistant..... 1
Bulyea l., rocks.....16, 21
Bulyea r., rocks..... 21
Butterfield, Messrs. E. A. and N. C., iron cls..... 35
Byrne, J. C..... 31
Cameron, A. E., investigations by... 6, 35
Cameron, W. G., field assistant..... 1
Cameron is..... 20
Camille bay 33
Campbell, G. D., field assistant..... 1
Campbell, R. S., field assistant..... 1
Camsell, Charles, explorations by... 6
Canoe routes..... 3
Cardy, J. D., field assistant..... 1
Carpenter, E. S., field assistant..... 1
Chalcopyrite 33, 34
Chambeuil l., rocks..... 14
Charlot r., rocks..... 11
Chipewyan 4
Chuck gp..... 31
Climate 8
Clut l..... 14
Cobalt bloom..... 37
Cochrane, A. S., early surveys..... 5
Cody, Knutson, and Paulsen, cls.... 32
Conglomerate 10, 12, 14, 16, 21
Consolidated Mining and Smelting Co. 25, 26
Copper. *See* Chalcopyrite
  Copper-nickel
Copper-nickel 33
Cornwall bay, galena..... 35
  Gold 28
  Pitchblende 36
  Rocks 12, 19
Cypress r., rocks.....11, 17
Dardier, H. V., mining work by.....33, 34
Day, Jas. E..... 28
Dolomite 10, 12
Dowling, D. B., surveys by..... 5, 21
Dykes. *See also* Basic intrusives....11, 16
  Diabase 24
  Granite 21
Early exploration in area..... 4
Elevations in area..... 7
Elliot bay, rocks.....11, 16, 18, 20
Ellis bay..... 34
Elsley, B. C., field assistant..... 1
Extent of area..... 1
Faulting, Athabaska series..... 22
  Beaverlodge series..... 17
  Dykes 16
Faults 24
Fauna 9
Fish Hook bay, iron..... 36
  Pitchblende 36
  Rocks 12
Fishing 9
Fond-du-Lac 4
Fontaine l..... 21
Forests 9
Fort Wedderborne..... 4
Fredette l., cls..... 32
Gabbro 18
Galena 31, 35
Gallup, W. B., field assistant..... 1

Geology, economic.....25–38
General 10–24
Structural 24
G.I.M. gp..... 29
Gneiss 10
Graphite in..... 38
Godfrey, G. M., field assistant..... 1
Gold deposits.....25–33
Goldfields 4, 9, 25
Granite 14, 20
Gold associated with..... 1, 25
Relation to other rocks..... 23
Granite-gneiss 14–16
Graphite 38
Grease River area, rocks..... 13
Greenlee cl..... 25
Greenlee Gold Mines, Ltd..... 31
Greig, E. W., field assistant..... 1
Halfmoon bay..... 37
Harris gp. 29
Hart, E. A., field assistant..... 1
Haultain, A. G., surveys by..... 5
Hayter bay, rocks..... 13
Hazel gp., tests on ore from..... 25
Description 29
Hearne, Samuel, exploration by..... 4
History of area..... 4
Hogg. C. A. L., field assistant..... 1
Hogg, F. E., field assistant..... 1
Hudson's Bay Co..... 4
Industries 9
Iron 6, 35
Jamesonite 35
Jim cl..... 37
Juca gp..... 29
Kisiwak l., rocks..... 18
Lamprophyre dykes 16
Langley bay, rocks..... 17
Lead 35
Lee-Greenlaw. *See* Greenlee Gold Mines, Ltd.
Lehman. J. W., field assistant..... 1
Lepus is..... 13
Limestone 10
Sulphide deposits in..... 35
Lodge bay, gold..... 1, 25
Rocks 16, 20
Lucky. *See* Lucky Willy gp.
Lucky Willy gp..... 27
McConnell, R. G., surveys by..... 5, 21
McInnes Products Corp..... 9
Macintosh bay, rocks.....11, 20
MacKay, B. R., surveys by..... 5
McKee, C. W. 25
Mackenzie, Alexander, exploration by 4
Mackenzie, Roderick..... 4
Martin l., rocks..... 23
Max gp..... 29
Methy portage..... 3
Midas gp..... 32
Milliken l., rocks..... 12
Mineral Belt Locators Syndicate.... 36
Molybdenite 28
Moose is.....20, 26
Moss, A. E., field assistant..... 1
Mulock, W. N., field assistant..... 1
Munthe, G., field assistant..... 1
Murmac bay, rocks..... 13
Murmac Lake Athabaska Co., Ltd.. 25
Claims 28
Neely l., claims..... 32
Nero l..... 12
Niccolite..... 37
Nicholson, J. D..... 36
Nickel. *See* Copper-nickel
Norite 19
Copper associated with..... 34
North West Minerals, Ltd.....25, 26, 29
Nyman, —, prospector..... 26
Oldman is..... 19
Pegmatites 16
Piché, —, prospecting by..... 33
Pine Channel narrows..... 33
Pitchblende 36
Pond, Peter, exploration by..... 4
Population of area..... 9
Porphyries 11
Prospecting, areas favourable for.... 26
Quartz veins 22, 25, 33
Quartzite 10–13, 16
Radium. *See* Pitchblende
Rainfall 8
Reed bay, rocks 19
Reeve l., rocks 14
Robillard bay 33
Robinson, W. G., field work..... 1
Royal Canadian Air Force, photographic mapping..... 5
Sam gp..... 29
Sandstones. *See* Athabaska series
Schists 10
Serpentine 19
Shear zones 24
Sigurdson, B., field assistant..... 1
Silver 31, 35
Slate island..... 11
Smaltite 37
Sphalerite 35
Sterling Collieries, Ltd..... 34
Stibnite 35
Stocks 18, 20, 25, 26
Sucker bay, staking on..... 33
Sucker ck..... 38
Surveys, early..... 5, 6
Sutherland, B., field assistant..... 1
Sutherland, S., field assistant..... 1
Talbot, J. R., field assistant..... 1
Tallman, S. L., field assistant..... 1
Tazin gp.
Contact with Beaverlodge series... 17
Description, etc. 10–14
Iron 35, 36

Tazin l., rocks..... 11
Tazin r., rocks..... 11
Tazin Lake area, maps..... 5
Terraces 7
Thainka l., rocks..... 11
Thibault, J. G., field assistant..... 1
Thluicho l., rocks 11
Thomson, David, early surveys..... 5
Thomson, J. A., field assistant..... 1
Till, E., field work..... 1
Topographical Survey, Dept. of Interior, maps by..... 5
Topography of area..... 7
Transportation facilities..... 3
Trenholm, L. S., field assistant..... 1
Tsalwor l..... 11
Turner, Philip, early surveys by..... 5
Tyrrell, J. B., surveys by.....5, 21, 35
Tyrrell, J. W., surveys by..... 5
University of Alberta, tests on ore by 25
Valde, B.A., field assistant..... 1
Ventures, Ltd., work by..... 32
Vic cl..... 26
Vic l..... 26
Volcanic rocks.....10, 23
Willis, D. T., field assistant..... 1
Willy. *See* Lucky Willy cl.
Yah gp..... 31
Zinc 35