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CANADA

DEPARTMENT OF MINES AND RESOURCES

HON. T. A. CRERAR, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES AND GEOLOGY BRANCH

JOHN McLEISH, DIRECTOR

BUREAU OF GEOLOGY AND TOPOGRAPHY

F. C. C. LYNCH, CHIEF

MEMOIR 169

Geology and Mineral Deposits of a Part of Southeastern Manitoba

BY

J. F. Wright

Reprinted 1938

OTTAWA

J. O. PATENÂUDE, I.S.O.

PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

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CHAPTER I

GENERAL CHARACTER OF THE DISTRICT

INTRODUCTION

The part of southeastern Manitoba described in this report lies east and southeast of the south end of lake Winnipeg. It extends from a line from the mouth of Winnipeg river southeast to Lake of the Woods, north to latitude 51° 15′. Within this area of some 45,000 square miles, a variety of mineral deposits are known; they include the gold-bearing quartz veins of Beresford-Rice Lakes area in the basins of Manigotagan and Wanipigow rivers, the copper-nickel sulphide bodies along Oiseau and Maskwa rivers, and the tin and lithium deposits in pegmatite dykes along Winnipeg and Oiseau rivers. Mineral discovereies have also been made at other localities, including West Hawk, Little Bear, and Cat Lakes areas, but in these areas no extensive developments have yet been undertaken on the mineral prospects so far found.

The bedrock of the district is Precambrian in age and is divisible into two major groups, the older consisting of sediments and lavas and the younger of granite and related, deep-seated intrusives. To date the most promising mineral deposits have been found within the older group of volcanic and sedimentary strata, the large surrounding areas of granite being, so far as is known, barren or practically barren of commercially valuable minerals. The belt of pre-granite rocks, and hence the promising prospecting ground, of Beresford-Rice Lakes area, is approximately 60 miles long and varies in width from 1 mile to 15 miles. In this area free gold is widely distributed and underground work has been done on sixteen gold occurrences. During the summer of 1929, three of these gold deposits were being actively explored underground. The deepest workings are on the 950-foot level of the San Antonio deposit. The first gold production was from the Gold Pan deposit in 1916, when a small, high-grade shoot was mined. In 1923 and 1924 the Selkirk deposit produced some gold, and here underground work was carried to the 525-foot level. The only deposit at present producing is the Central Manitoba, where a 150-ton mill was built in 1927, and according to the annual report of this company, the production for the twelve-month period prior to April 30, 1929, was $509,356.79 in bullion extracted from 52,659 tons of ore. This deposit has produced over $1,750,000 in gold.

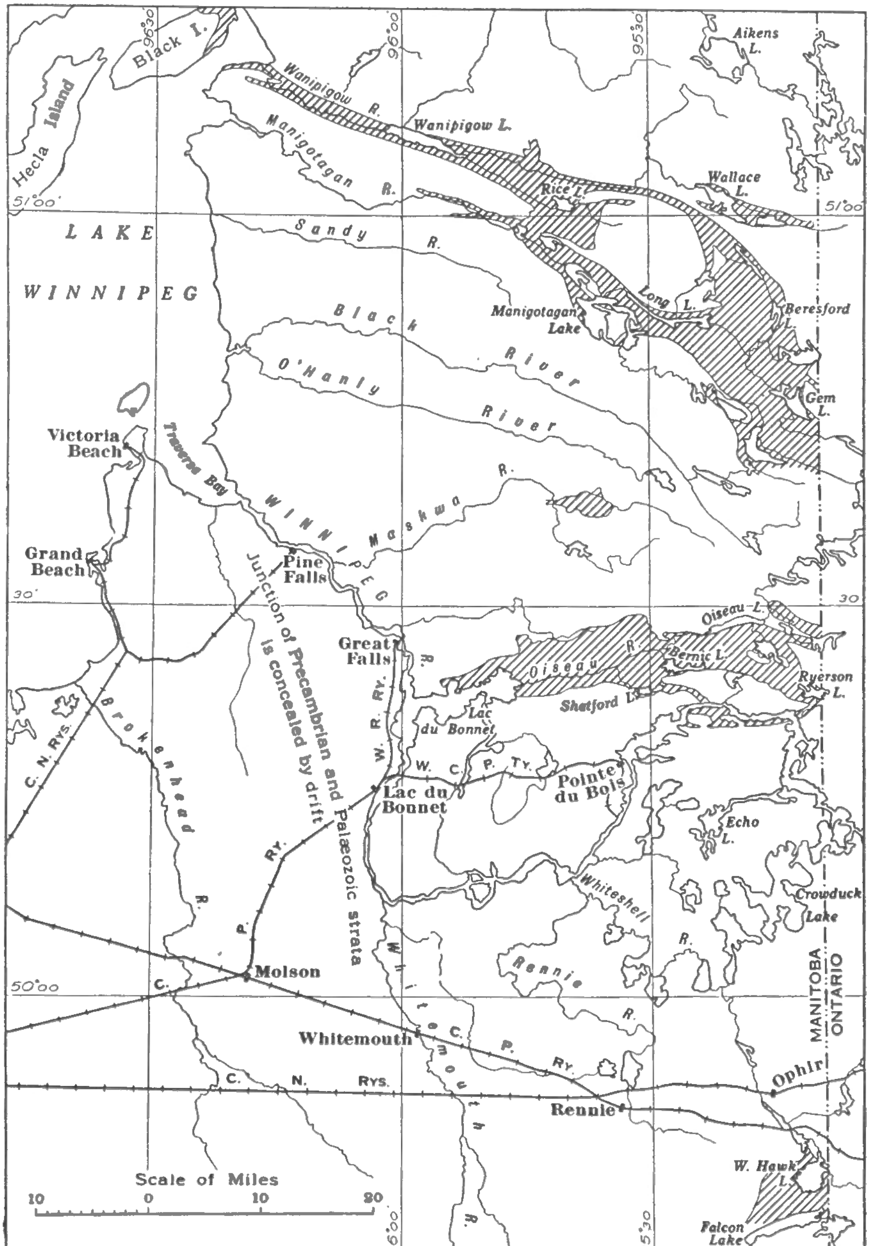

Figure 1. Index map of a part of southeastern Manitoba showing (by diagonal ruling) principal areas of Precambrian volcanic and sedimentary rocks.

The belts of pre-granite rocks, and, therefore, the prospecting ground, along Oiseau and Maskwa rivers are considerably smaller than the Beresford-Rice Lakes area, the Oiseau area being about 35 miles long and from 2 to 20 miles wide, and the Maskwa area being only 8 miles long and 5 miles across at its widest point. Considerable surface stripping and some diamond drilling have been done on five copper and copper-nickel sulphide bodies in Oiseau River area and on one copper-nickel deposit in Maskwa area. Attempts were made during the summer of 1929 to explore underground two tin-bearing pegmatite bodies in the vicinity of Shatford and Bernic lakes, Oiseau River area. A lithium-bearing pegmatite south of Winnipeg river and about 8 miles east of Pointe du Bois has been opened by surface stripping and a small quantity of lithium ore has been quarried and shipped from this deposit.

Although the transcontinental lines of both the Canadian Pacific and the Canadian National railways cross southeast Manitoba, the mineral deposits are not close to these lines or their northward branches. The various deposits may be reached from the railways by hydroplane or in summer by canoe along the water routes and in winter by sleigh across the frozen lakes and swamps. All heavy equipment and supplies for the year must be taken in during the winter months. Great Falls and Pointe du Bois are at present the starting points of the winter roads to the various properties. In summer the gold deposits of Beresford-Rice Lakes area can be reached in from one to two days travelling via Riverton across lake Winnipeg and up Wanipigow river by motor boat, thence by small motor boats and motor road to Long lake. Most parts of Oiseau River area can be reached in one day by motor boat and canoe, either from Lac du Bonnet or Pointe du Bois. The Maskwa River area can be reached in a day from Pine Falls, provided the water is not too low in Maskwa river. All these routes have quite a number of short portages.

The object of the present report is to present the geological and economic results of investigations made in the region and it is hoped that the information given will be useful to prospectors searching for new deposits and to operators exploring the deposits already known. It is to be expected that new mineral deposits will be discovered in the district from time to time and that new facts bearing on the structure of the rocks and mode of occurrence of the ore deposits will be noted as new deposits are discovered and as the deposits already known are developed to greater depth.

The report is based on field investigations carried out by the author during the seasons of 1922, 1923, 1924, 1926, and 1929. C. H. Stockwell in 1926 and 1927 made a special study of the lithium-bearing pegmatites and the account of these bodies is based, in part, on a manuscript report prepared by him. The gold deposits of Rice and Beresford Lakes area were studied during the seasons of 1922, 1923, and 1926, and the copper-nickel sulphide bodies of Oiseau and Maskwa Rivers area during 1924. The summer of 1929 was spent revising the geology of the more important mineral deposits and in mapping in detail the Wadhope area (Map 280A) of 48 square miles between Long and Beresford lakes, wherein a number of promising gold deposits are situated.

It is with pleasure that the author acknowledges his indebtedness to the officials of the various mining companies, prospectors, and others interested in the district for many courtesies extended during the field investigations.

Some of the canoe routes of southeastern Manitoba were explored geologically by J. B. Tyrrell in 1891, and a general description of the geology of the area was published in the Annual Report of the Geological Survey for 1900. Following the discovery of gold along the north shore of Rice lake, E. S. Moore, in 1912, examined and reported upon this district. Commencing in 1916, the region has been annually entered by various investigators. The following is a list of the more important reports and papers dealing with the geology and mineral deposits of the district.

1900. Tyrrell, J. B., and Dowling, D. B.: "East Shore of Lake Winnipeg"; Geol. Surv., Canada, Sum. Rept. 1900, pt. G., pp. 64-67 and 72-77.

1912. Moore, E. S.: "Region East of the South End of Lake Winnipeg"; Geol. Surv., Canada, Sum. Rept. 1912, pp. 262-270.

1913. Wallace, R. C.: "The Rice Lake Gold District of Manitoba"; Trans. Can. Min. Inst., vol. XVI, pp. 538-44.

1916. Dresser, J. A.: "Gold-bearing District of Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1916, pp. 169-175.

DeLury, J. S.: "The Manigotagan Gold District, Manitoba"; Can. Min. Jour., vol. 37, pp. 362-64.

Wallace, R. C.: "Area between Red River and Eastern Boundary of Manitoba and between Winnipeg River and the National Transcontinental Railway"; Geol. Surv., Canada, Sum. Rept. 1916, pp. 175-178.

1917. Bruce, E. L.: "Molybdenite near Falcon Lake, Manitoba"; Geol. Surv., Canada, Sum. Rept. 1917, pt. D, pp. 22-25.

De Lury, J. S.: "Molybdenite at Falcon Lake, Manitoba"; Can. Min. Jour., vol. 38, pp. 460-62 (Dec., 1917).

Marshall, J. R.: "Gold-bearing District of Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1917, pt. D, pp. 17-21.

Marshall, J. R.: "Star Lake Area, Manitoba"; Geol. Surv., Canada, Sum. Rept. 1917, pt. D, pp. 21-22.

1918. Bruce, E. L.: "Gold-quartz Veins and Scheelite Deposits of Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1918, pt. D, pp. 11-15.

DeLury, J. S.: "Tungsten Ore Deposits near Falcon Lake, Manitoba"; Can. Min. Jour., vol. 39, pp. 186-188 (June, 1918).

1919. DeLury, J. S.: "Some Economic Aspects of the Falcon Lake District, Manitoba"; Trans. Can. Inst. Min. and Met., vol. 22, pp. 320-328 (1919).

1920. Colony, R. J.: "A Norite of the Sudbury Type in Manitoba"; Bull. Can. Inst. Min. and Met., pp. 862-872 (Nov., 1920).

DeLury, J. S.: "Mineral Prospects in Southeastern Manitoba"; Man. Bull. (Dec., 1920).

McCann, W. S.: "The Maskwa River Copper-Nickel Deposits, Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1920, pt. C, pp. 19-29.

1921. Cooke, H. C.: "Geology and Mineral Resources of Rice Lake and Oiseau River Areas, Manitoba"; Geol. Surv., Canada, Sum. Rept. 1921, pt. C, pp. 1-36.

1922. Wright, J. F.: "Rice Lake Map-area, Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1922, pt. C, pp. 45-82.

1923. Burwash, E. M.: "Geology of Manitoba-Ontario Boundary, Winnipeg River to Bloodvein River"; Ont. Dept. of Mines, vol. XXXII, pt. II, pp. 1-48.

Wright, J. F.: "Geology and Mineral Prospects of the Northern Part of Beresford Lake Map-area, Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1923, pt. B, pp. 86-104.

1924. Wright, J. F.: "Geology and Mineral Deposits of Oiseau River Map-area, Manitoba"; Geol. Surv., Canada, Sum. Rept. 1924, pt. B, pp. 51-104.

1925. Wentworth, H. A.: "Recent Mining Developments in the Central Manitoba Mining District"; Bull. Can. Inst. Min. and Met., No. 162, pp. 941-51 (Sept., 1925).

Wright, J. F.: "Oiseau and Maskwa Copper and Copper-nickel Deposits, Southeastern Manitoba"; Trans. Can. Inst. Min. and Met., vol. 28, pp. 220-231 (1925).

Wright, J. F.: "Geology and Mineral Deposits of the East-Central Manitoba Mining District"; Trans. Can. Inst. Min. and Met., vol. 28, pp. 311-29.

Wright, J. F.: "Some Geological Notes on the East-Central Manitoba Gold Area"; Can. Min. Jour., vol. 46, pp. 91-95.

1926. DeLury, J. S.: Pegmatites of Southeast Manitoba"; Can. Min. Jour., vol. 47, pp. 695-696.

1927. DeLury, J. S.: "The Mineral Resources of Southeastern Manitoba"; Bull. Indus. Dev. Board of Man., pp. 1-37.

Gilbert, Geoffrey: "Gammon River Area and Rickaby Lake Schist Belt, District of Kenora (Patricia Portion)"; Ont. Dept. of Mines, vol. XXXVI, pt. III, pp. 73-84 (1927).

Wallace, R. C.: "The Mineral Resources of Manitoba"; Bull. Indus. Dev. Board of Man., pp. 1-56.

1928. Wallace, R. C.: "Copper-Zinc and Gold Mineralization in Manitoba"; Trans. Can. Inst. Min. and Met., vol. 31, pp. 42-56.

1929. Wright, J. F.: "Gold, Copper-Nickel, and Tin Deposits of Southeast Manitoba"; Geol. Surv., Canada, Sum. Rept. 1929, pt. B, pp. 136-171.

1930. Derry, Duncan R.: "Tin-bearing Pegmatites in Eastern Manitoba"; Econ. Geol., vol. XXV, No. 2, pp. 145-159 (March-April, 1930).

DeLury, J. S., and Cole, Geo. E.: "First Annual Report on Mines and Minerals"; Man. Dept. Mines and Nat. Res., vol. 1, pp. 101-119, 142-149 (1928).

Wright, J. F.: "Tin, Lithium, and Beryllium Deposits of Southeast Manitoba"; Can. Min. Jour., vol. 51, pp. 515-517 (May, 1930).

PHYSICAL FEATURES

The part of southeastern Manitoba described in this report is within the Canadian Shield, just east of the junction of the Canadian Shield with the Manitoba lowlands division of the Great Plains physiographic province. The Manitoba lowlands are underlain by nearly horizontal, early Palæozoic strata, which along their eastern edge overlap the Precambrian complexly folded formations and the deep-seated intrusive rocks of the Canadian Shield area. The surface of the Manitoba lowlands and the adjoining part of the Shield is, in general, flat. But although the surface of the Shield is plain-like in general appearance, in detail it is hummocky, due to numerous, low ridges of about the same height and intervening swampy depressions. From near the Manitoba-Ontario boundary, the hummocky, yet plain-like surface falls westward and southwestward towards lake Winnipeg and Winnipeg river at an average rate of about 8 feet a mile, and along the east shore of lake Winnipeg and southwest of Winnipeg river the westward-sloping surface passes under the early Palæozoic sediments. The few areas of Precambrian rocks outcropping to the west like islands within the area of Palæozoic strata, suggest that the general character of the surface of Precambrian rocks beneath the Palæozoic strata is somewhat like the surface east of lake Winnipeg. The, in general, even, westward-sloping surface of the Shield truncates various rocks and structures, and is a remnant of a peneplain.

The elevation of the surface of the Canadian Shield at its junction with the Palæozoic strata along the east shore of lake Winnipeg, is approximately 720 feet above sea-level. Eastward the elevation of this surface gradually increases to from 1,100 to 1,200 feet along the Manitoba-Ontario boundary line some 50 to 60 miles east of lake Winnipeg. The average elevation of the surface of Beresford-Rice Lakes area is approximately 1,050 feet above sea-level, the highest elevation noted in the area being 1,225 feet. In this area the relief is seldom as much as 200 feet, the average height of the hill tops above the adjacent valley bottom or level of the nearby lakes being estimated to be from 50 to 70 feet. In Oiseau River and Lac du Bonnet areas, the elevation of lac du Bonnet is 820 feet above sea-level and that of Shinewater lake along the Manitoba-Ontario boundary is 1,134 feet. The relief in these areas is seldom over 125 feet, the average elevation of the hill tops being about 1,000 feet above sea-level. Adjacent to lake Winnipeg and along Winnipeg river, the average relief of the surface is less than in the higher area to the east and north, as deposits of stratified clay extend eastward for 20 to 30 miles from lake Winnipeg and have partly filled the depressions in this area. An exception to this generalization is the small area north of Goldeye lake, 2 miles up Wanipigow river from lake Winnipeg, where several round hills rise 180 feet above the lake level. These hills are conspicuous features for several miles away, and a good general view of the surrounding country is obtainable from their tops.

The drainage of the district is west and south to lake Winnipeg and Winnipeg river, respectively. From north to south the more important rivers are the Wanipigow, Manigotagan, Black, Maskwa, and Oiseau. The headwaters of Wanipigow, Manigotagan, and Oiseau rivers are in Ontario just east of the Manitoba-Ontario boundary and within a short distance of each other. Black and Maskwa rivers are wholly in Manitoba and drain the triangular outlined area between Manigotagan and Oiseau rivers. These rivers are typical of those of the Canadian Shield in general, consisting of smooth flowing stretches separated by rapids and waterfalls. The tributary drainage of the rivers of the district is not well developed, and many swamps and muskegs are not, or are only partly, drained, and a few lakes have no outlet.

The rivers do not follow well-defined valleys, but flow along depressions between rock ridges and drop over waterfalls and rapids from one depression to the next lower. Winnipeg river, draining the southern part of the district, nowhere along its whole course of 160 miles, from Lake of the Woods to lake Winnipeg, follows a well-defined valley, but, instead, flows between the rock ridges and from one depression to another in a winding course trending northwest. The profile of the river is not that of a well-graded stream, but consists of a series of nearly flat stretches representing lake expansions, and short steep drops at points where the river descends by rapids or falls from one basin to the next. Where the river crosses areas underlain by granitic rocks the shoreline of the lake expansions is very irregular and there are numerous bays; where the country rock is lava or sediments, as is the case east of Lamprey falls, the river is narrower and flows in a general straight course parallel the strike of the beds. The other rivers of the district show features similar to those described for Winnipeg river, although in the case of the smaller river these features are not so noticeable. The absence of well-defined river valleys, the ungraded profiles, and the irregular shoreline of lake expansions, indicate a post-Glacial age for the present drainage lines, although the rivers may in part follow pre-Glacial drainage courses.

In some parts of the district bedrock is well exposed, whereas in others, and especially along the contact between the various formations, outcrops are scarce. In the large areas recently swept by severe forest fires, as east of Red Rice and Long lakes, outcrops are numerous and ridges may be nearly bare rock. In areas burnt five or ten years ago, travel is difficult because of the many windfalls and the thick, second growth jackpine. Small spruce swamps are numerous through the district, but only a few of these are over a mile across.

The bedrock topography has been only slightly modified by glacial erosion. The trend of the rock ridges and of the drainage courses is closely related to the structure and type of the underlying bedrock. The surface features of areas underlain by lavas and sediments with massive, hard beds alternating with schistose soft beds markedly contrast with the features of areas of granite of fairly uniform composition and without structural trends. Physiographically the district, therefore, naturally falls into divisions whose outlines are determined by the distribution of the lavas and sediments within the granite.

The topography of the districts underlain by alternating beds of quartzite and slate or basalt and schistose andesite, and tuff, especially areas east of Long lake, west of Moore lake, and along Oiseau river from Oiseau lake to lac du Bonnet, is characterized by parallel, east-west or northwest-southeast trending ridges separated by steep-walled valleys. Sections of these valleys are occupied by streams and lakes as illustrated by Moore Lake valley, Manigotagan river east of Long lake, or Oiseau River valley. The linear feature of the topography is directly related to the structure and type of underlying rock, the valleys being parallel to the strike of the steeply dipping, thick, resistant beds of quartzite, arkose, dacite, or basalt, which form the ridges. Schists and other soft rocks generally outcrop along the valley sides and bottoms, and, as rocks of this nature are likely to contain gold-bearing quartz veins and sulphide bodies, prospectors are advised to explore carefully all depressions of these areas.

In contrast with the long, parallel ridges of the areas underlain by sediments and lavas are the irregularly shaped, discontinuous knobs and ridges of the granite areas. These granite knobs are, in most cases, covered with small jackpines, and rise out of the surrounding swamps and muskegs as do islands above the water of a lake. In the granite areas near the west side of the district, small lakes with irregular shorelines and numerous islands are abundant.

AGRICULTURE, FORESTS, AND WATERPOWERS

Farming has not yet been attempted on any large scale within the district, though garden vegetables have been grown successfully and locally small areas of land suitable for agricultural purposes are available. Unfortunately, near the centre of the present mining development north of Long lake, little land suitable for farming is available. The companies operating in these areas even find it difficult to locate near their properties patches of soil suited to the growing of potatoes and garden vegetables. To the west, however, along the Manitoba Government motor road east of Red Rice lake and along Wanipigow valley westward from Gabrielle portage there are considerable areas of clay land between the rock ridges. Small areas of land have already been cleared in the vicinity of the mouths of Manigotagan and Oiseau rivers, and a considerable area is cleared and under cultivation at St. Georges, on Winnipeg river between Pine Falls and Great Falls and east of Lac du Bonnet. Long stretches of clay-covered territory are present adjoining Maskwa river and Cat creek, its main tributary. In these areas most of the clay land between the rock ridges would grow good crops if cleared and drained. This, in some cases, however, will be expensive, in consequence of the heavy growth of trees and the low, flat character of the ground.

It is estimated that about half the area of the part of southeastern Manitoba being considered in this report, has been swept by severe forest fires. Over large tracts of the burned areas the soil has been eroded from the rock ridges, consequently large commercial trees will not again grow there. A few patches of timber, however, have not been burned, and in the area north of Long lake and from the east end of Long lake to Gem lake some timber has been cut for mining purposes. During the summer of 1926, the timber of the district was surveyed by parties representing the Dominion Forestry Service and the Manitoba Paper Company. No reports of the results of these investigations have been published. It is apparent however, from a casual examination of much of the area, that the timber patches are too small and too scattered to be exploited profitably under present transportation conditions. Most of the trees are of a size suitable only for pulpwood, and spruce, jackpine, and poplar are the main commercial varieties. Some of the mining companies at present have to haul timber for 5 miles or more, and in some parts of the district the supply of mine timber will soon be exhausted within a radius of 8 or 10 miles of the properties under development.

The waterfalls of Winnipeg river are the main source of electrical energy in southeastern Manitoba, and officers of the Dominion Water Power Branch have reported in Water Resources Paper No. 3 (1915) on the waterpower resources of this river. The investigation showed that there are nine natural power sites between lake Winnipeg and the Ontario boundary, and it is estimated that with a regulated minimum flow of 20,000 cubic feet a second, the nine sites could produce over 418,000 horsepower in terms of 24-hour continuous power. Three of the nine sites are now developed and a fourth was being developed during 1929 and 1930. The site farthest up the river is at Pointe du Bois, where the city of Winnipeg municipal plant has a developed output of 65,000 horsepower of electrical energy. The site at present under development is at Seven Sisters falls about half-way between Pointe du Bois and Lac du Bonnet. The two other developments are at Pinawa (30,000 horsepower developed), and at Great Falls where 168,000 horsepower can be developed. The latter plant is controlled by the Manitoba Power Company.

Though waterfalls are numerous along the other, and smaller, rivers in the district, only a few of these falls are high enough to be possible power sites. The drainage basins of these rivers are not large and during dry seasons the water supply is low, thus necessitating large dams and storage basins. It is improbable that any of these smaller power sites will be developed now that a transmission line has been built from the Manitoba Power Company's plant at Great Falls to the Central Manitoba mine at Long lake, 43 miles to the north.

CHAPTER II

GENERAL GEOLOGY

SUMMARY STATEMENT

The bedrock of the district east and southeast of the south end of lake Winnipeg is of Precambrian age and the rocks are divisible into two major groups: (1) an assemblage of sedimentary and volcanic strata; and (2) intrusives, ranging in composition from peridotite to granite. The areas of sedimentary and volcanic rocks are comparatively small, the most widespread rocks of the district being granite and granite-gneiss. The sediments comprise slate, chert, iron formation, greywacke, quartzite, arkose, conglomerate, and, derived from the foregoing, quartz-biotite, quartz-sericite, and quartz-garnet schists and gneisses. The lavas range in composition from rhyolite to basalt and over large areas are altered to chlorite, sericite, and carbonate schists. Fragmental beds of volcanic materials are locally developed; a few of the lava flows show excellent pillow structure and some of the lavas are porphyritic. In some localities the sediments and lavas are interbedded; thin bands of bedded materials are present in most areas of the volcanic rocks, but in some quite large areas of sediments no lava was recognized. The members of this assemblage are steeply folded; only locally are the dips as low as 45 degrees. No evidence of a marked structural or stratigraphic break was recognized within this great group of surficial rocks, which has been designated the Rice Lake series and which resembles lithologically the Keewatin as described by Lawson in 1885 in Lake of the Woods area some 75 miles south of Beresford-Rice Lakes area. The Rice Lake series is divisible into three groups or phases based on the absence or presence of lava flows and certain other lithological features. These three phases with their main lithological types are shown in the table of formations on page 11.

The areas of rocks belonging to the Rice Lake series are interesting geologically and economically, as they furnish the data to unravel a part of the Precambrian history of the region, and it is in them that the more important mineral deposits of the district are found. For these reasons the field work in the district has been confined almost entirely to an investigation of these rocks and their contained mineral deposits. The type area of these rocks is in Beresford-Rice Lakes area along the basins of Manigotagan and Wanipigow rivers. The most complete section of the series is exposed along a line extending from 5 miles southwest of the east end of Long lake northeast to beyond Moore lake, a distance of about 15 miles. Other areas of lavas and sediments, similar lithologically to the rocks of the type area of the Rice Lake series, occur along Maskwa and Oiseau rivers 25 and 40 miles, respectively, south of the type locality at Long lake. The volcanic and sedimentary strata of these two areas presumably are of the same age as the Rice Lake series, although this cannot be demonstrated by tracing the formations continuously from one area to the other, for the intervening areas are underlain by granite and granite-gneiss. For the same reason it is impossible at present to correlate the phases of the Rice Lake series with the somewhat similar lithological formations of nearby areas of western Ontario. It is concluded that the Rice Lake series may be older or equivalent in age to the Couchiching and Keewatin. Perhaps all of the series in the Ontario areas designated as Couchiching, Keewatin, Seine, and Timiskaming are represented in the Manitoba field. The various series of surficial origin cannot be correlated definitely until more specific data are available regarding the age of the intervening granites.

The deep-seated intrusives of southeast Manitoba cut the members of the Rice Lake series as dykes, bosses, and large batholith-like bodies. Peridotite and gabbro are the oldest of these intrusives known and small, elongated bodies of these rocks are present locally in areas underlain by the volcanic members of the Rice Lake series. Deposits of nickel and copper-bearing sulphides occur in shear zones within the lavas adjacent to some masses of peridotite and gabbro. In the areas north of Long lake and east of Rice lake, dykes of granite porphyry are abundant, and here many gold-bearing quartz veins are present. Several other, larger, intrusive bodies, some of them also porphyritic and ranging in mineralogical composition from quartz diorite through granodiorite to granite, are developed within the area of Rice Lake rocks in Oiseau and Beresford-Rice Lakes area. Granite and granite-gneiss surround the areas of Rice Lake rocks, which apparently represent only those parts of the original series that extended deep within the large intrusive bodies and thereby escaped erosion during the unroofing of the granite masses. The end phases of the period, or periods, of granitic invasion are represented by numerous dykes and small bosses of microcline pegmatite, pegmatitic albite granite, and albite pegmatite. The tin and lithium deposits are associated in origin with the albite pegmatites of the end phase of the period of granitic invasion. No evidence was noted to prove more than one period of granitic invasion and the small and large intrusive bodies of basic, intermediate, and acidic composition are all considered to be different phases of the same period of igneous activity.

The rock succession as known in southeastern Manitoba may be tabulated as follows:

Table of Formations

Quaternary	Recent and Pleistocene	River alluvial and peat Lake Agassiz clay Glacial till, sand, and gravel
	Unconformity	
Palæozoic	Ordovician	Upper Mottled limestone Lower Mottled limestone Winnipeg sandstone

Table of Formations—Continued

Unconformity

Precambrian	Intrusives	Diorite and diabase
		Intrusive contact
		Albite granite and pegmatite Microcline pegmatite Microcline granite and granite-gneiss Oligoclase granite and granite-gneiss Quartz diorite and granodiorite with porphyritic phases Granodiorite and granite Granite porphyry dykes Peridotite, gabbro, diabase, and quartz diorite
	Intrusive contact	
	Rice Lake series	*Wanipigow phase.* Greywacke, quartzite, and arkose, with thin slate beds and conglomerate lenses *Beresford Lake phase.* Basalt, diabase, andesite, dacite, and rhyolite (in part altered to chlorite-epidote, chlorite-carbonate, actinolite-chlorite, and sericite schists) and beds of varying thickness of greywacke, chert, garnet schist, iron formation, tuff, and other pyroclastic materials *Manigotagan phase.* Quartzite, cherty quartzite, greywacke, slate, chert, and conglomerate in part recrystallized to quartz-biotite and quartz-garnet schist and gneiss

RICE LAKE SERIES

MANIGOTAGAN PHASE

General Character and Distribution

The Manigotagan phase of the Rice Lake series comprises light-coloured to black, quartzose and argillaceous sediments of fine to medium grain. The weathered surfaces of many outcrops of these sediments show excellently the bedded character of the materials by an alternation of thin layers of white, greenish grey or dark grey to black rocks. Such a bedded character is developed especially well south of the northwest end of Gem lake, where alternating beds of slate, chert, cherty quartzite, and greywacke-like sediments are developed over a wide area. Many other outcrops, however, do not show so markedly the bedded character of the materials, although the more massive, siliceous rocks associated with the bedded types are considered also to be water deposited beds of impure sand. Such beds are in some localities followed by dark, laminated, slaty beds or by beds of light grey quartz-sericite schist considered to be sediments altered to schists. Thin beds of conglomerate and grit were noted in the sediments of this group at only a few localities, and are considered to be intraformational conglomerates in lens-like bodies. The sediments are schistose and gneissic adjacent the large granite bodies where a variety of quartz-biotite and quartz-garnet gneisses and schists have resulted from the recrystallization of the sedimentary strata.

Sediments of the general character indicated above outcrop extensively in the southern part of Beresford-Rice Lakes area from Turtle lake southeast along Manigotagan valley through Manigotagan lake, south of Long lake to Flintstone lake, and up Moose river across the Manitoba-Ontario boundary to beyond Wingiskus lake. Sediments similar lithologically to those of this large area also outcrop in Oiseau Lake area from Ryerson lake on the Manitoba-Ontario boundary, and 18 miles south of Wingiskus lake, northwest to Oiseau lake. In both areas the sediments of this group outcrop along edges of a large district occupied by granite.

Lithological Character

The conglomerate members of this group are best developed between Booster and Flanders lakes, and in Ryerson, Summerhill, and Davidson lakes. One bed extends, with some interruptions, from northeast of the outlet of Booster lake southeast for 1½ miles. This bed averages nearly 100 feet in thickness, but its thickness is variable and ranges from 10 feet to over 200 feet. Where the conglomerate member is thin, the remainder of the bed is a coarse grit and, or, quartz-feldspar mica sediment. Only boulders of granite and dark, vitreous quartz were recognized in this conglomerate. D. R. Derry[1] has studied in detail the conglomerate on Ryerson lake near the Ontario-Manitoba boundary and roughly classifies the percentage of some fifty representative boulders as follows:

	Per cent
Light grey biotite granite	38
Light brown granite	12
Grey granodiorite	20
Fine quartzose rock in tabular boulders	22
Quartz in small pebbles	8

A few of the granite boulders are as much as 1 foot in diameter, but the most abundant boulders and pebbles range from ½ to 3 inches in diameter and these are round plate and lens-shaped. A few boulders are elongated through squeezing and shearing of the beds during folding. The matrix is quartz-mica schist and some of the boulders and pebbles are oriented with their longer axis parallel the strike of the bed and also parallel the schistosity of the matrix. The foliation of the matrix, however, bends around and parallels the outline of many of the larger boulders. On both sides the conglomerate horizon is followed by quartz-mica gneiss, some beds of which are garnet bearing and others are of coarser grain than the typical biotite gneiss, and perhaps originally were arkose or grit. The marked similarity of the sediments above and below this conglomerate horizon, together with the absence of evidence of an erosional surface or of structural discordance of the strata at this horizon, suggest that the rock is an intraformational conglomerate. The abundant granite pebbles in the conglomerate and the sandy arkosic nature of the associated sediments indicate that a granite body was exposed nearby at the time the sediments were being deposited, though in the areal mapping no outcrops of this granite were recognized.

[1]Ont. Dept. of Mines, vol. 39, pt. III, p. 31 (1930).

Another area where conglomerate, assumed in 1926 to belong to the Manigotagan phase of the Rice Lake series, was noted is along the southwest branch of Manigotagan river from Lily lake east to the Manitoba-Ontario boundary and beyond through Bee, Eden, and the south side of Eagle Rock lake in Ontario. This conglomerate is exposed on the north shore of Slate lake near its east end, where small, round pebbles of granite, felsite, quartzite, chert, and grey schist are embedded in a fine-grained matrix of siliceous and dark, slaty materials. This conglomerate bed here is 20 feet thick, dips 80 degrees north, and is bordered on the north side by beds of arkose and on the south side by dark, fine-grained, slaty beds. On Bee and Eden lakes to the east, the pebbles are up to 3 or 4 inches in diameter and the conglomerate beds are 20 to 40 feet or more in thickness. Here, the conglomerate is interbedded with grit, quartzite, slate, and iron formation. At the outlet of Lily lake, the next lake west of Slate lake on Manigotagan lake, and along the projected westward strike of the conglomerate horizon, the sediments are grits composed of angular quartz and feldspar fragments up to one-quarter inch across. These coarse-grained sediments vary markedly in appearance from the nearby, very fine-grained, well-bedded, quartzose sediments so typical of the Manigotagan phase throughout the whole area studied, and furthermore the strike of the gritty beds at the east end of Lily lake is at an angle of nearly 20 degrees to the average trend of the fine-grained sediments to the northwest. The marked contrast between the lithology of the conglomerate horizon and its associated beds and that of the typical Manigotagan sediments as developed south of Gem lake, on Flintstone lake, and south of Long lake, suggests that further detailed work in the area east of Lily lake may demonstrate that the conglomerate horizon there developed does not belong in the Manigotagan phase, but perhaps represents either beds of the Wanipigow phase or a part of a younger formation folded within the area of Manigotagan sediments. The eastward continuation into Ontario of this belt of conglomerate and associated quartzose sediments, and also of the area of typical Manigotagan sediments, was mapped in 1926 by Geoffrey Gilbert. This author states that here also "the relations of members of the schist series [sediments and lavas] are uncertain" and concludes that "it seems improbable that they [sediments and lavas] can be separated into a lower volcanic series and an upper sedimentary series; that is to say, the terms Keewatin and Temiskamian, as ordinarily used, do not apply strictly to this region."

The abundant members of the Manigotagan phase are fine-grained, greyish quartzite, greenish to dark grey, slightly schistose, fine-grained rocks designated greywacke, and black, bedded or dense rocks with poorly developed slaty cleavage called metargillite. Strata of the foregoing types are present from south of Long lake to Flintstone lake and south of Oiseau lake in Oiseau Lake area. Many outcrops in these areas show excellently the bedded or water-sorted character of the materials and members of the three types mentioned are at many localities interbedded. Some outcrops show no evidence of bedding, and these are of slightly coarser texture than the bedded types. Under the microscope the quartzites show a mosaic of rounded quartz grains of about 0·2 mm. diameter, a few subangular feldspar grains, and numerous flakes of biotite, white mica, small areas of clayey appearing materials, and a few grains of magnetite and pyrite. Other beds of quartzose rock, designated cherty quartzite, weather white, but on the fresh surface are black and glass-like, with abundant, small, glistening grains of quartz. The bedding of such rocks is obscure, although markings on the weathered surface resemble laminæ. In thin section, angular and subangular grains of quartz and feldspar are set in a matrix of microcrystalline quartz, some sericite, carbonate, and greyish material. The individual, rounded, quartz grains of other beds of dark-coloured quartzite are easily recognizable in hand specimens. Some of the beds of dark, coarse-grained quartzite contain enough magnetite to cause a local attraction of the compass, hence such beds probably were originally ferruginous sandstones. The many beds of greenish grey, dense-appearing rocks interlayered with the quartzites, and termed greywacke, are similar texturally to the quartzite. These in some outcrops are slightly schistose and in thin section they carry considerable chloritic material and also calcite, epidote, and leucoxene. Associated with the quartzite and greywacke are other beds of dense, dark grey to black rocks considered to represent clayey sands; in the field such dark types showing poorly developed cleavage were called metargillite. Under the microscope they consist of angular and irregular-outlined areas of quartz in a matrix of chloritic and other greyish, nearly opaque, fibrous material. No feldspar is recognizable; small needles of a green biotite are abundant in small areas of the thin section. Fissile slates are also interbedded with the quartzose sediments at a few horizons, as south of the east end of Long lake and south of Lily lake and on Slate lake. These are black to slightly purplish rocks, in some outcrops showing lamination, though at most localities evidence of stratification has been obliterated by secondary cleavage. Some of the thin, slate, metargillite and chert beds of this group are compressed into a series of drag-folds, which may be seen typically developed on the point just south of the outlet of Slate lake or east of the portage about half-way from Lily lake to Moose river. The axial plane of many of these drag-folds dips northward and their axis plunges northwestward.

Grey to black chert is interbedded at a few horizons with fine-grained quartzose sediments of the Manigotagan phase. The chert beds vary in thickness from a few inches to 10 feet or more, and are associated with cherty quartzite, slate, and sericite schist, the whole chert-bearing horizon being only from 40 to 300 feet in thickness. At a typical locality, as along the southwest shore of Gem lake northwest of the outlet, the chert is dark grey to black and is obscurely bedded. The chert horizon here is from 250 to 300 feet thick. Fragments of chipped chert on the beach suggest that the locality on Gem lake was a source of chert and flint used by the Indians in making arrowheads. The thin sections of the chert studied microscopically show interlocking, round and subangular, quartz grains averaging 0·04 mm. in diameter with a few fragments three times larger and many slightly smaller than the average size mentioned. Fine specks of magnetite are abundant in the dark-coloured cherts, also some chloritic and other isotropic, clayey-appearing material. In some chert beds pyrite is abundant in small crystals and as fine grains along joint planes. Quartz veins and numerous, branching stringers of quartz are locally present in chert beds. Interbedded with the chert are layers of cherty quartzite, greywacke-like beds, and quartz-sericite schist. The interstratification of the chert with quartzose clastic beds suggests that the cherts are also water-sorted materials, perhaps in part formed by precipitation of silica carried in colloidal form. No typical beds of chert were noted among the fine-grained, quartzose sediments of Oiseau Lake area, although along the south shore of Oiseau lake, calcareous, cherty-appearing beds alternate with calcareous, magnetite-rich and garnet-quartz beds.

Quartz-sericite schists are locally developed as a result of deformation of beds of quartizite and greywacke, along and south of Manigotagan river east of Long lake. These are light-coloured, fine-grained rocks with the flat surfaces of the micaceous minerals oriented parallel. In thin section the quartz grains are granulated and show undulating extinction. The abundant constituent is sericitic mica in long shreds and flakes. Some pyrite, magnetite, and calcite are the accessory constituents noted. Quartz-sericite schists are also derived through deformation of the volcanic rocks and the schists of both types are similar in appearance in their outcrops, although the specimens of schist of sedimentary origin studied microscopically contain considerably more of quartz than do the specimens of the volcanic schists.

Quartz-biotite and quartz-biotite-garnet gneisses and schists are developed from beds of the Manigotagan sediments over a considerable area north of the granite contact through Manigotagan lake and eastward to Flintstone lake, and south of the granite contact east and southeast of Oiseau lake. Inclusions of micaceous gneiss and schist are abundant locally within the granite adjacent to the areas of these recrystallized sediments, also small granite and pegmatite dykes are present within the sedimentary gneisses for a considerable distance from the granite bodies. At some horizons a typical lit par lit gneiss is developed by the injection of layers of granite along the bedding and foliation planes of the sediments.

The quartzose gneiss and schist are typically grey, foliated rocks of medium grain, the more micaceous beds being dark grey to black. Quartz and brown biotite are the abundant constituents, the quartz being estimated to form nearly one-half and the biotite three-eighths of the area of the thin sections examined microscopically. A few of the quartz grains of some specimens have rounded outlines; in most specimens, however, the original clastic texture has been destroyed through recrystallization. The biotite is strongly pleochroic and in the more schistose specimens it occurs in long shreds and flakes with frayed ends arranged in parallel lines across the area of the thin section with intervening areas of quartz grains and only a few mica flakes. In some specimens grains of orthoclase, microcline, and oligoclase were recognized. No hornblende and very little chlorite were noted. Calcite, pyrite, magnetite, titanite, and apatite are all present in most specimens. In a few thin sections, eight-sided crystals and irregular-outlined and angular pieces of red garnet, of the variety almandite, are abundant. The garnet crystals are crossed by cracks and included bits of quartz and mica are present in some of the garnet. In the field, garnet-rich beds alternate with those that do not carry visible garnet. A characteristic feature of the minerals of the thin sections is for quartz grains to include bits of feldspar and biotite, or biotite to carry fragments of quartz.

Southwest of the east end of Long lake, the quartz-mica-garnet gneiss and schist grade northward, away from the granite body, into bedded, noncrystalline types through a zone about 1 mile wide wherein beds of biotite schist and normal quartzite and greywacke are interlayered. This transition zone is well exposed on the bare rock ridges about 2 miles southwest of the east end of Long lake, where beds of dark grey quartzite, light to slightly pinkish, cherty quartzite, dark grey, biotite quartzite, and fine-grained black rocks carrying small red garnets alternate. Only small pegmatite and quartz bodies cut these rocks; within the next mile southward granite bodies appear and these and the pegmatite bodies become larger and more numerous. As the granite bodies increase in number and size, the sediments become coarser grained and gradually the bedded and laminated rocks are succeeded by schistose and foliated mica and garnet-bearing gneiss. This transition across the strike from bedded to foliated rocks indicates a sedimentary origin for the quartz-mica and garnet gneiss and schist, and as the foliated rocks are adjacent to the granite, the change in texture and mineral content is perhaps due to metamorphism by the granite rather than to any marked difference in the original character of the sediments.

BERESFORD LAKE PHASE

General Character and Distribution

The Beresford Lake phase of the Rice Lake series is predominantly of volcanic rocks and comprises the larger part of the original Rice Lake series as defined by E. S. Moore in 1912. Although beds of sedimentary strata, including greywacke, tuff, chert, and iron formation, are locally numerous, these bedded types constitute only a small part of the total of this group. The volcanic rocks are light grey, greenish, and black, and are of fine to medium grain. Some of the lighter-coloured flows are porphyritic. In the field the volcanic members of this group are readily divisible on the basis of colour and texture into light grey, fine-grained, and porphyritic rhyolite, greenish to dark grey, fine-grained, and porphyritic dacite, fine-grained, black andesite, and medium-grained, greenish to black basalt and diabase and their derived schists. The microscopic study shows that quartz is only sparingly present in some of the grey lavas, and these are perhaps trachytes. A few outcrops of the volcanic rocks show pillow structure exceptionally well developed, whereas many others are of massive or slightly schistose types of uniform appearance across the exposure. Other flows show zones of brecciated material along one side, assumed to be the top, and large, lenticular bodies show angular fragments of volcanic rock in a fine-grained, schistose groundmass of grey material, in some cases slightly bedded and in others with no visible sign of bedding. In addition to the rocks of known volcanic origin, many other outcrops of green to black, medium to coarse-grained, basic, igneous rocks whose origin is unknown, are included within the Beresford Lake volcanic group. In the field work of 1926, a few of the larger bodies of these rocks were mapped saparately as intrusive bodies of gabbro and diorite on the basis of their coarser texture as compared with the known volcanic rocks. At a few localities, bodies of these coarser-grained, igneous rocks show chilled contacts against sediments. Such chilled contacts, however, might be the fine-grained margin of lava flows, and the detailed work in Wadhope area in 1929 did not definitely establish that many bodies of these coarser-grained rocks were of intrusive origin, and, therefore, of different age from the volcanic rocks. Such rocks, showing a diabase texture under the microscope and whose materials are for the most part altered to secondary products, are now mapped and described as basalt and diabase, and are considered to be in part extrusive and perhaps in part intrusive in origin.

Rocks of the various types mentioned in the foregoing paragraph are present in the Beresford-Rice Lakes area southeast of Rice lake, from near the east end of Long lake east to Garner lake and northwest to and beyond Halfway lake, and south of Lily and Slate lakes. In the Oiseau River area the volcanic rocks are exposed in a long belt north of Oiseau river extending from just north of the northeast end of lac du Bonnet eastward to near the west end of Oiseau lake, in the part of the area east and west of Bernic lake, south of Shatford lake, and along Winnipeg river east of Pointe du Bois and north to Ryerson lake. Volcanic rocks are also developed in Maskwa River area, sediments being exposed here only sparingly. In these three areas, the more important gold-bearing quartz veins, copper-nickel-bearing sulphide bodies, and lithium and tin-bearing pegmatites are in the volcanic rocks, locally known as greenstone and diabase, hence the areas of these rocks are important from a prospecting viewpoint.

Lithological Character

Rhyolite and Associated Pyroclastics, Tuffs, Sediments, and Schists. Thin bands of white to greenish grey, fine-grained and porphyritic, acidic rocks outcrop along Manigotagan valley both east and west of Long lake. Acidic rocks of this type, and presumed to be of volcanic origin, are not widespread and were not noted in Oiseau and Maskwa Rivers areas. Some of the outcrops of these acidic rocks along Manigotagan valley show markings resembling pillow structure, others show wavy lines resembling flow structure; the majority of the outcrops, however, are of a light-coloured, felsitic-looking, porphyritic rock showing no evidence of origin. Some of these bands of acidic rock outcrop fairly continuously in the form of low ridges and are traceable several miles along their strike, whereas many other bodies are discontinuous.

The thin sections of the acidic rocks examined microscopically show rounded and subangular, quartz and feldspar grains or phenocrysts in a microcrystalline aggregate of quartz, feldspar, biotite, sericite, calcite, chlorite, and much grey, undeterminable, glassy-appearing material. Some thin sections do not show markedly the contrast in size of grain betweeen phenocrysts and groundmass, there being present only a few of the larger grains, with considerable areas of grains of smaller size and other areas of microcrystalline and undeterminable materials. A few of the feldspar phenocrysts are oligoclase-albite, others are so altered to kaolinite, sericite, and saussurite as to be undeterminable in thin section. Other grains of partly kaolinized feldspar are orthoclase. Sericite and calcite are the dominant secondary minerals and the proportion of the secondary products varies greatly in different thin sections. Only a few flakes of sericite are present in some thin sections, whereas in others sericite or muscovite are abundant, and the rock is a typical sericite schist showing the bending of the schistosity of the groundmass around the phenocrysts, thus indicating the effects of deformation since the rock was formed.

At the east end of Long lake, acidic rocks of the foregoing character are interlayered with: (1) bedded quartzose sediments between chert and quartzite in texture; (2) pyroclastic beds composed of angular to rounded fragments of felsitic porphyritic rock from ½ to 5 or 6 inches across in a schistose matrix of angular bits of acidic rock and white mica; and (3) tuff beds locally showing stratification and composed of angular bits of acidic rock up to ½ inch across in a schistose, fine-grained groundmass of white mica and grey to slightly greenish, apparently chloritic materials. This assemblage of light-coloured rocks is assumed to represent acidic lava flows and clastic sediments showing various degrees of sorting, and consisting for the most part of volcanic ash and other fragmental volcanic materials. A few bands of felsitic-appearing rocks, varying from 50 to 200 feet in width, are also interlayered with the darker-coloured, more basic lavas in the area for a mile or more north of Bidou lake, east of the northeast corner of Long lake. These more acidic rocks in this area are assumed to be flows of rhyolitic lava rather than felsites intrusive into the more basic lavas, as the intrusive acid dykes, so abundant in this vicinity, all show angular phenocrysts of feldspar, and at most localities their intrusive relations are apparent.

Dacite and Trachyte and Their Porphyritic and Schistose Phases. Greyish, fine-grained, and porphyritic lavas of the mineralogical composition of dacite and trachyte are present in both Beresford-Rice Lakes and Oiseau River areas. These lavas are typically developed east of the east end of Long lake to Grassy bay[1] on Manigotagan river, and east of Bernic lake in Oiseau River area. Some outcrops of both the even granular and porphyritic types show pillow structure, and a fragmental margin is developed in some flows. The feldspar phenocrysts of the porphyritic lavas are rectangular and in some outcrops are up to one-quarter inch long. In thin section the average size of the phenocrysts is 1·5 mm., and that of the feldspar grains of the groundmass is nearly 0·4 mm. The majority of the feldspar phenocrysts are oligoclase; only a few are orthoclase. The weathered surfaces of some outcrops exhibit phenocrysts of bluish quartz. Under the microscope, the oligoclase shows albite twinning and is in part altered to zoisite, albite, quartz, and calcite. Many of the phenocrysts are oriented with their long directions parallel, and in the plane of the schistosity of the groundmass. In specimens of grey schistose lava, the phenocrysts are broken into angular fragments distributed in lens-shaped areas parallel the schistosity of the groundmass. The few

[1] Or Grassy Rice bay.

orthoclase phenocrysts are for the most part kaolinized, and it is difficult to determine the relative proportion of orthoclase to plagioclase in the groundmass. In addition to feldspar, quartz is present in the groundmass of most specimens, also biotite, hornblende, magnetite, calcite, epidote, zoisite, chlorite, and leucoxene. Considerable of the quartz may be secondary. In a few specimens quartz is estimated to form 15 per cent or more of the area of the groundmass, and in such rocks some of the quartz is considered to be primary; these quartz-bearing lavas are, therefore, dacites.

The rock of a few large outcrops of grey trachyte east of Long lake changes in texture from a fine-grained, non-porphyritic type on the south side to medium-grained, massive porphyritic lava, followed to the north either by a fine-grained, porphyritic, slightly schistose lava showing poorly developed pillow structure, or by a fragmental rock composed of lenticular and angular fragments of a porphyritic rock, similar in appearance to the nearby porphyritic lava, in a fine matrix of greenish grey, chloritic material. The fine-grained pillow and fragmental lava assumed to represent the top parts of flows is followed to the north by a narrow band of fine-grained lava assumed to be the bottom of a younger flow. On a few of the traverses east of the east end of Long lake, this succession of alternating bands of lava differing in texture was noted several times within 500 feet north and south, the areas north and south of the zone of lava showing textural changes being underlain by massive or schistose lava of similar lithological appearance, but showing no sign of textural variation in the exposures examined. No evidence of erosion of the underlying lava was noted along the few assumed flow contacts examined, the contact, though sharp and definite, is undulating, fine-grained lava filling the depressions within the fragmental lava. Tuff beds were not noted among the thick, massive, and schistose dacite and trachyte flows east of Long lake. East of Bernic lake, however, some greyish rocks, near trachyte in mineral content and associated with porphyritic and even granular dacite and trachyte of the type described in the foregoing paragraph, may be consolidated, water-deposited, volcanic products, as in thin section they appear to contain fragments of lava, in addition to angular bits of quartz and feldspar, and an abundance of chloritic material. It is difficult even after a detailed examination of outcrops and thin sections of specimens to decipher the origin of some beds of these greyish rocks, which may be highly altered lava, tuff, or greywacke. The areas of rocks whose origin is doubtful have been mapped as lava.

Andesite, Chlorite Schist, Tuff, and Chert. Black, fine-grained rocks of the mineralogical composition of andesite are abundant members of the Beresford Lake phase. The andesitic rocks are typically exposed southeast of Rice lake, from 1½ to 2½ miles northeast of Long Lake, in the area between Slate lake and Moose river, north of Oiseau river, in the vicinity of Bernic lake, and in Maskwa River area. A few outcrops of the fine-grained lava show pillow structure well developed, whereas many others show no structural or textural features to indicate the origin of the rock. Some of the andesitic rocks are so fine grained as to be almost non-crystalline in appearance. Although the massive andesite appears fresh in hand specimens, the minerals of many of the specimens studied microscopically are altered to secondary products. In slightly altered specimens, lath-shaped crystals of plagioclase and hornblende are the abundant constituents. The plagioclase is oligoclase-andesine in some specimens and andesine in others. The hornblende is green, highly pleochroic, and shows frayed chloritic margins. In addition to hornblende, small flakes of brown biotite are abundant in some specimens. Small specks of magnetite are distributed throughout the thin section, also bits of zoisite, epidote, chlorite, calcite, and leucoxene. In the schistose rock the original texture is destroyed, the feldspars are gone to small bits of quartz and albite and the hornblende and biotite to chlorite and epidote. The plagioclase appears to be the first mineral to be altered, as in the majority of the specimens studied the plagioclase is completely or in part gone to grey, kaolinitic-appearing material, calcite, zoisite, albite, and quartz. The hornblende is only slightly chloritized, in some specimens showing only traces of the original plagioclase crystals. Epidote is abundant in some andesite, either distributed in small grains or localized in round to tabular areas that weather an epidote-green colour. Epidote and quartz are the abundant minerals of such areas and much of the epidote is in crystal form. Some masses of epidotized rock are 3 feet long, the average size of their cross-section, however, is about 11 by 7 inches. Such masses of epidotized rock may be lava that crystallized early and immediately was altered by solutions from the surrounding liquid materials. Seams of epidote also are abundant along some narrow zones in andesite.

Thin bands and lenses of chert-like material with excellent white or greyish lamination lines are locally abundant in the andesitic lava, especially in Wadhope area south of Stovel lake, north of the east end of Long lake, and west of Oro Grande. The lamination-like lines on the surfaces of some outcrops of this rock are crenulated and these present a pattern similar in appearance to that on a piece of planed and stained lumber where rings of wood of slightly different colour form complex markings. In other outcrops the lines are straight or only slightly crenulated. This fine-grained, laminated lava appears to be a phase that cooled quickly under differential pressure causing a flowage movement, thereby developing lamination-like markings. It was thought, accordingly, that such bands or lenses might be formed near the margins of flows, and, if so, this feature might assist in determining structure. This material, however, is of local distribution in the lava and its occurrence was of little value in structural studies.

Dark grey to greenish black, schistose rocks, showing on weathered surfaces either evidence of stratification or bits of light-coloured rock in a schistose groundmass, are interlayered with the andesites at a few localities. In thin section these rocks are composed of angular bits of quartz and feldspar in a matrix of secondary minerals among which chlorite, calcite, epidote, and kaolinite are the most abundant. Rocks of this character within the area of andesitic lava are interpreted as representing deposits of slightly water-sorted volcanic products, perhaps of andesitic composition.

Thin, lenticular beds of chert, cherty tuff, and cherty iron formation are present within the areas of andesitic lava north of the east end of Long lake. The cherty rocks weather white and are dark grey to greenish grey on the fresh surfaces. Host specimens are dense and glassy in appearance, only a few show visible, small, glistening grains of quartz. The chert breaks with a conchoidal fracture into splintery fragments. In some outcrops the chert is bedded, several grey and black laminæ, from one-eighth to one-quarter inch in thickness, alternating within a few inches across the strike. The ferruginous cherts show bedding excellently, five or more, black, iron-rich and light silica layers alternating within a thickness of an inch. Within the chert horizons are other layers of grey rock, from 2 inches to 10 feet or more in thickness, that do not show bedding, but whose weathered surfaces show angular fragments of quartz and feldspar in a cherty matrix. The several chert and cherty tuff beds outcropping south of the Central Manitoba mine were studied in some detail. The largest bed known at this locality is that containing the Kitchener and other nearby, gold-bearing, quartz veins. This bed varies in thickness from 20 to 100 feet and is at least 6,400 feet long. Microscopic study of thin sections of the chert shows an aggregate of quartz grains ranging from 0·01 to 0·06 mm. in diameter. Many of the quartz grains are rounded as of clastic origin, others have interlocking, crenated boundaries and may be recrystallized silica. All the thin sections contain considerable greyish, saussurite-like material, some calcite, chlorite, and sericite. The darker beds contain abundant chloritic material and grains of magnetite. The cherty tuffs without visible sign of bedding show angular fragments up to 1 mm. across of quartz, feldspar, epidote, biotite, and chert in a matrix similar in appearance to that of the bedded chert. Some outcrops exhibit alternating layers of laminated chert and non-laminated tuff. The contact of chert with andesite is sharp and definite wherever observed. The chert or cherty tuff beds do not show variation in size of grain from one side of the bed to the other, ripple-marks, crossbedding, or other evidence to indicate the original top and bottom of the beds. Lenticular bodies of chert up to a foot long were noted within andesite just south of a chert bed exposed along the wagon road just east of the Central Manitoba messhouse. The bedded character of some of the chert indicates that the materials were water sorted. The chert beds between flows of andesitic lava are considered to be clastic deposits formed during the interval between successive flows of lava and in shallow basins of water filling depressions on the surface of the lava field. Many of the chert beds are intruded by small bodies of granite porphyry and others contain quartz veins. The Kitchener and Eclipse veins are within chert adjacent to the contact of a body of massive diabase or basalt. The chert beds within the lavas are thus of considerable economic interest and should be prospected carefully for gold-bearing quartz veins.

Basalt and Diabase. At various horizons among the volcanic and intercalated sedimentary rocks described in the foregoing paragraphs are bands of green to black, medium to coarse-grained, igneous rock that may be either intrusive sills and dykes or flows of basaltic composition. In 1926 some areas of these basic rocks were mapped as intrusive gabbro and diorite. The more detailed studies of these rocks completed during 1929 indicate, however, that the minerals of the medium-grained, basic rocks are altered to secondary products similar to those of the nearby, fine-grained, andesitic lava, and this suggests that these rocks belong to the volcanic series rather than to the younger intrusive group whose minerals are fresh or only slightly altered. The basic rocks of doubtful origin are typically developed at the northeast end of Long lake, at intervals between Long and Moore lakes, northeast of Rice lake, and north of Bernic lake. Some of the areas of rocks of doubtful origin are up to 1 mile wide and 7 or 8 miles long; others are less than 1,000 feet wide and from 3,000 to 5,000 feet long.

The rocks designated basalt and diabase are of variable texture and appearance. An abundant type shows rounded spots of hornblende in a light green matrix, giving a mottled appearance. In a few outcrops white lumps up to three-quarters inch in diameter and composed of feldspar and chloritic material are abundant in a chloritic groundmass. In other specimens flashing cleavage faces of hornblende up to one-quarter inch long are visible in a lighter-coloured, feldspathic groundmass. Augite occurs only sparingly in a few specimens. Over wide areas the rocks are massive to slightly schistose, greenish to black, medium-grained, hornblende-rich types. In such areas no beds of chert or tuff were recognizable. In other areas of basaltic rock, as northeast of the east end of Long lake, thin layers of what are considered to be rhyolitic lavas and others of chert are present. At this locality the bedded tuff at one horizon is in lens-shaped masses within depressions on the north side of a basaltic lava, as if the tuff and chert were deposited in depressions on the lava flow in the interval between the next flow of basalt. This bed and its relations are described in greater detail in a succeeding section. Some outcrops of medium-grained, basaltic rock show poorly developed markings resembling pillows and other outcrops contain round and lenticular lumps, from 4 to 18 inches across, of epidote-green colour and similar to the lumps in the andesite. The epidote lumps, however, are not so abundant nor widespread in the basalts as they are in the andesites, and in the more acidic lavas, as the dacite and rhyolites, this concentration of epidote is not noticeable. A specimen of one of these lumps from basalt is almost entirely of epidote crystals and grains. Other thin sections contain some quartz and chlorite in addition to epidote. The basaltic lava forming the matrix also contains considerable epidote. Lavas carrying epidote lumps are in some outcrops followed to the north by pillow lava, in others by a greyish rock of more acidic character and in part brecciated. Epidote lumps are typically developed on the Anaconda mineral claims south of the road from the Central Manitoba to Oro Grande deposits, and north of the road from Long Lake to Central Manitoba deposit on the Buckeye and Hunter mineral claims.

In places the contact between basaltic lava and andesitic lava is sharp and definite, and here the two types of rock are easily distinguished from one another and mapped separately. In other areas, however, the line of contact does not appear to be sharp, and across the strike basaltic lavas appear to pass gradually into andesitic lavas, the rocks of the contact zone being of slightly coarser grain than the typical andesite and finer than the basalt. Also, basaltic lavas are followed along their projected strike by andesitic lavas on the opposite side of intervening, narrow, drift depressions. No evidence of displacement of the flows by transverse faulting could be found at such localities.

In all, fifteen thin sections of basaltic rock from different parts of the district have been studied microscopically. The minerals are in part or completely altered and the hornblendic rocks might be termed metabasalt, metamorphosed dolerite, or diabase. The thin sections of the least-altered specimens showed a twinned plagioclase, near labradorite, and abundant green hornblende and a few bits of augite. Some of the hornblende may be secondary after augite. Small areas of the labradorite crystals are altered to greyish, saussurite-like material. The outline of the plagioclase crystals is distinct in some specimens, but the surface of the mineral is coated with grey, kaolinitic, or saussurite-like material and the feldspar is undeterminable. Bits of greyish feldspar are included within hornblende; needles of hornblende penetrate some lath-shaped areas of feldspar. The thin sections of the more highly altered, basaltic rocks do not show the outlines of the original feldspar crystals, but show irregular-outlined areas of grains of untwinned, clear feldspar, between albite and oligoclase, bits of quartz, calcite, zoisite, and greyish, undeterminable material. A green amphibole is the abundant constituent in most thin sections. In the schistose rocks, the amphibole is in long, greyish to greenish, chloritic shreds. Some of the amphibole crystals are 2 mm. long. The larger crystals exhibit frayed ends and irregularly outlined sides. Considerable of the amphibole is common hornblende with good cleavage lines, and a part is actinolite in needles and fibrous clusters. Much greenish, chloritic material is present in some thin sections, also considerable, nearly colourless, uralitic-appearing material. Biotite was not recognized in the specimens studied. Magnetite, titanite, and leucoxene are abundant in all specimens. The characteristic alteration of the feldspar to secondary products similar to those developed from the feldspars of the andesitic pillow lava indicates that the coarse-grained basic rocks underwent the same type of alteration as did the nearby lava, and this suggests that the basic rocks also belong to the volcanic series, for the feldspars of the younger intrusives are normally fresh and unaltered although they are penetrated by the hornblende crystals.

Andesite and Dacite Lava and Derived Schists and Thick Beds of Greywacke, Impure Quartzite, Siliceous Carbonate, and Iron Formation. In Beresford-Rice Lakes area the predominantly volcanic rocks described in the foregoing sections are followed to the north by flows of black and grey lavas and beds of quartzose sediments. This horizon of intimately intermixed lavas and sediments outcrops northwest from Garner lake through Beresford, Moore, and Bennett lakes, and farther west along Wanipigow valley and also in the basin of Wallace and Siderock lakes. The individual flows and beds of sediments resemble lithologically the rocks already described under the Beresford Lake phase. The sedimentary members, however, are relatively much thicker and more continuous along their strike than in the area of volcanic rocks, north of Long lake and east of Rice lake.

In Oiseau River area sediments and lavas are interbedded along the south side of the area of volcanic and sedimentary strata assumed to be of Rice Lake age. In this area lavas and sediments are intimately interbedded along Winnipeg river east of Lamprey falls and at Shatford lake.

The sediments of these areas include quartzite, quartz-sericite schist, and beds carrying abundant red garnet, and the lavas are basaltic and andesitic types.

A characteristic member of this group includes the beds of greywacke and impure quartzite extending from Garner lake along Garner creek to Beresford lake and northwest through Moore and Bennett lakes. These are light to dark grey weathering rocks of variable grain size, medium-grained and dense, almost cherty, types being interbedded. Their bedded character, shown by variations in both colour and grain size, is plainly visible on the weathered surface of most outcrops. A few beds show a cleavage parallel the bedding planes. This sedimentary horizon is at least 1,500 feet thick and has been followed 17 miles along its strike. North of Beresford lake the sediments overlie basalt apparently conformably and to the east are followed by grey and black lavas and derived schists with many thin beds of greywacke, tuff, and iron formation.

The volcanic rocks associated with the quartzose sediments are similar in texture and mineral alteration to the lavas already described. A few flows exhibit excellent pillow structure, the most widespread type, however, being a fine-grained, greenish black, slightly schistose rock without pillows. A microscopic study of thin sections of the black rocks intercalated with the sediments in Beresford, Moore, and Wallace lakes shows the feldspars altered to either saussurite-like material or albite, quartz, and calcite, and the hornblende to actinolite and chlorite. The thin sections of the black rocks of these areas resemble closely in appearance those of the andesites already described. Grey, porphyritic, schistose rocks are also present, and these in outcrop and thin section resemble the dacites from east of Long lake. A few outcrops are of typical actinolite, chlorite, or sericite schist. Other slightly schistose rocks contain small fragments of lighter-weathering materials, and these are perhaps consolidated ash. At a few localities, as on the east shore of Beresford lake and the northwest corner of Garner lake, the weathered surfaces of these beds are rough, due to differential weathering of hard and soft parts of the rock. Such rocks in thin section are composed of areas of saussuritized feldspar, large areas of calcite, numerous flakes of brown biotite, and abundant green chlorite and magnetite. Beds of arkose and iron formation, consisting of alternating thin layers of greywacke and cherty magnetite beds, are present in the same general horizon of the carbonate-tuff beds. The iron formation beds are typically exposed along the shore of Garner lake just east of the portage from Beresford lake, east of Moore creek, along the north shore of Siderock lake near the west end, and on the large islands in Wallace lake. East of Moore creek, five iron formation beds, varying from 10 to 60 feet in thickness, were noted within 1,200 feet across the strike, the intervening exposed rocks being andesitic lava showing pillows, green actinolite schist, and bedded, greywacke-like schist. Lenticular masses of fresh-appearing diabase intrude some of the carbonate-tuff and iron formation beds at these localities. All the iron formation beds noted are too low in iron to be of commercial value at present. On Wallace lake, just east of the portage from Bennett lake, two thin beds of grey to white, laminated, siliceous limestone are interlayered with calcareous tuff and thick flows of massive basaltic lava showing pillow structure. Some of the greenish to black tuff, schist, and iron formation beds exposed along the shore of Beresford, Garner, Wallace, and Siderock lakes, are complexly drag-folded, indicating that the Rice Lake formations have been severely deformed. Other beds show markings resembling mud cracks in pattern, but apparently representing joint planes along which veinlets of siliceous material have been deposited.

The sediments interbedded with the lavas along Winnipeg river and at Shatford lake are medium-grained, quartzose, fine-grained, argillite-like, and garnet-rich types. The garnet beds are of local distribution. They are of some economic interest, as at a few points the garnet-rich rocks contain small quantities of iron and copper sulphides. A garnet bed outcropping at intervals from the west end of Shatford lake to over a mile east of this lake has been prospected at a few points for commercial sulphide bodies. This bed is along the contact between lava on the south and greywacke to the north, and it follows the dip and strike of the enclosing volcanic and sedimentary strata. The bed as exposed varies in width from 50 to 90 feet and its contact with the andesite on the south is sharp and definite, whereas to the north beds of greywacke and garnet rock alternate across widths of 12 to 15 feet. The garnet rock is typically dark grey to black. In some outcrops garnet is estimated to form over half the rock, and is distributed in zones varying in width from 2 inches to 3½ feet, and estimated to carry 90 per cent garnet, alternating with layers of black rock carrying only a few small garnets in clusters scattered irregularly. Some outcrops show this garnet-lean rock brecciated into angular fragments set in a matrix of fine, greenish black, chloritic material, which also carries red garnet. In other outcrops the garnets are irregularly distributed throughout the whole outcrop, and here there is no sign of a layered or bedded character.

The abundant garnet is almandite, and for the most part forms well-developed crystals varying from light pink to black in colour. In size the garnet crystals vary from one-tenth inch to over an inch across, the majority, however, being under one-quarter inch in diameter. In the four specimens of the garnet rock studied microscopically the garnets are in irregular-outlined grains and six-sided sections, and the mineral is colourless or very slightly pinkish or greenish. The grains are crossed in two directions by fractures, along some of which grey or greenish grey, chloritic material is developed. Small bits of quartz, feldspar, biotite, chlorite, and magnetite are abundant in most garnet grains. The garnet crystals penetrate and cut across biotite flakes, and evidently the garnet crystallized later than the biotite.

The thin sections contain, in addition to garnet, considerable quartz and feldspar in varying proportions and in small, subangular grains. The feldspar is mostly untwinned and some of it is orthoclase, although albite may also be present. A few grains of twinned plagioclase are present. Biotite is always abundant and is a deep brown, highly pleochroic variety. In one thin section actinolite is present in ribbon-like blades, and in areas with no definite outline. In another thin section there is considerable of a colourless mineral with reddish brown pleochroism and parallel extinction, which is probably anthophyllite, a silicate of magnesia and iron commonly occurring in recrystallized, garnet-mica schist. A few grains of hornblende and pyroxene are also present with the anthophyllite. A green, highly pleochroic chlorite, with deep blue interference colour, is an abundant constituent. Small particles and octahedral grains of magnetite are abundant either as a filling between the other mineral grains or as inclusions in ferromagnesian minerals. In two thin sections pyrrhotite, pyrite, and chalcopyrite are present in small, irregular-shaped patches and veinlets penetrating the silicate minerals, including garnet. The minerals are fresh except for small areas of biotite, which have been bleached to a colourless mica with a high interference colour. One band of quartzose sediments associated with lava and included in the granite, about 1½ miles southeast of Lamprey falls, carries abundant green chrome mica or fuchsite. Some of this material has been shipped to decorate stucco surfaces.

WANIPIGOW PHASE

General Character and Distribution

The Wanipigow phase of the Rice Lake series includes the medium to coarse-grained, quartzose sediments outcropping typically west of Rice and Red Rice lakes in Beresford-Rice Lakes area, and east from the east end of lac du Bonnet in Oiseau River area. In these areas the sediments are characteristically thick-bedded quartzite, grit, arkose, and greywacke with thinner, dark, slaty beds and lenses of conglomerate. Volcanic rocks are not known to be widespread, although grey lavas, showing pillow structure and similar in appearance to the dacite and dacite porphyry from east of Long lake, are exposed at a few localities along Wanipigow valley westward from Rice lake. The volcanic members of the group outcrop in long, narrow areas, and may be studied just north of the Manitoba government motor road about 2½ miles east of the west end of the road on Wanipigow river. Detailed field work may prove that some of the massive-appearing, grey rocks mapped as greywacke along Wanipigow valley are also of volcanic origin.

Lithological Character

Quartzite, arkose, and grit are abundant members of this group. At many localities the beds of the quartzite are thick; the character of the materials appears uniform through thicknesses as great as 20 feet or more. In places such thick beds grade into finer-grained, darker-coloured material. Thin sections of the massive quartzite show rounded quartz grains with a few bits of plagioclase feldspar, and some white mica and magnetite. At a few horizons the thick quartzite and arkose beds are separated by beds that are crossbedded on a large scale. This type of crossbedding consists of a single bed of diagonal layers bounded above and below by parallel beds marking the strike and dip of the formation. Other outcrops of quartzose sediments show peculiar markings thought to represent slip-bedding formed by adjustment of the beds relative to one another. At other horizons thin beds of slate and fine-grained, dark, greywacke-like rocks are present between the quartzite beds. Thin conglomerate beds also alternate with quartzite and slaty beds at several places along the south slope of the hill west of Red Rice lake. The conglomerate consists of rounded boulders of granite, green rock resembling basaltic lava in appearance, chert, and quartzite ranging from 1 inch to 6 inches in diameter, and embedded in a dark, dense groundmass. To the north of the conglomeratic horizon quartzite beds from 1 foot to 10 feet in thickness alternate with slate beds from 2 feet to 3 feet in thickness and sandy horizons showing crossbedding and other peculiar structures and markings. The arkose and grit beds show indistinct evidence of bedding and are composed of angular fragments of quartz and feldspar up to one-half inch long. Some outcrops contain considerable white, sericitic mica and other beds of sediments are typical quartz-sericite schist, with the quartz grains granulated and drawn into "eye" shapes. The sediments of this group, however, are much less metamorphosed on the whole than are the fine-grained, quartzose sediments of the Manigotagan phase previously described.

In Oiseau River area, long, parallel ridges of thick-bedded, quartzose sediments, similar in texture, mineral content, and degree of metamorphism to the sediments west of Rice lake, outcrop north and south of Oiseau river, for 10 miles east from the east end of lac du Bonnet. In both these areas the quartzose sediments outcrop prominently, due to their resistance to erosion. The sediments exposed along Oiseau river vary in colour from light grey to dark grey or nearly black. The quartzite is thick bedded and massive; the greywacke is as a whole thinner bedded, and, in a number of localities, is well laminated. The arkose-like sediments were noted only locally, and in two cases showed poorly developed crossbedding and contained a few, small, quartz pebbles. The coarse-grained, quartzose sediments along Oiseau valley appear to be conformably interlayered with or on top of the andesitic, volcanic rocks.

STRUCTURAL FEATURES OF THE RICE LAKE SERIES

Relations to Granite Bodies

As already indicated, the Rice Lake series is older than the granitic intrusives and also older than sill-like bodies of peridotite and gabbro and dykes of granite porphyry. The intrusive relations of the granite are indicated in many outcrops, where along the contact the granite exhibits a fine-grained, dense margin, an inch or more wide, against the lavas or sediments. Included bodies of the older rocks are, also, locally abundant within the granite, and at a few localities dykes of granite cut across the schistosity and bedding of the sediments. At a few localities a contact zone nearly a mile wide is developed between granite and sediments wherein the two types of rock are intimately intermixed. Granite pebbles in conglomerate beds and locally in lava[1] of the Rice Lake series indicate

[1]Wright, J. F.: "Rice Lake Map-area, Southeastern Manitoba"; Geol. Surv., Canada, Sum. Rept. 1922, pt. C, p. 51 and Pl. VI A.

that granites were exposed nearby at the time a part of the series was being deposited, but in the field no outcrops of these granite bodies were recognized. At a few localities west of Red Rice lake the granite magma had no noticeable effect on the adjoining Wanipigow sediments, and, along the foot of a northward-facing hill about 10,000 feet west of Red Rice lake, several outcrops close to the margin of the granite consist of angular fragments of granite in a schistose, sedimentary matrix, and the rock might be interpreted as having been deposited on the granite. Farther to the west, however, a dyke of granite from the granite body penetrates the Wanipigow sediments.

A noticeable feature is the close parallelism of the trend of the formations to the courses pursued by the margins of the large, granite bodies. This feature is shown exceptionally well from west of Bennett lake southeast to Beresford lake, where the strike of the strata changes from nearly east through southeast to nearly south within 15 miles along the strike parallel with a broad arch in the granite contact to the east. The strike and dip of the belts of sediments and lavas within the granite also parallel the trend of the beds of similar rocks in their larger, nearby areas. The marked parallelism of the trend of the beds with the courses of granite contacts, and the correspondence between the attitudes of masses of sediments and lavas within the granite and the attitudes of nearby, large areas, suggest that granitic magma penetrated the older rocks after they had been folded into their present positions.

Trend, Interbedded Character, and Basis of Subdivision

As indicated by the geological maps of the areas in southeastern Manitoba underlain by Rice Lake formations, the several groups of rocks are distributed in long belts trending northwest and west. These directions are the structural trend of the rock formations, and are indicated in the field by the rock ridges, valleys, drainage, and strike of the beds. The beds in these long, narrow belts are nearly vertical and, therefore, the width of the various belts, as shown on maps, represents more nearly the thicknesses of the formations than their original horizontal extent.

The evidence of detailed mapping of the areas underlain by members of the Rice Lake series proves that long, narrow bands of sediments are present among the volcanic rocks and vice versa. The strike and dip of the schistosity, secondary cleavage, and, in a few outcrops, the bedding of these rocks are parallel. The bands of various formations parallel each other along their strike, and at no place was evidence noted of a structural discordance between the various types of rocks included within the series. Many of the thin beds of chert and iron formation are known to occupy a conformable position within the Beresford Lake volcanics, and thus to represent sediments laid down on lava flows. However, as will be indicated in a later section of this report, the character of the folding the series has undergone is not known, and it is possible, therefore, that two or more unconformable series of rocks may be folded into apparently conformable positions, though it seems highly improbable that, for instance, all the various belts of sediments owe their position within the area of volcanic rocks to complex folding and faulting.

The basis of subdivision of the Rice Lake series of apparently interbedded lavas and sediments into three main groups is lithological rather than structural. Even a lithological division of the series, however, is not altogether satisfactory because boundaries cannot everywhere be sharply fixed between the several units in consequence of the intimately intermixed and changeable character of the strata at different localities along the strike. This feature is well illustrated in the area along Manigotagan river east of Long lake, where a few outcrops of pyroclastic beds and rhyolite flows are present among outcrops of quartzose sediments of the Manigotagan phase. North of a certain point at this locality the exposed rocks are predominantly lavas of the Beresford group whereas to the south one-half mile no lavas were recognized within the sediments of the Manigotagan group. The contact zone, wherein rocks of the two groups appear intermixed, is interpreted as representing a transition stage from sedimentary conditions to essentially volcanic conditions. The character of the strata and the relative proportion of lavas to sediments within these transition zones appear to be variable along the strike, and this also makes the fixing of contacts between the groups somewhat arbitrary. The difficulty in fixing a contact between two lithological units is well illustrated along Wanipigow valley where rocks designated the Beresford Lake phase at Beresford lake were traced northwest and found to grade into strata of different character and perhaps of the same age as a part of the Wanipigow phase as developed north of Rice lake.

Relations of Beresford Lake Lavas and Wanipigow Sediments

The relations of the Beresford Lake lavas to the Wanipigow sediments were studied in some detail in the vicinity of Red Rice and Rice lakes where the volcanic rocks end rather abruptly and Wanipigow sediments are exposed to the west along the projected strike of the lavas. A fairly large, drift-filled depression lies along this contact zone and outcrops are small and scarce in an area from 2,000 to 4,000 feet wide between the high ridges of lava on the east and of thick-bedded, quartzose sediments on the west. At first the Wanipigow sediments were assumed to have been faulted into their present position with respect to the lavas, but detailed field work on the high ridges south of Red Rice and north of Rice lake along the projected strike of such a fault failed to locate evidence of the continuation of the fault in these directions. Moreover, a number of outcrops in the area between Red Rice and Rice lakes are of both sediments and lavas, and apparently the sediments from the west and the lavas from the east interfinger. Just north of the northwest corner of Red Rice lake, porphyritic trachyte showing poorly developed pillows is followed to the north and south by quartzose sediments. The lava band is 260 feet wide, and 1,100 feet along the strike to the west the lava ends and crossbedded quartzite is exposed at this horizon. South of the outlet of Rice lake a large outcrop shows a quartzite band 300 feet wide bordered by porphyritic lava on its north and south sides. This quartzite horizon extends at least 1,000 feet within the area of lavas. Northwest of Rice lake and south of Round lake bands of grey trachyte and black pillow lava are exposed between areas of greywacke and quartzite. The lavas are of the same grain size adjacent to the beds of sediments as in the interior of the areas of volcanic rocks. The interpretation of the contact relations between the Wanipigow sediments and the Rice Lake lavas is that these two groups of rocks were formed during the same period, and that their interfingered contact represents a rather sharp line of demarcation between an area of dominant volcanic activity to the east and one of sedimentation in shallow water to the west.

Determinations of Structure, Folds, and Thickness of Beds

To determine accurately the detailed structure of the areas of steeply dipping sediments and lavas it is essential to know the top or bottom of the beds at many points throughout the area. Unfortunately, however, the top of the beds can be determined only locally, for in most parts of the district the original texture of the strata has been destroyed by shearing and recrystallization. In Beresford-Rice Lakes area, the prevailing dip of the bedding, cleavage, and schistosity is northward; only locally were southward dips noted. The top of some of the beds of fine-grained, laminated, quartzose sediments south of the northwest end of Gem lake is on the north side, as here several beds within a horizon a mile or more wide show a gradation from quartzite of medium grain on the south side to cherty, almost dense, quartzite on the north side. Many other, nearby beds do not show a change in fabric across the strike, but where the change is shown the contrast in size of grains along the edges of beds less than an inch in thickness is such as to be readily recognized on the weathered surface. The beds here strike northwest and dip from 75 to 85 degrees north.

At the east end of Long lake the top of some lava flows apparently faces north, for a number of outcrops show brecciated lava followed to the north by massive lava of fine to medium grain. The brecciated rock is interpreted as a flow breccia formed along the margin of the lava flows during extrusion. In some outcrops, fine-grained, grey lava adjoining the brecciated rock on the south shows poorly developed pillow structure. A few outcrops show the irregular north side of the brecciated lava to be followed by fine-grained lava, which grades into porphyritic to medium-grained rock, and this in turn into finer-grained, grey lava showing pillow structure or flow breccia. The flows showing thin, brecciated margins are traceable at intervals for a mile or more along their strike of a little south of east. The dip of the beds appears to be from 78 to 85 degrees north.

In preceding paragraphs chert, tuff, and iron formation beds have been described as occurring among the lava flows, particularly in the area northeast of Long lake. Many of these beds of sediments do not show features to indicate their top or bottom. One chert bed east of Bidou lake, however, appears to have been deposited on an irregular surface of a lava flow, perhaps developed in part by erosion in the interval between the extrusion of the flows. This bed was followed carefully along its strike and its north side is straight, whereas the south contact is irregular, causing the thickness of the bed to increase abruptly from 1 foot to as much as 14 feet at one point. One wide body of chert is about 10 feet long at the south side and 25 feet long at the north side, the ends converging with steep and flat stretches somewhat resembling steps. The cherty material is bedded, the south or assumed bottom layers are of cherty tuff and cherty quartzite and these are followed to the north by alternating layers of chert and cherty quartzite. The beds are fairly uniform in thickness throughout their length and are curved slightly to the south. This chert bed is exposed 700 and 1,200 feet east and west, respectively, of the thick mass described. The thickness of the bed along these distances varies from less than 1 foot to 3 or 4 feet. The chert is complexly drag-folded adjacent to the thicker portions of the beds. To the north the chert bed is followed by a thick mass of black, medium-grained, basaltic rock. This contact zone between greenish grey lava on the south and black, fine-grained rock on the north is fairly well exposed at intervals for 2 miles from east of Bidou lake southeast to Stormy lake. In this distance two additional thin lenses of chert were noted along this contact. Some of the chert is complexly drag-folded. No chert was recognized in other outcrops along the projected strike of the contact, which apparently is represented along considerable distances by a narrow zone of highly schistose rock. The irregular south side of the chert bed and the coarser grain of the sediments at the south side of the wide area of chert described above suggest that this chert bed was deposited on an irregular surface of the lava to the south, and if so the top of the strata here faces north. The lavas and intercalated sediments for ½ mile north and 1 mile south of this contact zone dip northward, and there is no evidence that in this section the beds are closely folded or overturned.

A few beds of the Wanipigow sediments show crossbedding to indicate their top, and in the area west of Rice lake and along Wanipigow valley east of Wanipigow lake, the coarse-grained quartzose and greywacke-like sediments strike nearly east and west and dip from 40 to 70 degrees north. The top side of the beds of these sediments showing cross lamination is to the north, and careful sections made across the area underlain by these strata did not show evidence of close folding or overturning of the beds.

In Oiseau River area the various formations of the sedimentary and volcanic complex assumed to be the equivalent of the Rice Lake series of Beresford-Rice Lakes area have been folded along a general east-west axis; but here, also, the absence of recognizable horizon-markers and definite knowledge of the top side of the beds make it difficult to work out this structure in detail. The mica schists exposed in the basin of Davidson, Booster, Flanders, and Ryerson lakes appear to be folded into one or more small anticlines and synclines. The conglomerate beds northeast of Booster lake apparently are along the axis of one of these anticlinal folds plunging to the northwest. The lava and interbedded sediments along Winnipeg river east of Lamprey falls also appear to be closely folded. The beds of the wide area of lavas and sediments along Oiseau valley and between the large granite bodies respectively north and south of the river dip from 70 to 85 degrees southward, and no evidence of overturning of the bed or close isoclinal folding was noted north of Oiseau river. South of the river, however, and especially in the vicinity of Shatford and Bernic lakes, the beds locally dip northward away from the intrusive bodies and perhaps a number of small local folds are developed along the south margin of the belt of sediments and lavas. However, the prevailing regional dip of the lavas and sediments along Oiseau valley is southward and an interpretation of their structure is that these rocks represent the remnant of the north limb of a synclinorium, whose axis, now occupied by intrusives, lay somewhere between Bernic lake and Winnipeg river.

The volcanic rocks of Maskwa River area are locally schistose; the trend of the schistosity is east and the dip from 65 to 85 degrees south. The few, thin, tuff beds recognized within the lavas also appear to dip southward and parallel the schistosity of the lavas. The foliation planes of a few outcrops of sedimentary, garnet-bearing gneiss along the north side of the area of volcanic rocks also dip steeply to the south. The Maskwa River area of lavas with minor amounts of sediments is regarded as a large, elliptical-outlined inclusion in the granite and granite-gneiss. The lavas and associated tuffs of Maskwa area are perhaps equivalent in age to the Beresford Lake phase of the Rice Lake series as developed northeast of the east end of Long lake.

Although the prevailing dip of the bedding, where recognizable, of the schistosity, cleavage, and axial planes of drag-folds is to the north in Beresford-Rice Lakes area and to the south in Oiseau River area, this does not necessarily indicate that the beds are not closely folded nor that the thickness of the strata exposed can be calculated from the width and dip of the various formations. In these areas the thick-bedded, quartzose sediments show a general regularity of strike and dip, whereas some of the intervening beds of slaty schist, tuff, greywacke, and iron formation are characterized by pronounced drag-folding. In these drag-folded horizons the bedding, where recognizable, is intimately crenulated and shows no definite relation in direction to the cleavage, which appears to be parallel to the axial planes of the drag-folds. It is thus impossible to determine the true dip of the drag-folded horizons unless vertical sections are exposed to show the actual downward continuation of the drag-folded beds. Although the cleavage and axial planes of the drag-folds may dip steeply and be parallel over wide areas, the beds at some localities may have comparatively flat dips, and be repeated several times in a series of close folds. A series of close, overturned, isoclinal folds may also be present, for these structures are difficult to recognize without definite horizon markers and a knowledge of the top and bottom sides of the beds. For the foregoing reasons, no very definite statement is made with reference to the detailed structure or thickness of the Rice Lake series. The following are estimates of the minimum thicknesses of the three phases of the Rice Lake series as developed in Beresford-Rice Lakes area: Manigotagan phase 5,400 feet; Beresford Lake phase 10,700 feet; and Wanipigow phase 12,100 feet. The Wanipigow phase is believed to be equivalent to a part of the Beresford Lake phases, and the minimum total thickness of the series exposed is estimated at nearly 16,100 feet. These estimates of thicknesses are based on a study of horizons within the series where tops of beds could be determined, and no evidence was recognized of close or overturned folding. All horizons wherein the structure was in doubt have been omitted from the calculations, consequently, the series may be many times thicker than indicated by the foregoing figures.

Faulting

No field evidence of faults having marked displacements was noted in the areas of Rice Lake formations mapped in southeastern Manitoba. Along a few zones there has been fracturing and schistifying of the rocks across considerable widths. The gold-bearing quartz veins and replacement, copper-nickel, sulphide bodies are along such deformed zones within the volcanic and sedimentary strata, and also locally within the granitic intrusives. There does not appear to have been very extensive movement along the mineralized shear zones. The Rice Lake series may be cut by strike faults having considerable displacements, but these are difficult to locate in an area where the rocks are considerably deformed and metamorphosed.

Summary of Succession and Basis of Correlation

The succession of strata and conditions of origin of the Rice Lake series of the original or Beresford-Rice Lakes area appears to be somewhat as follows:

(1) A period of dominant sedimentation during which fine-grained quartzose and clayey sediments, represented by the Manigotagan phase, were deposited, perhaps in part under considerable depths of water.

(2) A period, represented by the Beresford Lake lavas, during which essentially volcanic conditions predominated and many lava flows, ranging in mineralogical composition from rhyolite to basalt, were poured out. The different types of lava are in part interlayered, and locally associated with the volcanic rocks are beds of chert, iron formation, and tuff. These lenticular bodies of sediments are thought to represent deposits of volcanic ash and precipitates of material of volcanic origin formed during the intervals between the successive lava extrusions and in lakes on the surface of the lava field.

(3) A period, represented by the Wanipigow phase, wherein vulcanism conditions again gave place to sedimentation, perhaps under continental conditions. At some localities, as in the vicinity of Red Rice lake, the change from essentially volcanic conditions to sedimentation took place abruptly along the strike, as the coarse, gritty, quartzose sediments here appear to replace lava flows to the westward along the strike of the formations. In other parts of the area the change from vulcanism to sedimentation appears to have been gradational, and at these localities a considerable thickness of intercalated lava flows and bedded deposits accumulated.

The origin and succession of the Rice Lake series are regarded as somewhat similar to the Keewatin series as described by Lawson[1] in Lake of the Woods to the south as a period of " an extremely rapid process of deposition of intimately associated, and often alternating, volcanic ejecta-

[1] Geol. Surv., Canada, Sum. Rept. 1885, pt. CC, p. 49.

menta (both flows and tuffs) and aqueous sedimentation, the material for which was derived partly from the volcanic products and partly from more siliceous and acidic rocks which seem to have constituted the original floor or trough." It is plain that the Keewatin series as originally defined contained considerable sedimentary material in addition to lava flows, and in this respect the complex of volcanic and sedimentary strata of southeastern Manitoba closely resembles the Keewatin of nearby areas in western Ontario.

As the several areas of pre-granite rocks of surficial origin in southeastern Manitoba are surrounded by granite and granite-gneiss, it is impossible to trace the formations directly from one area to the other and thereby to present a well-proved correlation of the various groups of sediments and lavas. However, that the sediments and lavas of Beresford-Rice Lakes and Oiseau River areas may belong to the same series is suggested by the similarity of the general lithological features and succession of the strata of the two nearby areas, and also by the broad structural features of the district, for, as has already been indicated, the prevailing dip of the beds, schistosity, cleavage, and axial planes of drag-folds is steeply north in Beresford-Rice Lakes area, whereas in Oiseau River area the dip of these structures is southward. The intervening country between these two areas, so far as is known, is underlain by granite and granite-gneiss containing scattered, included masses of lavas, sediments, and basic, intrusive rocks. The outward dip of the beds on the north and south sides, respectively, of this granite body and the inclusions of older rocks within the intervening granite suggest that the granite body had a general, flat, upper surface and that the areas of lavas and sediments of Beresford-Rice lakes, Maskwa and Oiseau Rivers areas represent remnants or large roof pendants in the granite of the same series, designated the Rice Lake series, that once extended continuously over the granite between these areas. At the time of the granitic invasion, the Rice Lake formations are considered to have been broadly folded, permitting the granitic magma to reach relatively higher elevations along the crests of the broad, anticlinal arches while remaining at deeper levels in the adjoining synclinal areas representing structural depressions. Erosion has removed the sediments and lavas from the arches, but has not yet gone deep enough to completely remove the intruded rocks from the synclinal basins or structural depressions.

PLUTONIC INTRUSIVES

GENERAL CHARACTER AND DISTRIBUTION

Bodies of intrusive rock, ranging in size from a few feet to many miles across and varying in mineralogical composition from peridotite and gabbro to granodiorite and granite, are present in southeastern Manitoba. The basic intrusives are in small dykes and sill-like bodies and include peridotite, hornblende, gabbro, and diorite. Intrusives of this type cut members of the Rice Lake series north of Oiseau river, in Maskwa River area, and in the vicinity of Garner and Halfway lakes, Beresford-Rice Lakes area. Basic rocks are also present within the granite south of

Tooth lake, in English Brook area, and east of Goldeye lake near the mouth of Wanipigow river. Intrusive bodies near quartz diorite and granodiorite in mineral content, are present north of Winnipeg river east of Lamprey falls, and areas of the granitic body between Long and Gold lakes in Beresford-Rice Lakes area are near granodiorite in mineral composition. Dykes of granite porphyry are abundant in the formations of the Rice Lake series around the east and west ends of the granitic body between Long and Gold lakes. As indicated in foregoing sections of this report, granitic rocks are by far the most widespread types exposed in southeastern Manitoba. The granites vary slightly in colour, texture, and mineral content from point to point in the district. They are typically grey to pink in colour, of coarse grain, and only locally porphyritic. A pink microcline granite is typically developed along the south side of Oiseau River area. To the north this granite is followed by a grey oligoclase granite or granodiorite. The granites of Beresford-Rice Lakes area outcropping south of Manigotagan and Moose rivers and north of Wanipigow river carry abundant microcline and a high percentage of quartz. Both massive and foliated types are developed in these areas, also banded gneiss, due to the penetration of the granite magma along the bedding planes of the Manigotagan sediments. A few small bodies of a characteristic massive, pink, hornblende-bearing granite cut the foliated and banded gneiss in the area from Turtle lake to southeast of Manigotagan lake. Pegmatite dykes are abundant north of the microcline-granite body south of Winnipeg river, and also from Clearwater lake southeast through Manigotagan lake and up Moose river to beyond Tooth lake. The majority of these pegmatite bodies are rich in microcline. A few in Oiseau River area and in the vicinity of Cat lake, about halfway between Manigotagan lake and Pointe du Bois on Winnipeg river, however, are rich in soda feldspar and the tin and lithium deposits of these areas are in these pegmatites.

The intrusive rocks of the district are divided, for the purpose of giving a more detailed lithological description, into the following groups.

(1) Peridotite
(2) Hornblende, gabbro and diorite
(3) Porphyritic and non-porphyritic quartz diorite, granodiorite, and granite
(4) Dykes of granite porphyry
(5) Grey granodiorite and granite of Beresford-Rice Lakes area
(6) Grey granodiorite and oligoclase granite of Oiseau River area
(7) Pink hornblende granite
(8) Pink microcline granite, Oiseau River area
(9) Grey granite and granite-gneiss
(10) Microcline pegmatite
(11) Albite pegmatite and pegmatitic albite granite
(12) Diabase dykes

PERIDOTITE

Small, elongate bodies of black or dark green, massive, igneous rock near peridotite in mineralogical composition are present west from the east end of Oiseau lake, on Garner lake, and at Goldeye lake near the mouth of Wanipigow river. The nickel-copper sulphide bodies are close to masses of peridotite in Oiseau River area, and parts of the Goldeye Lake peridotite body altered to serpentine are being quarried for the manufacture of interior decorative stone. In general appearance these rocks are coarser in grain than the basic lavas and some outcrops weather brownish, others light grey, and others show parallel, light-coloured veinlets of asbestos-like material up to one-quarter inch wide. Some of the peridotite is crossed by cracks, and areas of the surface of such outcrops weather with small, irregularly oriented depressions, representing shrinkage joint planes formed during the consolidation of the magma. The weathered surfaces of other outcrops show markings somewhat similar to poorly developed pillows and also exhibit other features suggesting flow structures.

Thin sections of specimens of peridotite show a mat of fibrous minerals including pyroxene (tremolite), amphibole, serpentine, talc, and chlorite with no signs of the outline of the original mineral grains. The typical augite interference colour and right-angled cleavage are still recognizable in the centre of a few areas of altered material. Other minerals with a bluish interference colour, and holding abundant specks of magnetite, resemble the serpentine-like alteration products of olivine. A few irregularly outlined areas of a mineral with good amphibole cleavage, probably uralite, were noted within the fibrous material. No feldspar or feldspar alteration products were recognized in the peridotites of Oiseau River area. The peridotite on Garner lake contains rounded grains of feldspar included in the amphibole. This mass also contains considerable pyroxene showing a fine lamellar structure characteristic of some diallage. The surfaces of many outcrops of peridotite weather brownish and a few outcrops on Garner lake show numerous, short, irregularly oriented cracks, perhaps representing shrinkage joint planes formed by contraction during the consolidation of the magma. Noticeable features of the peridotites are the scarcity of fresh minerals and of feldspar, the great abundance of amphibole-like alteration material, and the uniform appearance of the materials of the thin sections studied.

What was judged to be a representative sample of peridotite was collected from the Martin mineral claim, north of Oiseau river and 3½ miles west of the west end of Oiseau lake. In hand specimen this rock appears perfectly fresh and massive, but in thin section no trace of the original minerals is recognizable, there remaining an aggregate of tremolite, serpentine, uralite, chlorite, and magnetite. The following is a chemical analysis[1] of a representative sample of this rock.

SiO_2	42.88
Al_2O_3	3.54
Fe_2O_3	10.38
FeO	4.90
MgO	25.13
CaO	6.50
Na_2O	none
K_2O	none
H_2O+	5.36
H_2O-	0.44
CO_2	trace
TiO_2	0.29
Ni	0.12
Au	none
	99.54

[1] Analyst, A. Sadler, Chemist, Mines Branch, Dept. of Mines, Canada.

The low per cent of Al_2O_3, which is regarded as rather stable under metamorphic conditions, indicates that the rock was not originally a norite, olivine norite, or differentiate in situ from a norite or gabbro magma. The absence of Na_2O and K_2O indicates that the Al_2O_3 must be accounted for in the ferromagnesian minerals. The CaO content is far too low for pyroxene-rich rocks. It is concluded from the available data that amphibole was an abundant primary mineral of these rocks and they are regarded as highly altered, amphibole peridotites. The analyses given correspond closely with that of the average of seven amphibole peridotites tabulated on page 29 of Daly's " Igneous Rocks and Their Origin."

A few small bodies of rock composed entirely of hornblende are present in the region. Two of these, respectively, on the Chance and Devlin mineral claims of Oiseau River area, were studied in detail. On the Chance claim the hornblende rock is banded by peridotite containing bunches and veinlets of large hornblende crystals and of sulphides. In some parts of these bodies the hornblende has developed as individual crystals one inch long. Some of the hornblende is deep green and highly pleochroic, whereas other lath-shaped crystals are nearly colourless and only slightly pleochroic. Some crystals of amphibole have a slightly brownish pleochroism. Other crystals are coloured and highly pleochroic in their central areas, but around the rims are colourless. The sulphides associated with this hornblende-rich rock clearly replace the amphibole, and the bleached and colourless character of some of the hornblende may have resulted from alterations by the sulphide-bearing materials. Wherever noted the bodies of hornblendite are small, not over several hundred feet long and from 2 to 12 feet in width.

The peridotite intrudes members of the Rice Lake series and is included as large fragments in the granite. At no place were peridotite and gabbro or other basic intrusives seen in contact, for wherever the two basic types approach each other, they are separated by a drift-covered depression. It is thought that the basic rocks represent sills or dykes that were intruded separately, but very probably at about the same time, into members of the Rice Lake series, their intrusion taking place before the invasion of the granite magma which forms the large bodies of granite exposed in the district.

HORNBLENDE GABBRO AND DIORITE

A number of dyke-shaped, intrusive masses of gabbro and diorite are present in areas underlain by members of the Rice Lake series. Many other outcrops of rocks with grain size and mineral composition similar to that of the intrusives, but whose age relations are unknown, are also present within the areas underlain by volcanic strata of the Rice Lake series. The larger intrusive bodies of basic rock recognized are in the area north of Oiseau river from the east end of lac du Bonnet to the west end of Oiseau lake, in Maskwa River area just southeast of the junction of Maskwa river and Cat creek, and in Beresford-Rice Lakes area from Garner lake northwest to Beaver lake north of Wanipigow river. Gabbro is also present in the granite areas south of Tooth lake on Moose river, north of Wanipigow river in the vicinity of Broadleaf river, and from south of English lake at intervals east to Goldeye lake near the mouth of Wanipigow river. In Oiseau and Maskwa Rivers areas some of the bodies of copper and nickel-bearing sulphides occur in members of the Rice Lake series adjacent to bodies of gabbro.

The gabbro and diorite are similar in their general appearance. Dark grey or white, shining crystals of feldspar and green and black amphibole are recognizable in most outcrops. In some outcrops, the amphibole is segregated in lumps, giving a mottled appearance. In others, white plagioclase predominates and the amphibole is distributed in narrow, irregular-outlined areas between the feldspar crystals. Some bodies are variable in mineral composition, for areas rich in plagioclase and others apparently composed almost entirely of ferromagnesian minerals are distributed irregularly throughout the mass, and without showing a tendency for basic and acidic phases to be located near one or other margin of the body as if the result of gravitative differentiation. The basic intrusive rocks are for the most part massive and although these rocks have been subjected to some deformation, they show little evidence of schistose or gneissic structure, except along a few zones 5 to 20 feet wide where the gabbro has been converted to a light green, in many cases reddish stained, chlorite-saussurite schist. Some of these zones of schistose gabbro carry gold-bearing quartz and along others magnetite, pyrrhotite, and chalcopyrite are present sparingly.

Under the microscope the texture of many specimens of gabbro and diorite is diabasic, the amphibole having crystallized later than the feldspar. In other specimens feldspar crystals contain rounded grains and needle-shaped crystals of amphibole, indicating that some at least of the ferromagnesian minerals crystallized early. The abundant feldspar of the gabbro is labradorite with a mean index of refraction near 1·560. In other specimens studied the feldspar is andesine or slightly more sodic, and these types are diorites. A few grains of quartz are visible on the weathered surface of some outcrops; such types perhaps have a mineral composition near quartz diorite. The feldspar crystals are characteristically lath shaped, some show undulatory extinction, others are bent, and a few crystals are broken, the cracks being filled with veinlets of clacite, actinolite, or uralite-like material. Bits of amphibole and magnetite scattered through some crystals give the labradorite a dark colour, whereas others are flesh-coloured, due to kaolin-like alteration products. Some plagioclase is in part altered in saussurite-like material containing bits of zoisite, epidote, and calcite.

The amphibole is for the most part a light green, highly pleochroic variety occurring in single, compact crystals and in aggregates of acicular crystals and shreds. Much of it is hornblende, though actinolite is present and other varieties of amphibole may be represented. No augite was recognized in the specimens examined microscopically nor was evidence noted to suggest that the hornblende is secondary after augite. The ends of many crystals of hornblende are frayed and these crystals have a bleached appearance, with flakes of brown biotite and bits of magnetite developed along the cleavage planes. Some of the amphibole is also altered to chloritic material and nearly colourless, slightly pleochroic amphibole associated with the areas of chloritic material may be pargasite. Magnetite is an abundant accessory mineral in the gabbro and diorite. Some of the magnetite is titaniferous, for the grains weather around the edges to a material white in reflected light and which resembles leucoxene. Apparently primary brown and green biotite are abundant in a few thin sections. No orthoclase has been determined in the thin sections of the gabbro and diorite examined. The minerals of these rocks are fresh and unaltered as compared with the minerals of the peridotites previously described and also as compared with the constituents of much of the basaltic lava of the Beresford phase of the Rice Lake series.

Variation in texture and mineral composition from the normal type of gabbro described in the foregoing paragraphs is shown locally where much coarser grained, more basic and more acidic phases are developed. In Oiseau Lake area, just north of the south line of section 28, range 15, township 17, a white, aplitic-looking band from 20 to 50 feet in width is exposed for 1,500 feet along the south side of a hill of gabbro. The south margin of the aplitic band is drift covered; slaty and cherty sediments outcrop beyond the drift-filled depression 250 feet to the south. The north contact with the gabbro is well exposed on the side of the hill, and is clearly gradational; the acidic rock grades northward within a distance of 15 feet into medium-grained, hornblende gabbro. In thin section the white rock from the south side of the outcrop carries abundant quartz and oligoclase and a little hornblende. The grains show crenulated, interlocking contacts. A specimen 30 feet north of the south edge of the exposed mass contains only a little quartz and shows a texture similar to the specimen described above. A specimen 15 feet farther north has lath-shaped crystals of feldspar and is typical gabbro. A noticeable feature of the specimens of acidic rock is well-formed crystals of titanite and of calcite, the latter showing rhombohedral forms. The texture and character of this acidic rock, along the edge of this gabbro outcrop, suggest that it originated from a digestion of sedimentary material by the gabbro magma.

A very characteristic feature of outcrops of some gabbro masses is white-weathering areas composed of large feldspar crystals with hornblende filling the interstices between the feldspar crystals. Some such areas are only a foot in diameter, but others 100 feet long were noted. Some of these areas show a sharp line of demarcation with normal gabbro, whereas in other cases a few, large, white, feldspar crystals are scattered through the gabbro for several feet from the main feldspar-rich mass. Outcrops of coarse, pegmatitic gabbro were seen only on top or near the top of gabbro hills, although not all gabbro hills showed this feature. The feldspar crystals are of variable size from $\frac{1}{4}$ to 2 inches long; large and small crystals are intermixed in some outcrops and in others the crystals are of uniform size. The feldspars determined are oligoclase and andesine from different outcrops. The hornblende crystallized later than the feldspar and is a fresh, highly pleochroic, green variety. Such bodies of coarser-grained rock within the gabbro are considered to represent segregations somewhat like pegmatite segregations in granite.

The basic phases of the gabbro are small, rounded patches of erratic distribution, and are present in most of the larger bodies of this rock. They appear as green and black areas and are composed of large crystals of hornblende and many small grains of magnetite. In appearance these masses resemble the peridotite, but in thin section the hornblende is fresh or only slightly altered in comparison with the minerals of the peridotite, which are almost entirely replaced by secondary products. These areas rich in hornblende apparently also represent local segregations of the minerals within the gabbro magma.

The gabbro-diabase-diorite masses within the Rice Lake series are in large bodies with their longer axes parallel to the strike of the enclosing rocks, except locally where the basic rock cuts across the general trend of the older rocks. Some bodies of gabbro show definite, chilled margins against the older rocks, whereas many show a schistose border in some cases containing blocks of the intruded rock. The sheared nature of the contacts and the general resemblance in colour and texture of gabbro and basaltic lava make it difficult in the field to differentiate masses of intrusive gabbro from some lava flows. For this reason many bodies of intrusive gabbro may have been mapped as basaltic lava. The detailed work east of Long lake during the summer of 1929 demonstrated that some bodies mapped as gabbro in 1926 were of extrusive origin, and, therefore, belonged to the Rice Lake series. In 1926, bodies of basic rock showing abundant angular and rounded lumps of feldspar up to one-half inch long were considered to be intrusive, but the observations of 1929 indicated that rocks carrying these feldspars graded into basalt showing pillow structure. The white-weathering lumps are apparently of secondary origin, as they consist of very small grains of albite, quartz, calcite, and some zoisite.

Age Relations of Gabbro

As already indicated, the age relations of the gabbro and peridotite are unknown, the two types of basic rock are assumed, however, to represent differentiates of the same magma. Gabbro and granite were seen in contact at three localities. At a locality near the centre of section 1, range 14, township 17, Oiseau Lake area, a gabbro mass striking parallel with the enclosing lava flows is cut off by the granite, just as are the volcanic rocks of the Rice Lake series on each side of the gabbro. Blocks of gabbro with sharp outlines occur within the granite along the projected continuation of the gabbro mass. At this locality the granite is definitely younger than the gabbro. In Maskwa River area the granite-gabbro contact is fairly well exposed north of Cat creek along the east side of the gabbro body of that area. The gabbro is coarse grained against a chilled margin of granite ½ to 2 inches in width; the granite is of normal grain size 2 to 3 feet from the gabbro. Small stringers of granite penetrate joint planes in the gabbro. The granite of this area is also older than the gabbro. Gabbro and granite are in contact from 2,000 feet south of the long, narrow, northeast-trending bay of Halfway lake. In places this contact appears to be a gradational one, suggesting that this gabbro mass is a phase of the body of granite and granodiorite to the west. No sharp line of contact was recognized; within 50 feet normal gabbro passes into normal grey granite and granodiorite. The contacts of the larger gabbro masses within granite areas were not observed, and it is not known whether at these localities the basic rocks represent basic segregations of the granitic magma, or inclusions of older rocks, or dykes cutting the granite. Some of the smaller areas of basic rock in the granite are known to be inclusions. As basic intrusives younger than the granite are scarce, and not known to be in large bodies, it is very probable that the basic masses in the granite represent either large inclusions or basic segregations within the granitic magma.

PORPHYRITIC AND NON-PORPHYRITIC QUARTZ DIORITE, GRANODIORITE, AND GRANITE

A large, roughly lens-shaped body of porphyritic and, locally, non-porphyritic rock, ranging in composition from quartz diorite to granite, occurs north of Winnipeg river in the northern half of township 16, range 16, and extends about half-way across the adjoining ranges on the east and west. The general features of this intrusive body are described in the section of this report dealing with the tin deposits near Shatford and Bernic lakes (page 101).

DYKES OF GRANITE PORPHYRY

Dykes of granite porphyry are abundant in the Beresford Lake phase of the Rice Lake series north of the east end of Long lake, southeast of Rice lake, around the east and west ends, respectively, of the body of granitic rock extending from north of the east end of Long lake to near Gold lake. The porphyries are light grey on weathered surfaces and dark grey on fresh surfaces. The rocks of the different dykes vary somewhat in texture and appearance, but always either dark, smoky quartz or white, glistening, tabular, feldspar crystals can be recognized on the weathered surface. Some outcrops of acidic, fine-grained porphyry resemble closely in appearance the rhyolite lava, and in the field it is difficult to decide the origin of these rocks unless the intrusive relations can be determined.

In thin section the porphyritic texture of these dyke rocks is prominent; the feldspar and quartz phenocrysts are set in a fine-grained matrix wherein quartz, orthoclase, albite, calcite, and sericite are recognizable. The feldspar phenocrysts include both orthoclase and a twinned plagioclase varying in composition from acidic oligoclase to andesine. The quartz phenocrysts are rounded and contain abundant, dust-like inclusions. Both the quartz and feldspar phenocrysts are traversed by cracks along which secondary minerals are developed. Ferromagnesian minerals are sparingly present, and both biotite and hornblende were noted. The minerals of many of the thin sections are greatly altered, only skeleton outlines of the feldspar remaining, the central area being replaced by an aggregate of kaolin, zoisite, calcite, white mica, and small quartz grains. The few specimens collected from the different dykes varied in composition from granite to diorite.

In size the porphyry dykes vary from stringers less than 1 foot wide up to masses 300 feet across. A few dykes were traced and found to be continuous 2,000 feet along the strike. Detailed mapping shows that many dykes exist in the area north of the east end of Long lake and north of Clearwater lake, and that the dykes become smaller and fewer in number passing outward from the end of the granite body. In most cases the dykes parallel the strike of the sediments and lavas, and seem to have intruded along shear zones, beds of chert or tuff, or along the contact between gabbro dykes and sediments and lavas. The contacts with the older rocks are sharp and definite; the chilled edges are only a fraction of an inch in width. In a few dykes small, angular inclusions of the intruded rock were noted. The porphyry dykes cut the gabbro, but are older than the quartz veins. No porphyry dykes were noted cutting the granite. A few, short, irregular, porphyry dykes were noted to extend from the east end of the granite mass north of Long lake into the lavas, and this, combined with the marked concentration of the dykes around the two ends of this intrusive mass, suggests that at depth these dykes may pass into this granite mass. The porphyry dykes of Beresford-Rice Lakes area are considered to be closely related in age and origin to the period of intrusion that gave rise to the granite mass that they surround.

GREY GRANODIORITE AND GRANITE OF BERESFORD-RICE LAKES AREA

A large, roughly oval area of medium to coarse-grained granite and granodiorite outcrops north of Long lake and smaller areas of a similar granite outcrop west of Beresford lake, north of Rice lake, west of Red Rice lake, and west of Beaver lake. The rocks of these bodies are light to dark grey, with a pinkish tint only locally. Many outcrops near the edges of the masses are porphyritic, the rock of the interior of the larger masses being more evenly granular. The rock within individual masses shows considerable variation in texture and mineral composition, massive, dark grey, coarse, granodioritic phases grading into typical light grey or pinkish, medium-grained granite and syenite. Inclusions of older rocks, so abundant in the large granite bodies along the north and south edges of the map-area, are absent or only sparingly represented in the granitic bodies within the sediments and lavas, and in these intrusives no typical, foliated granite-gneiss was seen, though locally a quartz-sericite schist is developed along narrow shear zones. The contacts of the smaller granite bodies with the members of the Rice Lake series are sharp and without lit par lit gneiss. No pegmatite dykes have been noted in association with the granites of this group.

Thin sections of the massive granite show the typical granitic texture with irregular-outlined feldspar crystals and areas of angular quartz grains and clusters of ferromagnesian minerals. Of the feldspars, a plagioclase, near oligoclase in composition, is the most abundant. Orthoclase is always present, but never exceeds in quantity the oligoclase. Microcline was not noted in any of the thin sections. Some of the plagioclase crystals show zonal growth, indicating a change in composition of the magma during crystallization. The orthoclase has a cloudy appearance and contains minute shreds of a white mica. The oligoclase of most thin sections is slightly kaolinized, and in a few sections it is partly altered to zoisite, calcite, and quartz. Hornblende and biotite are both present and these minerals are estimated to occupy about a quarter of the area of the thin sections. Hornblende is more abundant than biotite, and in some thin sections these minerals are partly altered to green chlorite and epidote, whereas in others they are unaltered. Magnetite is an abundant accessory mineral and a few grains of titanite and apatite are generally present.

The sediments and lavas surrounding the bodies of massive basic granite were only slightly metamorphosed by the action of the intruding magma. This feature is particularly noticeable at a few points along the contact of the granite and Wanipigow phase west of Red Rice lake, where exposures of sediments along the side of the granite hill are so little disturbed or altered as to suggest that the beds had been deposited on top of the granite. Farther west along this contact, however, outcrops show plainly the intrusive character of the granite. The strike and dip of the strata along the sides of the granite masses parallel the strike of the contact, whereas around the ends of the larger masses, as east of Gold lake, the granite contact cuts at an angle the structure of the older rocks. The bodies of massive granite within the sediments and lavas were not seen in contact with each other nor with the granite and granite-gneiss along the north sides of the area mapped; therefore, the age relations of the granites of the several separate areas are unknown. Shear zones within the massive granite are impregnated with gold-bearing quartz, and both the granite and gold-bearing quartz are cut by a few very narrow dykes of black, basic rock resembling a diabase.

GREY OLIGOCLASE GRANITE AND GRANODIORITE OF OISEAU RIVER AREA

A large mass of grey, granitic rocks extends along Winnipeg river east and west of Pointe du Bois. The rocks within this mass are variable in colour, texture, and mineral content. Their characteristic colours are light to dark grey or almost black, whereas types of pinkish or white tints occur only locally. The texture is fine to coarse, even-grained, porphyritic types being only locally noted. In these, the phenocrysts may be either feldspar or quartz. Much of the rock is massive or only faintly gneissic, due to the dark minerals or the feldspars being oriented parallel. A well-banded gneiss occurs only locally.

In mineral content the rocks of this large mass vary from granite to oligoclase-quartz diorite. The latter is a common type. Plagioclase is the most abundant mineral of the thin sections, and in different specimens varies from albite to andesine. The plagioclase of many specimens is oligoclase and in these orthoclase or microcline are only sparingly present. All types carry biotite, and it, in most cases, is accompanied by hornblende. Epidote is an abundant accessory mineral, and in a few specimens allanite occurs with the epidote. At some localities the several different types appear intimately intermixed, whereas a single type at other localities may extend over many square miles.

Inclusions of members of the Rice Lake series are locally abundant in the granite rocks of this group, which, therefore, were intruded after the strata of the Rice Lake series were deposited. Dykes of pegmatite cut these granitic rocks at some localities, as near Pointe du Bois. The contact of the grey, granitic rocks and the pink microcline granite is not sharply defined, as, south of Winnipeg river east of Pointe du Bois, the two types are intermixed in a zone from 1,000 feet to 1½ miles in width between the main masses of these rocks. These relationships between the two types suggest that these distinct types of granitic rocks represent differentiates of the same magma, the more basic, granodioritic phases perhaps crystallizing slightly earlier than the microcline-granite type.

PINK HORNBLENDE GRANITE

Small bodies of pink granite outcrop on Turtle, Clearwater, and Manigotagan lakes, Beresford-Rice Lakes area. This is a massive, medium-grained granite, in places characterized by excellent horizontal jointing. In thin section microcline is more abundant than orthoclase, and a plagioclase, between albite and oligoclase, forms about one-third of the total feldspar. Green hornblende is abundant and is the characteristic ferromagnesian mineral, for biotite is only sparingly present. This granite is not known to be gneissic, and the minerals of the thin sections are only slightly granulated and altered. Inclusions of mica schist and lit par lit gneiss were not noted in the massive pink granite. No pegmatite dykes were noted cutting this granite. It is not known whether this pink granite is a phase of the widespread grey granite to the south or a separate and younger intrusive.

PINK MICROCLINE GRANITE, OISEAU RIVER AREA

This granite outcrops south of the grey oligoclase-granite and granodiorite body described on page 44, and south of Shatford lake. The rocks of this group are described on pages 101, 109, and 110 of this report.

GREY GRANITE AND GRANITE-GNEISS

Granite and granite-gneiss outcrop extensively in southeast Manitoba and surround the areas underlain by members of the Rice Lake series and the smaller intrusive bodies described in the foregoing sections. Granite and granite-gneiss outcrop for at least 10 miles north of Beresford-Rice Lakes area and to the east are practically the only rocks outcropping on the canoe route from Garner lake to Red lake. From Manigotagan lake to Maskwa River area and from Flintstone lake to Oiseau lake, granite and granite-gneiss are the abundant types outcropping. A few small, included areas of older black schist, grey gneiss, and gabbro are present in all areas of granite that have been examined.

The granite of these large bodies is similar in appearance and mineral composition over wide areas. The most common type is massive, fine and medium grained, and grey to slightly pinkish. In most areas, however, massive and gneissic phases are intermixed; the areal extent of massive types is much greater than that of the gneissic granite. Massive and gneissic types grade into each other. Lit par lit gneisses are locally developed along the borders of the granite masses. Gneissic phases and lit par lit gneisses are more extensively developed in the area between Turtle and Tooth lakes than elsewhere, the granite east of Beresford lake and north of Wanipigow being predominantly massive. Where gneissic granite is extensively developed, it is cut by pegmatite and aplite dykes, and the surrounding rocks are severely metamorphosed and recrystallized.

In thin section under the microscope the granite is seen to contain a twinned plagioclase between oligoclase-albite and oligoclase in composition, orthoclase, microcline, quartz, biotite, and in some specimens a few crystals of hornblende. The granite in the vicinity of Moose and Frenchman lakes contains primary muscovite in addition to biotite. The minerals are fresh with the exception of a few of the plagioclase and orthoclase grains, which are slightly kaolinized. The larger grains show granulated outlines and a few are crossed by cracks along which quartz and white mica have developed. Accessory minerals are not abundant in the thin sections and include a few grains of magnetite, pyrite, titanite, apatite, and zircon. The secondary minerals are epidote, calcite, and shreds of chlorite.

In thin sections of the foliated granite the quartz and feldspars are crushed and show undulatory extinction. Much of the feldspar is recrystallized to albite and inclusions of quartz in feldspar or feldspar and quartz in biotite are characteristic. Considerable sericite is present in long, needle-shaped shreds and the biotite flakes show frayed ends. The gneissic phases of the granite of this area are believed to have originated at a late stage in the crystallization of the minerals, to have been caused by local movements due to adjustments within the magma, and, therefore, are not the result of widespread regional deformation after the magma had completely crystallized.

Basic rocks of the mineral composition of gabbro and quartz diorite were noted locally within the large areas of granite. These more basic rocks are massive, coarse grained, and dark grey to black. In thin sections their plagioclase varies from oligoclase to andesine in composition and together with hornblende occupies over three-quarters of the area of the sections. Some orthoclase and biotite are present. The minerals are slightly altered to zoisite, calcite, and chlorite. Some areas of these basic rocks are small, and only a few are up to 2,000 feet in width. Areas of these more basic rocks within the granite may represent local segregations of the basic constituents within the magma or inclusions of older intrusive bodies.

The granite intrudes the Rice Lake series at every point where the contact between these two groups of rocks was observed. At many places inclusions of the older rocks are abundant within the granite adjacent to the contact. At most points along the contact the older rocks have been in part recrystallized and southeast of Turtle lake and westward from Gabrielle portage on Wanipigow river many beds of sediments have been altered to grey, feldspar-rich rocks resembling in appearance aplitic granite or acidic lava.

No field evidence was found to indicate the presence of granites of more than one age. An older granite was exposed in the district at the time of the deposition of the Rice Lake series, for conglomerate beds locally developed within this series contain granite pebbles. No outcrops of this older granite have been recognized.

MICROCLINE-PEGMATITE

Dykes and irregular-shaped masses of pinkish pegmatite carrying abundant microcline feldspar are locally abundant in the district, especially around the north contact of the body of microcline-granite in Oiseau River area, in the vicinity of West Hawk lake, and along Manigotagan river from Turtle lake southeast to Tooth lake on Moose river. These pegmatites are of irregular grain size, microcline crystals up to 2 feet across being developed in some bodies. Quartz is an abundant constituent in many bodies, and some albite and muscovite are generally present. The bodies of pegmatites are discontinuous along their strike and vary in thickness from less than 1 foot to over 100 feet. So far as is known, accessory minerals are not abundant in the microcline-rich pegmatites; the lithium-bearing minerals and cassiterite are in pegmatites carrying abundant soda feldspar.

ALBITE PEGMATITE, APLITE, AND PEGMATITIC ALBITE GRANITE

A few boss-shaped and smaller irregular-outlined bodies of pegmatite and pegmatitic granite carry abundant pinkish white soda feldspar, muscovite, and garnet, together with deposits of rarer minerals, including lepidolite, spodumene, montebrasite, cassiterite, beryl, and other minerals. These rocks are described in detail on pages 102, 103, 110-113.

DIABASIC DYKES

Dykes of basic rock younger than the granite are not abundant in southeast Manitoba. Near the west end of Oiseau lake a small dyke of diabasic rock cuts the granite, and east of Clearwater lake, Beresford-Rice Lakes area, several narrow dykes cut the granite. The dyke rocks are of fine to medium grain, dark green to black, and locally weather reddish. The thin sections examined show a diabasic texture, the feldspar is between andesine and labradorite, and hornblende is the abundant ferromagnesian mineral, augite being present only sparingly. These dykes cut the members of the Rice Lake series and the granite wherever they have been recognized.

GLACIAL AND POST-GLACIAL DEPOSITS

The last continental ice-sheet that crossed the area left the usual deposits of glacial drift. Along the western and southern sides of the area the glacial deposits are covered by stratified clay and sand laid down in Lake Agassiz, a very extensive, shallow lake formed in front of the retreating ice field. The glacial deposits are widespread, but for the most part are thin, though locally, as determined by diamond drilling, they reach a thickness of 200 feet. The last ice invasion was from the northeast, the striæ trending from south 20 degrees west to south 50 degrees west. The rock surfaces are everywhere fresh and polished and glacial grooves and striæ are numerous. A number of small limestone boulders were noted in the drift around lac du Bonnet. Assuming the limestone boulders were carried from the nearest exposures of Palæozoic limestone to the west, the last ice tongue to cover the southwest corner of the district must have come from the northwest. In Upper Whitemouth River area, just south of lac du Bonnet, W. A. Johnston[1] notes evidence of the existence of two till sheets and two advances of the ice, the older from the northeast and the younger from the northwest. No evidence of the younger ice advance was noted in Beresford-Rice Lakes area in the northeast corner of the district and apparently this ice-sheet did not extend far northeast of Winnipeg river.

In much of the district the glacial deposits are covered by muskeg, thick moss growth, or stratified clay, so that it is difficult, except on lake shores or in prospect trenches, to obtain information regarding the character of the deposits laid down by the retreating ice-sheets. Boulders and blocks of Precambrian rocks are scattered over the surface of much of the district. Deposits were seen of gravel, sand, and boulder clay in the form of ground moraine deposited in front of an ice-sheet retreating northward. Some deposits are of roughly stratified sand and gravel, evidently of fluvioglacial origin. This material may take the form of small hills elongated in a general northwest direction and they somewhat resemble small moraines. Such hills are present north of lac du Bonnet, along the City of Winnipeg railway about 6 miles west of Pointe du Bois, a mile south of Wanipigow river, and for 5 or 6 miles east of Wanipigow lake and along Wanipigow valley 5 miles east of Gabrielle portage.

The Lake Agassiz deposits comprise stratified clay and silt. Recent swamp and lake deposits of peat and muck locally overlie the clays. Although the stratified clays were widespread in the western and southern parts of the district, the deposits are not known to be thick, diamond drilling records indicating at one point some 50 feet of clay in Oiseau River area. These clay deposits have filled many of the inequalities of the underlying surface, hence are of variable thickness from point to point. Lakes are not numerous in areas covered by Lake Agassiz clays, whereas small lakes are very abundant east of where the clays are developed. The deposits of clay filled many of the depressions occupied by lakes beyond the east limits of the deposits. The general absence of lakes in the area underlain by Lake Agassiz deposits and their abundance to the east is shown strikingly on the recently issued topographic maps of the country just east of lake Winnipeg.

In Beresford-Rice Lakes area stratified clays extend up to between 830 and 860 feet above sea-level, as determined by an aneroid. These clays have not been recognized along Wanipigow valley beyond the rapids 6 miles east of Gabrielle portage or beyond Quesnel lake along Manigotagan river. No evidence of beach or other shore features of Lake Agassiz was seen in this area, the eastern margin of the lake perhaps being formed by the retreating ice. The stratified clays are greyish and when wet are very sticky. For this reason it is difficult to build motor roads across areas of these clays without surfacing with gravel and crushed rock. Some layers of clay are sandy, and in some sections along Wanipigow valley the clays are overlain by stratified sand. The areas of stratified clay are suitable for agriculture, but such areas are generally heavily forested, consequently, they are difficult to bring under cultivation.

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[1] Geol. Surv., Canada, Mem. 128, p. 27 (1921).

CHAPTER III

ECONOMIC GEOLOGY

INTRODUCTION

A variety of mineral resources are present in southeast Manitoba and during the past few years some of the mineral deposits of the district have been developed. The first deposit to attract attention was one of hematite and limonite on the east side of Black island, where in 1880 or thereabouts an attempt was made to develop a deposit of iron ore. The non-metallic resources of the country adjacent to the railways east of Winnipeg early received attention, and in 1894 the dolomite beds of Tyndall area, 30 miles east of Winnipeg, were investigated as a source of building stone. The quarries in this area are today the most important source of building stone in the western provinces. The search for metallic minerals within the Precambrian of the district dates from 1895 when prospectors from Lake of the Woods examined the country in the vicinity of West Hawk lake. Some mining claims were staked at that time for gold. In 1897 the Lac du Bonnet Development and Manufacturing Company commenced developing a number of gold and silver prospects in Oiseau River area, but this company had no great success in this work and soon abandoned mining.

The present mining activity in the part of southeast Manitoba underlain by rocks of Precambrian age dates from 1911 when free gold was discovered in a quartz vein on the north shore of Rice lake. In 1912 and succeeding years additional quartz veins carrying free gold were discovered in the country surrounding the lake. In 1915 a small mill was built on the Gold Pan and in succeeding years some gold was produced from a small but very high-grade ore-shoot. By 1916 the prospecting activity had extended from Rice lake east along Manigotagan river to Long and Beresford lakes and northwest of Wanipigow lake on Wanipigow river. By 1921 a number of mining companies had been formed to develop the gold deposits of this new field. Many of these companies were financed in Winnipeg. Unfortunately the managements did not have the benefit of experienced advice, for all the enterprises were unsuccessful due to the high cost of transporting equipment to the field and the generally small size or low grade of the deposits exploited. In the summer of 1924, however, the Wad Syndicate of Winnipeg and Boston, and the Anglo-Canadian Explorers of Toronto became interested in the possibilities of this large gold-bearing field. These companies were directed by experienced mining men and engineers, and prospectors were sent to thoroughly investigate a number of the more promising gold occurrences. This led to the proving up of the Kitchener, Tene, and Hope veins, and considerable work on the Oro Grande. A 150-ton unit of a gold mill was built on the Kitchener in 1927 and at the end of 1929 this vein was reported to have produced over

$1,000,000 in gold. In the summer of 1929, San Antonio and Gem Lake gold deposits were being explored underground, work having reached the 725-foot level on the former and the 500-foot level on the latter.

In 1916 the West Hawk Lake area again attracted considerable attention from prospectors, and discoveries of gold, molybenite, tungsten, tin, and platinum were reported from this area in the four succeeding years. Only a small amount of development work has been completed on the deposits of this area. In 1917 nickel-copper-bearing sulphides were discovered in Maskwa River area, 30 miles north of Lac du Bonnet, and in 1919 deposits of a similar type were discovered north of Oiseau river, 30 miles east of Lac du Bonnet. Between 1922 and 1929 a number of the sulphide bodies of these two areas were investigated by various mining companies. In 1924 lithium-bearing minerals were discovered in pegmatite bodies along Winnipeg river east of Pointe du Bois, and in the next two years a large area north and south of Winnipeg river was prospected for deposits of these minerals. The original discovery, the Silver Leaf deposit, was explored by surface stripping and three carloads of lithia ore were shipped. Additional deposits of lithium minerals were found in the area surrounding the original discovery and to the northeast of Bernic lake and also at Cat lake, 10 miles southeast of the Maskwa nickel-copper sulphide bodies. In the autumn of 1928, the occurrences of cassiterite, the oxide of tin, in the pegmatites in the vicinity of Shatford and Bernic lakes, attracted attention, and in the summer of 1929, several Winnipeg companies were organized to prospect for and to exploit the tin deposits of Oiseau River area.

In the immediately following pages, the mineral resources of the area are treated in the following order: (1) Gold deposits of Beresford-Rice Lakes areas and nearby fields; (2) Copper-nickel deposits of Oiseau and Maskwa River areas; (3) Cobalt deposit west of Werner lake; (4) Tin deposits of Shatford-Bernic Lakes area; (5) Lithium deposits, by C. H. Stockwell; (6) Beryllium deposits, by C. H. Stockwell; (7) Fuchsite-bearing rock suitable for stucco material, by C. H. Stockwell; (8) Molybdenite near Falcon lake, by E. L. Bruce; (9) Occurrences of gold and scheelite, Star and Falcon Lakes area, by E. L. Bruce; (10) Silica deposits on Black island, lake Winnipeg; (11) Clay deposits on Punk island; (12) Serpentine deposit at Goldeye lake; and (13) Hematite deposit on Black island.

GOLD DEPOSITS OF BERESFORD-RICE LAKES AND NEARBY FIELDS

DISTRIBUTION

Gold-bearing quartz veins occur at intervals throughout an area some 60 miles long and from 10 to 15 miles wide, extending northwest from between mileages 85 and 92 on the Manitoba-Ontario boundary to near lake Winnipeg. Within this long, narrow area the more important known deposits are localized in small areas which in their order of occurrence from southeast to northwest are designated as follows: (1) Gem Lake area, 5 miles long east and west and 3 miles wide, lying south of Slate lake on the southwest branch of Manigotagan river and west from the Manitoba-

Ontario boundary; (2) Beresford Lake area, extending north 3½ miles and west 1½ miles from the outlet of Beresford lake; (3) Central Manitoba area, 4 miles long east and west and 1 mile wide, extending through Wentworth lake and including the Kitchener, Hope, and other deposits; (4) Eldorado area, 1 mile wide and extending 2½ miles southeast from the outlet of Halfway lake; (5) Cryderman area, situated south of Palomar lake, 2 miles long northwest-southeast and a mile wide; (6) Gold Lake area, south of Gold lake, 2 miles wide north and south and 2½ miles long east and west; (7) Rice Lake area, north of Rice lake, 2 miles long east and west and ½ mile wide north and south; (8) Red Rice Lake area, 1 mile wide and extending 1 mile east and west of Red Rice lake; (9) Beaver Lake area, extending 2½ miles northwest from the east end of Beaver lake and 1 mile wide; (10) Saxton Lake area, extending 1 mile east and west from the northwest end of Saxton lake, and ½ mile wide; (11) Wanipigow Lake area, extending 3 miles north of Wanipigow lake and 6 miles east and west; (12) English Brook area, southeast of the south end of English lake and about 3 miles square; and (13) Little Bear Lake area, township 18, range 14, east of principal meridian.

On subsequent pages are given descriptions of various properties in each of the above-defined local areas. The descriptions are based on field examinations made in 1926 and 1929.

GENERAL GEOLOGY AND MINERALOGY

The gold deposits are quartz bodies of variable size occurring along shear zones within members of the Rice Lakes series and certain of the bodies of granitic rocks cutting this series. Narrow ,jointed, and schistified zones carrying small bodies of quartz are widespread, especially in the volcanic members of the Rice Lakes series, whereas, apparently at only a few localities, are large shear or fault zones developed. Some of the large, persistent shear zones do not contain quartz and others carry large bodies of quartz that is not gold-bearing. Free gold, in quartz, however, is widely distributed and has encouraged mining companies to follow closely the developments in progress.

Many of the shear and fault zones and their enclosed quartz bodies are located along structural features such as the contact between lava flows, or the contact between a lava flow and chert, tuff, or quartzose sediments, or the contact of small, intrusive bodies with lava or sediment. The quartz-bearing shear zones on the Kitchener, Tene, and Hope mineral claims of Central Manitoba area are either along the contact of a thick mass of gabbro and diabase with a thin chert bed or in the gabbro-diabase body, their position, apparently to some extent, being controlled by irregularities of the south contact of the body of medium to coarse-grained gabbro and diabase. The San Antonio deposit in Rice Lake area is in a medium-grained, basaltic rock just north of its contact with thick beds of arkosic sediments. The Oro Grande shear west of Beresford lake is in the east side of a body of medium-grained, basaltic rock between beds of andesitic lava and tuff. The Gem Lake deposit is along a wide, schistose zone developed within andesitic lava adjacent to a body of medium-grained, basaltic rock. The shear zones in the granitic intrusives, as at the Eldorado and the Luleo west of Beaver lake, are within central parts of tongue-shaped bodies or else close to the contact of the bodies of intrusive rock with the older lavas and sediments. At these and many other localities, the rocks are schistose across widths varying from 10 to 300 or more feet, but intense fracturing and granulation is localized to narrow, lenticular zones within the main zones of deformation. The quartz bodies are small and lenticular where they lie along zones wherein ribbon schist and white sericitic schist are developed, as on the Wolfe mineral claim northeast of Red Rice lake. Such zones probably were formed by a granulation of the rock and a recrystallization of the minerals under conditions of intense compression, hence practically all the openings for the later circulation of the quartz minerals would be eliminated. In those zones within brittle rocks, as chert, cherty tuff, and some bodies of fine-grained basic rock, the shearing resulted in the development of a zone wherein the rocks are intensely fractured and in part rendered schistose. The quartz bodies along such zones as illustrated by the Kitchener body are fairly continuous and uniform in size, although small, angular, and long, narrow bodies of country rock are numerous within the quartz. It thus appears that areas underlain by rocks of varying competency under deformation are favourable to prospect, and, perhaps, the variable texture and composition of the intercalated volcanic and sedimentary strata of the Beresford phase of the Rice Lake series explain the localization of the majority of the quartz bodies of the district to areas of these rocks, as contrasted with the sedimentary Manigotagan and Wanipigow phases of the series, constituted of rocks that are fairly uniform over considerable areas and are practically barren of quartz bodies.

The fracture shear zones cut all the rocks recognized in the area, with the exception of the pink hornblende granite in the area from Turtle to Manigotagan lakes, and a few, small diabase dykes which cut the quartz bodies. Although the large granite bodies of the area contain shear zones, gold-bearing quartz was recognized only in the granite and granodiorite body between Long and Gold lakes, the small mass south of Tinney lake, and the granite area north of Wanipigow river from Beaver lake west to English brook.

The shear zones vary markedly along their strike, in width and in the degree of alteration of the rock; a belt of schist 20 feet or more in width may narrow within 300 feet along the strike to less than a foot of fractured and only slightly schistose rock. Several such elongated lenticular masses of schist may follow one another along the strike and are also likely to be similarly developed down the dip, but in many cases they occur singly. The zones of deformed rock follow closely the dip and strike of the schistosity and of the bedding of the enclosing rocks, the angle between the average trend of a shear zone and the strike of the schistosity or bedding of the country rock in no case being over a few degrees, the slight divergence shown at some localities being a slight zigzagging across the formation, as a consequence of the irregular widening and narrowing of the schist zone. Along some shear zones, and especially those within granite and chert, the boundary between the schistified, and jointed rock, and massive rock is sharp, whereas in lavas in most places the shear zones gradually pass outward into schistose lava carrying lenses and veinlets of quartz, some of which carry free gold and pyrite in cubes and grains. Calcite, siderite, and ankerite are abundant in the schistose rock adjoining some quartz bodies. The laminæ of the schist bend around some of the quartz lenses and the larger pyrite cubes. In some shear zones layers of apparently massive rock from 2 inches to a foot or more in width are present. Along the strike many zones end by fingering out into several narrow seams of schist with intervening, massive rock. The wall-rock along some shear zones is striated, the striæ in some cases being nearly vertical and in others nearly horizontal. There is no direct evidence, however, of marked displacement of the strata on opposite sides of the shear zones, the movement necessary to granulate the rocks and to render them schistose apparently being only slight at any one place.

The quartz is distributed along the shear zones, either irregularly in small lenses and veinlets or continuously in bodies of variable size and outline. Small, angular fragments of wall-rock are abundant in some quartz bodies; other deposits consist of alternating layers of quartz and wall-rock. At a few localities elongated, lenticular bodies of quartz are arranged "*en échelon*" within zones of schistose rock. The quartz bodies along a few shear zones have sharp, definite walls, the schistosity of the enclosing rock curving to follow the general outline of the quartz body. The schist adjacent to most quartz bodies, however, carries some quartz in small veinlets and lenses, the contact between the main quartz body and schist being gradational. Some of the quartz in the wall-rock carries gold, the average gold content across mineable widths so far as is known being less than $1.20, and too low to mine profitably in combination with the quartz. The quartz bodies thus comprise the only type of gold ore at present known in the field.

The quartz bodies are divisible into the following three types, on the basis of colour, texture, and mineral content: (1) composed of dark, smoky, medium-grained quartz; (2) composed of white, finely crystalline, sugary quartz; and (3) composed of white, coarsely crystalline, pegmatitic quartz carrying albite feldspar. Of these three types the first (the dark, smoky quartz) is considered the most valuable and the ore-bodies at present under development are of this type of quartz. In this quartz the gold is in very small particles, fairly evenly distributed throughout the body. In some ore the gold is not visible to the naked eye and in the Kitchener vein no gold has been recognized even under 400 degrees magnification under the microscope. This quartz, however, shows a colour of gold on fine grinding and panning. Much of the smoky quartz is without mineralization, chalcopyrite and pyrite being confined to the margins of the body or adjacent to included bits of country rock. At only a few places does the pyrite show crystal faces. Only a few grains of albite and calcite have been noted in the specimens of this quartz studied microscopically.

Ten specimens of dark-coloured quartz from different deposits have been studied microscopically. All are similar in general appearance. The quartz shows no sign of crystal faces and is in interlocking grains of variable size and outline. The thin sections typically consist of large quartz grains, the interstices being filled by smaller quartz grains. In small areas of some thin sections the large quartz grains fit together closely, with a slight dove-tailing into one another. In some areas the quartz is brecciated and the resulting small grains show wavy extinction. The whole area of other grains do not extinguish at once, one side becoming dark shortly before the other. Other quartz grains show irregular, ragged outlines. Long, narrow areas of small grains of quartz cross some thin sections, perhaps formed along a zone of fracturing. These features suggest that the quartz crystallized under considerable stress or has been deformed since it crystallized. The quartz of the smaller veinlets within schist is similar in its general features to that of the larger masses. Small specks of magnetite, chlorite, hematite, and rutile lie in some of the quartz grains, giving them a cloudy appearance in thin section. Free gold was noted in four thin sections, distributed among the small quartz grains showing wavy extinction, and as threads and films along cracks within the larger quartz grains, and as small specks in apparently unfractured quartz. A few bodies of the smoky quartz are known that do not carry gold, and others carry on the average too little gold to be mined profitably.

Bodies of white, sugary quartz (the second type) are present at the same localities with the smoky quartz, and in a few deposits both white and smoky quartz are present in the same quartz body. Some of the smoky quartz is cut by veinlets of white quartz, but these were perhaps formed by recrystallization of the dark quartz along fracture planes. Although the quartz exhibits noticeable differences in colour, texture, and mineralization, and the several varieties do occur with sharp boundaries in the same body or in different bodies along the same shear zone, no definite evidence was noted from a study of the deposits of the whole area to prove that the different types of white and dark quartz and their contained mineralization are not of about the same age. In thin section under the microscope the white quartz is similar in general appearance to the smoky quartz. The size of grain of the white quartz is more uniform, however, large areas of a thin section being of medium size grains; whereas other areas are of smaller grains averaging nearly one-tenth millimetre in diameter. The large and small grains are not intermixed, as in some of the smoky quartz, and there has been only slight granulation and straining of the white quartz. Crystals of calcite, ankerite, and siderite are abundant in some of the white quartz, also albite in twinned crystals. The gold lies between quartz grains near nests of carbonates. At the Cryderman deposit gold is present along cleavage planes in calcite in chlorite schist adjacent the main quartz mass. The gold is erratically distributed throughout the white quartz, and for this reason certain samples cut from bodies of white, even, granular quartz assay high, whereas others do not show a trace of gold, and the average for the whole mass is disappointingly low.

Bodies of the third, or white, pegmatitic variety of quartz are widespread, although only a few masses of this type of quartz are present at any one locality. Representative bodies of this quartz lie north of the west end of Long lake and east of Red Rice lake, respectively. The masses are large and either long, dyke-like, or circular but irregular-outlined bodies.

Both white and pink feldspar are locally abundant constituents and white, muscovite-like mica is, also, locally present. The body north of Long lake carries some chalcopyrite. This type of quartz, however, is usually barren of sulphides or other minerals excepting feldspar and some mica. Although free gold has been found in quartz of this type, the deposits usually do not assay even a trace of gold. Bodies of quartz of pegmatitic character are not considered likely to carry gold in commercial quantities. In the future these quartz bodies may be valuable as a source of silica.

The cause of the different colours shown by vein quartz has been investigated by a number of workers and until recently the explanation advanced was the presence of different types of foreign material in the quartz. Recent, detailed investigations[1] indicate that nearly all quartz becomes smoky brown when subjected to radiation from radium compounds, and, also, that the smoky colour is destroyed if the quartz is heated to 400 degrees or is continuously heated at 235 degrees. The smoky colour of heat-decolourized quartz is restored by radiation. Holden advances the theory that "smoky quartz owes its colour to atoms of silicon, formed by the disintegration of silica, through the action of radium radiations". The free silicon atoms produce a shattering of light, thus giving a smoky colour. "The particles of free silicon are of atomic, not colloidal, dimensions." Colloidal gold[2] has also been formed experimentally by exposing tubes containing a jelly of silicic acid, uranium nitrate, and gold to X-rays. It is concluded that radioactive material in the earth's crust may give short wave rays which would be a factor in gold deposition. The presence of radioactive substances in or near some bodies of quartz may explain the widespread association of gold and smoky quartz in the Manitoba field.

As already stated, bodies of carbonate-chlorite schist, and massive, grey, carbonate rock are present along some shear zones. Carbonate rocks are extensively developed in the workings of the San Antonio deposit, where one body of massive, grey, carbonate material up to 40 feet wide has been outlined on the 600-foot level, and a number of smaller, lenticular bodies of carbonate have been intersected along drifts on the 300, 600, and 725-foot levels. The contact of carbonate bodies with chlorite schist or more massive, basaltic wall-rock is gradational, the carbonates being fairly abundant in the schist away from the main body. In thin section under the microscope the grey carbonate rock shows an aggregate of small grains and crystals of ankerite, siderite, calcite, albite, quartz, pyrite, and pyrrhotite, with shreds of chloritic material. All the minerals are fresh appearing. Carbonate bodies are cut by small veinlets of quartz, variously oriented; the majority have a dip under 30 degrees and apparently were formed along joint planes. The bodies of grey carbonate rock are considered to have originated through a rearrangement and crystallization of the constituents of the wall-rock, perhaps by the action of hot solutions rich in carbon dioxide. This alteration was completed before the gold-bearing quartz was introduced. In the specimens studied no evidence was recognized of the original texture and minerals of the adjoining wall-rock.

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1 Holden, Edward F.: "The Cause of Colour in Smoky Quartz and Amethyst"; Am. Min., vol. 10, No. 9, pp. 203-52 (Sept., 1925).

2 Cadenhead, A. F. G.: "The Effect of Radiations in Reactions in Gels"; Can. Chem. and Met., vol. 10, p. 202 (Sept., 1926).

ORIGIN OF THE DEPOSITS

The gold deposits of Beresford-Rice Lakes area are aggregates of quartz bodies of variable size occurring along planes of fracturing and shearing crossing all Precambrian rocks excepting a few bodies of massive, pink hornblende-granite and small dykes of diabase. Although many quartz bodies of the area carry some gold, only in a few is the average gold content high enough and the deposit of sufficient size to give promise of profitable development. The majority of the gold deposits are in areas underlain by the Beresford Lake or volcanic phase of the Rice Lake series; only a few deposits are known within the sedimentary members of this series or in dioritic and granodioritic phases of the intrusives. Many deposits within the volcanic strata are localized along chert and tuff beds between lava flows, along what appears to be the contact between lava flows, and along the contact of gabbro bodies with chert, tuff, and lava. The deposits follow closely the dip and strike of the bedding and schistosity of the enclosing strata. Fracturing and shearing of members of the Beresford Lake or volcanic phase of the Rice Lake series took place at many horizons throughout the area, perhaps because of the variable character of the rocks of this group, which comprises massive, thick flows and schistose, thin flows, ranging in composition from rhyolite to basalt, and numerous thin beds and lenses of chert and tuff. In contrast with the variable character of the volcanic group, the sedimentary strata and intrusives over considerable areas are fairly uniform in texture and mineral composition, and shear zones along which quartz bodies could develop are only locally present in them.

The presence of albite feldspar in the quartz and the pegmatitic character of other quartz bodies suggest a high-temperature type of deposit related to a granitic magma. On the other hand, tourmaline, pyrrhotite, magnetite, and other minerals characteristic of high-temperature quartz veins are absent or only sparingly present. Gold-bearing quartz veins are considered by most workers to represent residual products of a granite magma. It has been concluded by W. H. Emmons[1] that probably 95 per cent of the known lode ore deposits are related in origin to granite and granodiorite intrusives. The relation of gold deposits to bodies of acidic intrusive rock in some areas suggests that the deposits were formed after the magma had crystallized and, therefore, that they represent a residual product of the crystallization that migrated upward and outward through fractures in the intrusive body and the surrounding rocks. As the gold-bearing quartz veins in Beresford-Rice Lakes area are of wide distribution, it is impossible to assign the source of the deposits to any particular granite body. If related to any of the exposed intrusive bodies, the deposits must have formed considerably later than the period of crystallization of the parts of these bodies now exposed, for gold-bearing quartz extends into the granite at least 535 feet below the surface. So far as is known the deposits may have originated from a younger, acidic magma that never reached the level of the present surface, for all the known granite bodies

[1] "Relations of Metalliferous Lode Systems to Igneous Intrusives"; Trans. Am. Inst. Min. Eng., vol. 74, p. 29 (1926).

in the area are assumed to belong to the same period of batholithic intrusion. In this connexion it is interesting to note that in the Black hills of South Dakota, 600 miles to the southwest, gold deposits are related to granite porphyry intrusives of Tertiary age, which cut the Precambrian and younger strata of this area. It is believed, also, that the Tertiary intrusives have supplied some gold to the Precambrian ore deposits.[1] It is concluded that in the Manitoba area gold deposits may be found in any of the rocks of the district. The most favourable localities to prospect, however, appear to be areas surrounding the smaller granite bodies and underlain by lava flows and their interlayered beds of tuff, chert, and iron formation, as in these rocks numerous, fairly large, fracture and shear zones were developed and afforded channels for the migration and deposition of the gold-bearing materials escaping from the granitic magma.

GEM LAKE AREA

Gem Lake area includes a belt of volcanic and intercalated sediments lying between the southwest branch of Manigotagan river on the north and Moose river on the south, and extending from the Manitoba-Ontario boundary west to near Flintstone lake. The area is about 5 miles long, east and west, and 3 miles wide. Prospecting in this area commenced in 1925. In the summer and autumn of 1926 a number of gold-bearing quartz veins were discovered and one hundred or more mineral claims were staked.

Bedrock consists of grey to black lavas, for the most part highly altered to secondary minerals, and thin beds of tuff and other, laminated, quartzose sediments. Some of the light grey lavas contain abundant quartz and probably are rhyolite. The greenish grey lava contains but little quartz and flows of this type were perhaps trachyte and andesite. Some flows are green to black, are more massive than the others, and are of medium grain; they are classified as basalts. Some of the bodies of basaltic rock may be intrusives and not flows. Some flows of grey, acidic lava south of Kickley lake show agglomeratic phases. Quartz-sericite and quartz-chlorite schists are fairly abundant members of the group. The sediments interbedded with the lavas include grey tuff, chert, laminated cherty quartzite, greywacke, slate, and more arkosic types. Dykes and lenses of granite porphyry up to 3 feet in width intrude some of the tuff and chert beds and narrow, dyke-like masses of basic rock, very probably representing lamprophyre dykes, are locally abundant in some of the lava. The strike of the beds is north 80 degrees west and the dip from 70 to 80 degrees north. The cherty and slaty beds are drag-folded, and these structures appear to plunge about 40 degrees westward. The detailed structure of the area of volcanic rocks is unknown. The assemblage of interbedded flows and sediments may be younger or older than the quartzose sediments of the large areas, respectively, occurring along Moose river on the south and Manigotagan river in the north, or they may be a volcanic horizon within the quartzose, sedimentary series.

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[1] Paige, Sidney: "Geology of the Region Around Lead, South Dakota"; U.S. Geol. Surv., Bull. 765, p. 47 (1924).

Gem Lake Mines, Limited

The most important gold deposit at present known in this area is on mineral claims controlled by Gem Lake Mines, Limited, and situated just north of the west end of Kickley lake, at mileage 90½ on the Manitoba-Ontario boundary. The claims were staked in June and July, 1926, by Messrs. D. A. Foster and Sandy McDonald. Later in the summer of 1926 the group was taken over from the locators by W. S. Kickley and associates, of Winnipeg. Surface work was commenced at once, and this work uncovered a body of schistose rock, carrying quartz veinlets, that for a length of 110 feet and an average width of 7·8 feet averaged $8.20 in gold a ton. The average width of quartz stringers present in this zone is nearly 2·4 feet for 210 feet along the strike. The results of the preliminary work were considered encouraging enough to warrant further development, and Gem Lake Mines, Limited, was organized in February, 1928, to continue the development of the deposit. A complete mining plant was installed using wood-burning boilers for steam power. By the end of the summer of 1929, a three-compartment shaft had reached the 500-foot level, and on the 125- and 250-foot levels, respectively, 1,500 and 1,100 feet of cross-cutting and drifting had been completed. Underground exploration was commenced on the 375- and 500-foot levels in the autumn of 1929. A report by Mr. Harry Donaldson, mine superintendent, states that in all about 9,000 feet of drifting and crosscutting had been completed in the four levels at the end of 1930. Two ore-shoots of importance were located on the 500-foot level, and here the shearing and mineralization are reported to be more favourable than on the upper levels. One body of quartz on the 500-foot level is 3½ feet wide for 112 feet and averages $16 a ton in gold. A new vein was located in a drift on the 375-foot level west and south of the shaft. Underground exploration was in progress during the summer and autumn of 1931. Faulting and other complicated structures, reported below the 250-foot level, have made it difficult to correlate the ore-shoots on the several levels without exploration between the levels, and for this reason no definite estimates of proved ore have been made. During the summer of 1931, the shaft was continued from the 500-foot level to the 775-foot horizon, and work is in progress on the 625- and 750-foot levels.

The gold-bearing quartz is in a highly schistose zone of greenish grey lava about 400 feet wide at the shaft. In thin section under the microscope the greenish grey rock is a chlorite-calcite schist; the shreds of chlorite and grains and crystals of calcite are arranged in parallel layers distributed in alternating bands, giving a ribbon-like appearance to the schist. The twinning lamellæ of some of the calcite crystals are twisted and displaced, indicating some strain subsequent to their crystallization. Considerable quartz and untwinned feldspar (albite?) are present in aggregates of small grains; epidote and magnetite are accessory minerals. More massive-appearing, green to black lava outcrops both north and south of the deposit; the contact of the highly schistose and fairly massive type is gradational. In thin section the texture of the more massive rock is diabasic, with lath-shaped crystals of andesine-labradorite. The ferromagnesian minerals are gone for the most part to uralite and chlorite; only traces of what appears to have been augite and hornblende remain. Much of the feldspar is saussuritized or apparently recrystallized to albite, calcite, zoisite, and quartz. Titaniferous magnetite and leucoxene are abundant.

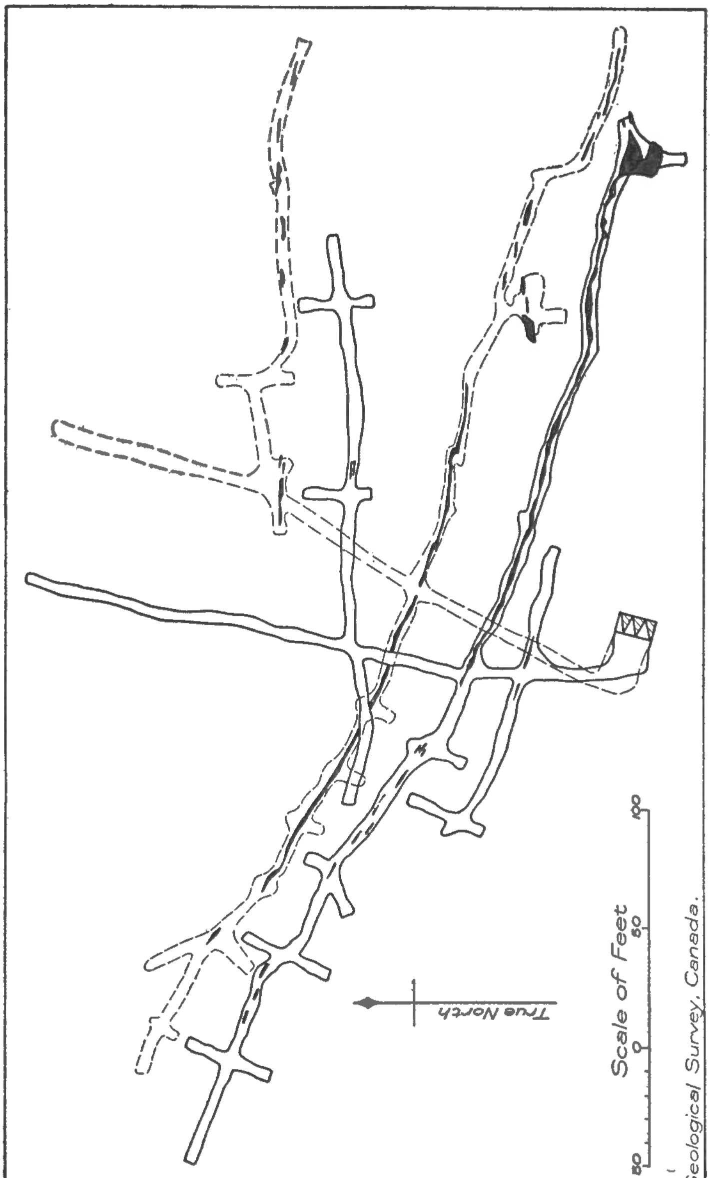

Figure 2. Plan of 125-foot and 250-foot levels, Gem Lake Mines, Limited, Beresford-Rice Lakes area, Manitoba. Outline of 125-foot level shown by continuous line; outline of 250-foot level shown by broken line; quartz veins shown by solid black.

The accompanying plan (Figure 2) indicates the underground work completed up to the end of June, 1929. The two crosscuts running north from the shaft, cross a part of the belt of schistose lava exposed in the surface trenches. The three drifts on the 125-foot level and the two on the 250-foot level follow narrow shear zones within the belt of jointed and schistified rock. On the 125-foot level, in the first shear zone north of the shaft, only two small lenses of barren quartz were found. They lie on the opposite sides of the main crosscut. In the second shear zone on the 125-foot level, a quartz body was followed practically the whole distance of the drift running east from the crosscut. At the east end of this drift a mass of white, sugary-appearing quartz was exposed across 18 feet, but as the gold content was low no further work was done on this quartz body. Only a few, small lenses of low-grade quartz were found in this drift west of the crosscut. Along the third (the northernmost) shear zone on the 125-foot level, quartz is very sparingly developed. The continuation of the crosscut on the 125-foot level north of the third shear zone, crossed jointed and schistified, greenish, chloritic lava with no well-defined shear zones.

On the 250-foot level, two shear zones were intersected by the crosscut extending north from the shaft. Along the southern of these a series of quartz veins and stringers in the schist average approximately 3 feet in width for 145 feet west from the crosscut. The assays in this section indicate an ore-shoot averaging $44 a ton in gold across an average width of 3·5 feet and 145 feet in length. This ore-shoot was not located in the workings on the 125-foot level, and, so far as is known, the ore-shoot at the surface and on the 250-foot level are two unconnected bodies. The quartz bodies may plunge westward following the structure of the rocks suggested by the westward plunge of the axial planes of the drag-folds in the surrounding area. If the plunge of the ore-shoots should prove to be westward, the work on the 125-foot level may not have been extended far enough west to intersect the downward continuation of the ore-shoot at the surface. Although quartz is fairly continuous on the 250-foot level east of the ore-shoot, the gold content of the quartz here is low. In the northern of the two schist zones on the 250-foot level some quartz was found at intervals, but the gold content was not of commercial grade.

At places the shear zones developed by the various drifts are indefinite and hard to follow, and perhaps other shear zones and quartz bodies occur undiscovered in the belt of jointed and schistified lava. The quartz bodies are lenticular, consequently considerable work, including raising as well as drifting and crosscutting, will have to be done to determine the general size and arrangement of the ore lenses.

G. X. Group

Of the many gold prospects that have been discovered in Gem Lake area, only that one occurring on the G. X. group was examined. A trail leads west from the Gem Lake property to the G. X. group, situated 1,500 feet south of the west end of Bud lake. At this locality schistose, grey, trachytic, and andesitic lavas are exposed, some of which are porphyritic with white feldspar phenocrysts up to one-quarter inch long. The prospecting work has been done on the south side of a hill bordered by a wide swamp to the south. Two trenches along the north edge of the swamp expose rusty weathering, bedded, quartzose sediments carrying abundant pyrite. In all, sixteen trenches have been dug, some of them to depths of 10 feet in bedrock. The main trenches are along a line 800 feet long and trending south 50 degrees west magnetic. In the trenches at the northeast end of this line, sheared, trachytic lava is exposed. Some quartz in sheared, grey lava is exposed in the ten trenches located within a distance of 350 feet from the southwest end of the workings, but no continuous, well-defined body of quartz has been found. The quartz varies in width from 8 inches to 5 feet. Both white and smoky quartz are present, and some of it carries free gold. Iron sulphides are not abundant in the quartz. In two of the trenches exposing wider quartz masses, the schistose lava carries veinlets of quartz and grains of pyrite across widths of 10 feet. No information is available regarding the average gold content of the quartz bodies exposed.

BERESFORD LAKE AREA

Prospecting in the vicinity of Beresford lake dates from 1915, though only a few mineral claims were staked prior to 1919 when the Oro Grande group was staked by G. H. Porter and the Edna group by J. C. Irving. In 1921 the Madeline and a number of other groups were staked by Messrs. William Walton, Willie Quesnel, and Gunnar and Leo Berg. Some surface work has been done on a number of deposits by the Wad Syndicate, Anglo-Canadian Explorers, Deep Rock Mining Company, and the owners of mining claims. Underground work was done on the 125- and 500-foot levels of the Oro Grande deposit.

The bedrock exposed in this prospecting area (extending about 3½ miles north and 1½ miles west from the outlet of Beresford lake) is greenish grey to black, basaltic lava intruded by gabbro-diabase and by a narrow body of granite extending from the Madeline group north to the Edna group east of Tinney lake. Bedded quartzite and greywacke are exposed along the shore of Beresford lake, east of the basaltic lava. Within the lavas are thin layers of grey, bedded, tuffaceous materials, and nearby flows of basaltic lava show pillow structure. In thin section, the minerals of the massive-appearing lavas are for the most part altered to chlorite, calcite, albite, quartz, and epidote. Some of the lava contains light green weathering lumps of epidote and quartz. Some of the grey rocks intermixed with the darker-coloured types may have originally had the composition of trachyte, dacite, and andesite. In the gabbro-diabase, labradorite and green hornblende are the abundant constituents and are only in part altered to zoisite, calcite, and chloritic material. The granite is for the most part slightly schistose, and many of the quartz and feldspar grains are broken into angular fragments. The schistosity of the lavas and the bedding of the tuffs trend from north to north 30 degrees west, and the dip is from 65 to 80 degrees east.

Oro Grande

The Oro Grande deposit is well exposed along the top of a ridge of gabbro-diabase, and illustrates the discontinuous mode of distribution of the quartz within the shear zones so characteristic of many of the deposits of the gold area. A little surface work had been done on this deposit prior to the summer of 1923, when Mr. W. M. Dowdell located quartz rich in free gold at the edge of the swamp near the south exposed end of the quartz body. The deposit was optioned by Anglo-Canadian Explorers of Toronto in the winter of 1923-24 and the surface work was commenced at once. In the summer of 1924 an inclined prospect shaft was sunk 50 feet at a point 50 feet north of where the gold-bearing quartz had been located at the edge of the swamp extending southward. In this shaft high-grade gold ore was reported across an average width of 3½ feet. A number of trenches and pits were excavated north of the prospect shaft along a course bearing north and 400 feet long. These disclosed a quartz-bearing schistose zone, but the results of this work were disappointing, the bodies of quartz and the schistose wall-rock carrying abundant cubes of pyrite did not average commercial ore. The company also explored the deposit at depth by means of diamond drill holes located along a line 150 feet east of the deposit and extending 400 feet south of the southernmost outcrop. In this way the southward continuation of the deposit under the swamp was investigated, as was also, to shallow depths, the southern parts of the exposed stretch of the deposit. At a point on the east side of the swamp and about 600 feet southeast of the prospect shaft, a vertical shaft (the main or Solo shaft) was sunk to the 125-foot level and a crosscut was driven 300 feet west to the shear zone, which was followed 375 feet north and 75 feet south. Only small bodies of quartz of lower average grade than that of the prospect shaft were found at this level and work was abandoned by the Anglo-Canadian Explorers.

In the spring of 1928, Oro Grande Mines, Limited, was organized to continue the development of the deposit. The main shaft was continued from the 125- to the 500-foot level. At this depth a crosscut was run west 125 feet and a jointed and schistified zone in gabbro-diabase was followed north 500 feet. Some crosscutting was done near the north end of this drift. Work was discontinued in the late autumn of 1928.

The jointed and schistified zone outcropping on the Oro Grande mineral claim may be continuous for 6,200 feet along a general trend of north to north 30 degrees west, for to the south and to the north along the projected strike of the Oro Grande deposit, a shear zone is exposed at intervals on the following claims, listed in order from south to north, Victor No. 2, Solo, Oro Grande, Robert R, and Mandalay. Considerable trenching of this shear zone has been done on the Victor No. 2, Robert R, and Mandalay mineral claims. The quartz bodies exposed are all small and lenticular. Free gold occurs sparingly. The bodies of quartz and schistose rock that might be of commercial grade ore are all considered too small to warrant development at present.

Tinney Group

The Deep Rock Mining Company of Yorkton, Saskatchewan, owns the Tinney group of mining claims lying south of the south end of Tinney lake. The main work has been done on the Tinney Nos. 1 and 3 mineral claims. On Tinney No. 1 a body of white quartz 4 feet wide is exposed at the surface. A prospect pit at this locality proved that this quartz body was less than 2 feet thick and was developed on the nose of a small drag-fold in the lava, a low dip accounting for the wide outcrop. The shear zone is crooked and extends 300 feet in a general direction of south 30 degrees east. On Tinney No. 3 the shear zone is in granite. Here a prospect shaft was sunk 30 feet on one of the larger quartz bodies. The shear zone is exposed for a length of 500 feet along a direction south 30 degrees west. The quartz is in lenses and is white, fine grained, and carries a little pyrite and chalcopyrite. The zone of sericitic, schistose granite is of variable width, being 12 feet wide at the north end. Free gold was not seen in the quartz and no information is available regarding the average gold content of the deposits exposed on Tinney Nos. 1 and 3.

Edna Group

Three quartz bodies are exposed on the Edna group just west of the south end of Tinney lake. The northernmost of the three deposits outcrops at the shore of the southwest corner of Tinney lake and passes just north of the northwest corner of Tinney No. 3 mineral claim. It is exposed by trenches at intervals over a stretch of 1,180 feet along a strike of north 68 degrees west. The dip is vertical or steep to the north. The wall-rock is sheared basalt; granite outcrops 200 feet to the south. The basalt is sheared across widths of from 6 to 22 feet, and the quartz is distributed in the resulting chloritic schist as lenticular bodies and narrow, parallel veinlets. One quartz body is exposed with an average width of 12 feet for a length of 30 feet. Free gold is present in some of the quartz, but the average assay values across mineable widths for the whole length of the deposit are low. The other two deposits are 200 and 400 feet, respectively, to the southwest, and are in granite. The quartz outcropping here is lenticular in outline and white in colour. The average grade of bodies of quartz and sericite schist wide enough to work profitably is low, although free gold is locally abundant.

Claims North of Tinney Lake

Two long, narrow, shear zones are exposed in a belt of fine-grained, andesitic lava and agglomerate extending northwest from the north end of Tinney lake, but in these schist zones the quartz is erratically distributed in veinlets less than a foot wide and in lenses up to 4 feet wide and 50 feet long. The quartz is a white, barren-appearing variety, containing only a few grains of pyrite and chalcopyrite.

Madeline Group

Seven main schist belts carrying quartz are exposed on the Madeline group. The bedrock is basaltic lava with thin beds of greywacke-like tuff. The shear zones are in the basalt along the side and ends of a body of granite. Several of the shear zones extend from the basalt into granite, and projections of granite into the basalt are schistose and carry quartz. The schistose zones and their quartz bodies are exposed by prospect trenches and pits for lengths of from 100 to 600 feet. The strike of the deposits is north of east, their dip is variable. The largest quartz body is 600 feet south of the cabin near the winter road from Long lake to Oro Grande. This deposit is for the most part within granite along the west contact of the granite and basalt. A body of smoky quartz trends north 40 degrees east, averages 3 feet in width for 200 feet, and is reported to assay $8 a ton in gold. The other shear zones nearby, and 1,000 feet to the south on the Gunnar fractional mineral claim, carry quartz in small, irregular, discontinuous bodies. Thick drift along the projected strike of some of these shear zones has made it impossible to trace the deposits throughout their lengths. The schist zones, however, may be short, and may have formed along fracture planes developed around the granite body during its intrusion. Two wide schist zones are developed in basalt adjacent to the granite body on the sides of hills 400 feet north and 800 feet west, respectively, of the cabin. Quartz stringers and lenses are visible in prospect pits that expose widths of 12 feet of schistose basalt carrying pyrite cubes. The gold content of these bodies of quartz and schist is reported to be erratic, samples from one side of a trench assaying $8 or $10 in gold a ton, whereas on the opposite side the assays might show only a trace of gold.

Maberly Group

On the Maberly group, staked by Messrs. Blair and McConnel, twelve zones of schistified basalt carry lenses of quartz. Thin flows of porphyritic trachyte and beds of iron formation and tuff are interlayered with the basalt. Some brecciated grey lava is present and a few, small, irregular-shaped dykes and lenses of granite porphyry intrude the strata. The basalt is altered to chlorite schist showing small drag-folds across widths of 50 feet. The schist carries small veinlets of quartz. The outline of the schist area is irregular but roughly circular; the longer axis trends north 22 degrees east, whereas the schistosity strikes north 55 degrees west. The largest exposed quartz body is 600 feet south of the cabin on the trail leading north from the northeast side of Grassy bay on Manigotagan river. The quartz of this mass is white and carries iron carbonate, chlorite, white mica, and some tourmaline, pyrite, and chalcopyrite. Another body of quartz is 30 feet in diameter with veinlets extending 50 feet into the schist along the planes of schistosity. Of an area 200 feet in diameter, one-third is estimated to be white quartz and the remaining two-thirds chlorite schist containing quartz stringers, pyrite, and iron carbonate. The average gold content of the whole mass is reported to be low. Along the other eleven shear zones examined on this group, the quartz is distributed in stringers with no surface indications of a body of ore of commercial size or grade, although free gold occurs in the quartz of a number of these deposits.

Shirley Claim

Two narrow shear zones are exposed on the Shirley mineral claim to the east of the south end of the Maberly group. These deposits are small.

East of Beresford Lake

About 750 feet east of the northeast corner of Beresford lake a bed of siliceous, iron-bearing sediments within trachytic lava has been brecciated and is injected with white quartz. The brecciated, quartz-injected bed strikes south 20 degrees east and dips 78 degrees east. The mass is exposed for a length of 500 feet with an average width of 8 feet and in some parts the quartz is estimated to form about three-quarters of the body. The gold content apparently is low; no free gold was seen. Some work has also been done at a point 2,600 feet along a trail leading from the east side of the first expansion of Beresford lake north of its outlet. At this locality ten trenches expose a jointed and schistified zone in diabasic rock. The zone trends north 15 degrees west and dips 78 degrees east, and is exposed for 300 feet with an average width of 4½ feet. Light-coloured, sugary-appearing, and smoky quartz are intermixed. Iron carbonate is abundant in some of the quartz and in the schist, and locally pyrrhotite and pyrite are present.

Vicinity of Garner Lake

Considerable surface stripping has been done at points from 600 to 2,000 feet west of the northwest bay of Garner lake. Wide, schistified zones are exposed here in dark, diabasic, and grey, trachytic rocks. The quartz is white and is in small, irregular masses and veinlets erratically distributed across masses of crenulated schist 100 feet wide. Two shear zones are exposed on the Garner group near where the portage leading to Gem lake leaves the south shore of Garner lake. West of the portage, a mass of white and smoky quartz 275 feet long and up to 6 feet wide is exposed in prospect pits and trenches. In a shear 100 feet to the north, the quartz mass is 200 feet long and averages 2½ feet in width. The smoky quartz carries free gold and sulphides. The wall-rock is a dark, fine-grained, quartz-biotite rock, probably a greywacke-like sediment. Peridotite and gabbro outcrop at the lake shore and on the islands to the north. A tongue-shaped mass of granite extends westward from the large granite body to the east and several parallel shear zones are exposed along the side of the hill north of the granite tongue. Only a few prospect pits have been made at this locality.

Midway Group

A shear zone in andesitic lava is exposed for 1,000 feet and at intervals for another 1,200 feet on the Midway group of mineral claims, controlled by William Walton and associates and located west of the intersection of the winter road from Long to Beresford lakes and the creek from Wentworth to Stormy lakes. The strike of the schist zone is north 60 degrees west and the dip is steep to the north. Small, dyke-like masses of granite porphyry outcrop at intervals along this shear zone. The intrusive rock is in part altered to a quartz-sericite schist. The quartz bodies are narrow and discontinuous. In some trenches quartz averages one-half of the mass across widths of 6 feet. Some of the quartz carries free gold.

Central Manitoba Mines, Limited

The most extensive developments in the gold field to date have been on the Kitchener, Tene, and Hope groups controlled by the Central Manitoba Mines, Limited. According to information supplied by the Mining Lands Branch, Department of Interior, the Kitchener mineral claim was staked in the autumn of 1915 by Mr. Louis Simard for Letitia Germaine of Manigotagan. The Tene mineral claim was staked in June, 1922, and the Hope in March, 1924, by Mr. S. Clifford. Some fifty mineral claims had been staked in this vicinity for a Winnipeg syndicate in 1916. Some of these mining claims were surveyed, but the titles to all the claims held in this locality by this syndicate were allowed to lapse before the present mining activity commenced. Practically no surface prospecting had been done on this ground before the Wad Syndicate commenced work on the Hope mineral claim in the autumn of 1924. During 1925 this syndicate did considerable surface work and some diamond drilling. The Kitchener and Eclipse ore-bodies were outlined by drilling and a surface plant was brought in, and by the summer of 1926 work had reached the 375-foot level on the Kitchener vein. In 1926 the Wad Syndicate and Anglo-Canadian Explorers amalgamated their interests and Central Manitoba Mines, Limited, was incorporated to continue the development of the property. John Taylor and Sons of London, England, took a controlling interest in the property. In 1925 and 1926 some work was done on the Growler vein, west of the Kitchener, and on the Tene 6, Roger, and Hope veins to the east. An electric power line was built from Great Falls on Winnipeg river, 45 miles to the south, in the winter of 1927, also a telephone line to establish a connexion with the mine and the Winnipeg office. A 150-ton cyanidation mill was built during the summer of 1927, and this mill was operated continuously from October, 1927, to October, 1931. The production for the year ending April 30, 1931, was $408,900 in gold and to date the property has produced over $1,750,000 of gold.

The exploration at present is being concentrated on the deposits near the east end of the group, and during 1930 much of the ore has been taken from the Tene 6 shoot. In 1929-30 several holes, about 2,000 feet long, were drilled to explore the Kitchener and Eclipse quartz bodies at depth, but apparently no ore of importance was located in the drill intersections. In 1931 an agreement was made with the Ripstein interests to mine the ore of the westward extension of the Tene 6 deposit on the Tene No. 1 mineral claim. The ore from these deposits is hauled to the mill about 3,000 feet to the west by two one-ton trucks. A vertical shaft is now being sunk to explore the Hope deposit. In 1931 John Taylor and Sons retired as mine managers and the property is now managed by the Wad Syndicate, with Mr. I. M. Marshall as mine superintendent.

The bedrock (*See* Figure 3) exposed on the south side of the mineral claims is andesite and basalt with thin chert and tuff beds belonging to the Beresford Lake phase of the Rice Lake series. The volcanic rocks are followed to the north by a body of medium-grained gabbro and diabase, apparently intrusive into the lavas. Andesitic lava, showing pillow struc-

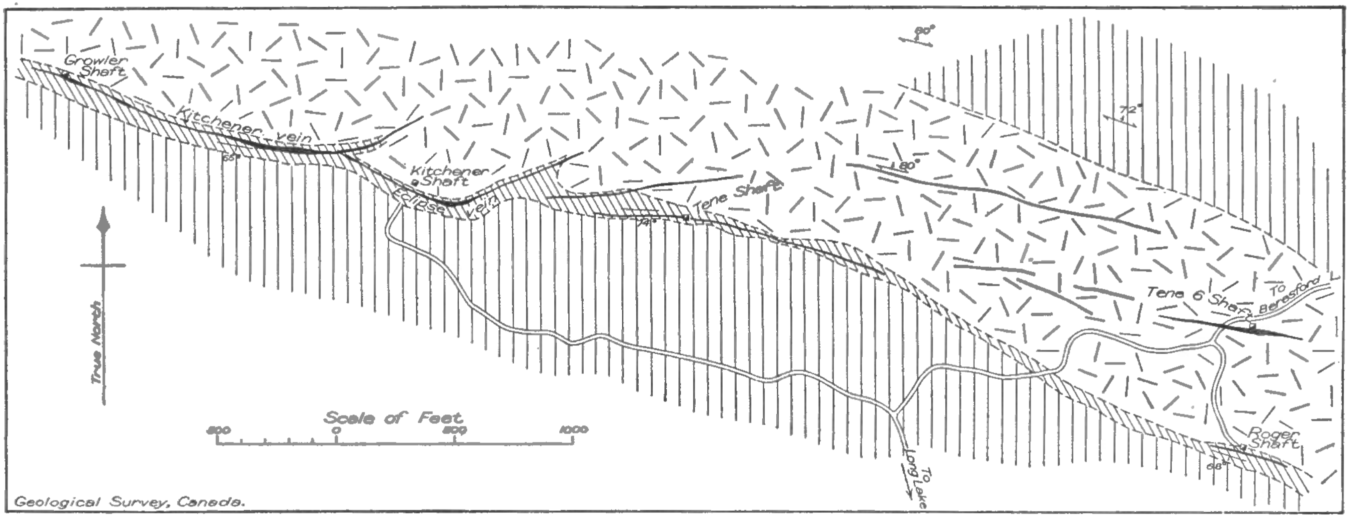

Figure 3. Plan showing geological relationships of the Kitchener, Eclipse, Tene, and other veins, Central Manitoba Mines, Limited, Beresford-Rice Lakes area, Manitoba. Quartz veins and shear zones shown by solid black; andesite and basalt by vertical ruling; chert and tuff by diagonal ruling; gabbro and diabase by irregular, pecked pattern.

ture, outcrops north of the gabbro body, which varies from 400 to 850 feet in width. Small dykes of granite porphyry cut the gabbro, andesite, chert, and tuff. Bodies of the granite porphyry are exposed along the workings on the 375-foot level of the Eclipse vein, and in the chert along the 520-foot level of the Kitchener vein. The Growler, Kitchener, Eclipse, and Tene veins are within the chert adjacent to the south margin of the gabbro and diabase. The Tene 6 and Hope veins are within the gabbro-diabase mass.

The gabbro-diabase typically is a massive-appearing, medium-grained, black rock. Locally, slightly porphyritic phases are developed. Other large outcrops have the appearance typical of diabase. Some outcrops are mottled, due to large, rounded, hornblende crystals lying in a fine-grained, feldspathic, and chloritic groundmass. Other outcrops show large crystals of greyish feldspar surrounded by hornblende and chlorite. The proportion of dark to light minerals varies within short distances, and some specimens contain quartz. The mass varies in mineralogical composition from quartz diorite to gabbro, the various types being intermixed; the abundant type is a hornblende gabbro. What appear to be small inclusions of andesite and chert are present in the gabbro along its contact. Underground, along the Kitchener and Eclipse veins, a crush-breccia of chert is cemented with the gabbro. In most places the gabbro-chert contact is sharp and the gabbro is a dense rock that within a distance of 1 foot or more away from the contact changes gradually to a phase of medium grain. At a few places the margin of the gabbro over a breadth of a few feet is slightly prophyritic. At other places a zone from 2 inches to 10 inches in width is developed wherein veinlets of gabbro and beds of chert alternate. A few of these gabbro veinlets cut across the chert layers and a number of small apophyses from the gabbro mass penetrate 2 or 3 inches into the beds of laminated chert.

The chert bed containing the quartz veins varies in thickness from 20 to 100 feet. It has been traced fairly continuously along the gabbro contact for 6,400 feet, and possibly extends another 4,000 feet, although the last 2,000 feet of this distance is drift covered. The chert is a very fine-grained, greenish grey, white, and black laminated rock. Interlayered with it are grey, massive, siliceous rocks composed of fragments of quartz, feldspar, and felsitic rock. This coarser material perhaps represents slightly water-sorted volcanic ash. Some beds of the chert are complexly folded and brecciated and the Kitchener and Eclipse veins lie in a folded and brecciated zone of the chert. A few, small, discontinuous dykes of granite porphyry were recognized within the chert. The granite porphyry is grey with rectangular-shaped feldspar phenocrysts in a dense groundmass. The dykes have narrow chilled margins against the chert. The granite porphyry dykes cut the gabbro but are cut by the quartz veins. The only rock noted cutting the quartz veins was a small, discontinuous, black, diabasic dyke cutting across gabbro, chert, and the Kitchener vein west of the main shaft.

South of the veins, the strike of the schistosity of the lavas and sediments is from south 74 to 81 degrees east, and the dip steep to the north. An examination of the outcrops of the chert bed south of the gabbro body suggests that the bedding of this horizon is also parallel to the schistosity and, therefore, dips north, but underground work indicates that the dip of the chert-gabbro contact along the Kitchener vein (*See* Figure 4) varies from vertical to 40 degrees south, the average dip being 62 degrees south above the 400-foot level and about 40 degrees south from the 400 to 520-foot levels. The regional dip of members of the Rice Lake series north of the east end of Long lake is north. It is impossible, however, to determine the top or bottom of the beds adjacent to the veins, hence it is not known whether a synclinal fold is here developed or whether the beds are locally overturned. Careful searches failed to locate outcrops of a chert bed similar to the one wherein the veins are developed, either north or south of the veins, and this suggests that the southward dip is perhaps due to local overturning of the strata rather than close folding. Possibly the southward-dipping chert and andesite strata may owe their present position to faulting, but no evidence of extensive faulting has been found in the rock exposures south of the quartz veins. West of the Growler mineral claim the gabbro-diabase body ends abruptly. A belt of highly schistose rock, trending approximately north 50 degrees west, outcrops along the west side of a small depression between andesite on the west and gabbro on the east. Projected eastward, this belt of schistose rock would pass under a long, swampy depression lying about 2,000 feet south of the Kitchener vein and extending south of east to Dove lake. Diamond drill holes inclined at 60 degrees and pointed a little west of north from the north edge of this depression south of the middle of the Kitchener vein, intersected a zone of carbonate schist, which may represent a fault zone. The numerous swamps and the lack of definite structural features in the rocks exposed, make the determination of structure difficult, and the deep drilling so far completed has not been extensive enough to permit correlating the structures intersected.

The gold-bearing quartz veins on the Central Manitoba property are located along what appears to be a zone of fracturing varying in width from 25 to 250 feet and over 2 miles in length. Within this main belt of deformation, there are a number of smaller zones wherein the rocks have been sheared and brecciated, and in a few of these lenticular shear zones gold-bearing veins have developed. The shear zones and gold-bearing quartz veins are roughly arranged *en échelon* along a strike of from south 75 to 85 degrees east. At the west end of the property the dip of the shear zones is nearly 60 degrees south, in the central area on the Tene 6 claim the dip is steeply north or vertical, and on the Hope claim at the east end the dips are from vertical to 75 degrees south.

The quartz veins on the Growler, Kitchener, and Tene mineral claims, at the west end of the zone of fracturing, are mainly within the chert adjacent to the gabbro, but their eastern ends pass into the gabbro (*See* Figure 2). The underground workings along the Kitchener and Eclipse veins show this relationship excellently (*See* Figure 4). Just west of the Kitchener shaft, the gabbro contact swings slightly south, and at this point the shear zone and quartz veins leave the chert and extend into the gabbro. On the 125-foot level a band of chert, varying from 1 to 5 feet in width, also continues within the gabbro for 50 feet or more along the

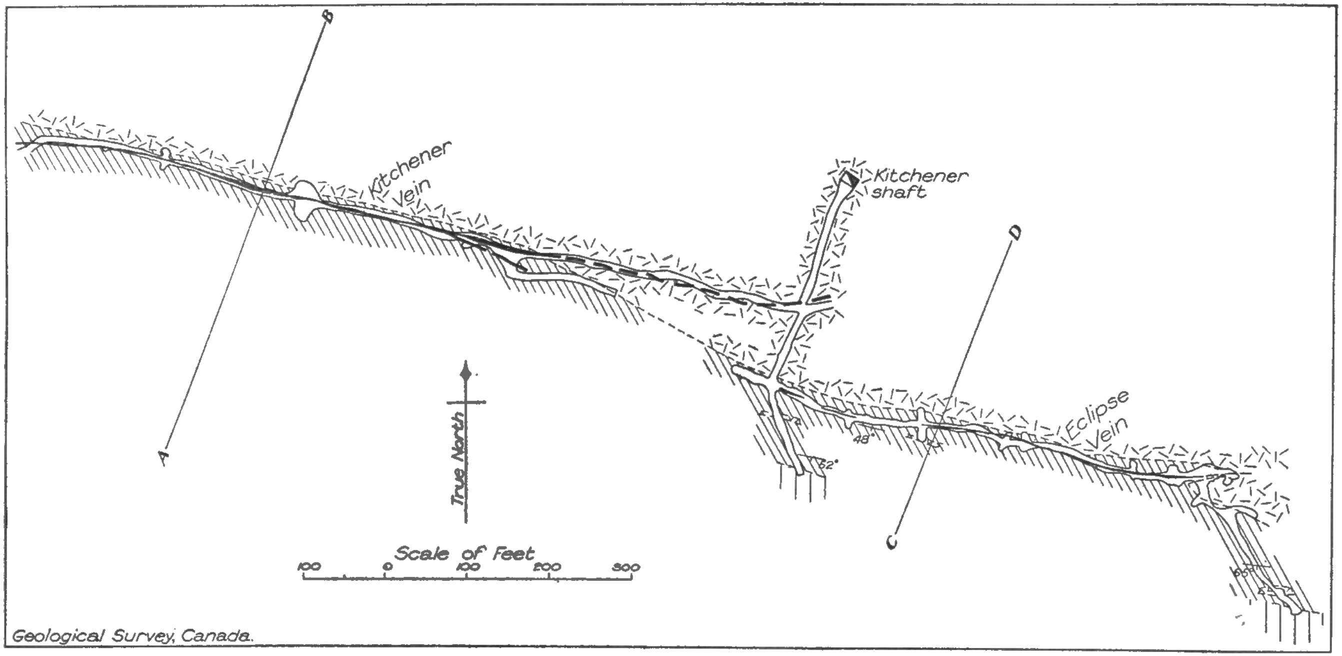

Figure 4. Plan of part of 375-foot level, Central Manitoba Mines, Limited, Beresford-Rice Lakes area, Manitoba. Quartz veins shown by solid black; andesite by vertical ruling; chert and tuff by diagonal ruling; gabbro and diabase by irregular pecked pattern; granite porphyry by angle pattern. (For cross-sections along lines AB, CD, *See* Figure 5.)

shear zone, and this tongue-like body of chert is interpreted as being a layer forced apart from the main chert bed by the magma that consolidated to form the gabbro body. Just east of where the Kitchener vein enters the gabbro, the Eclipse vein commences a short distance south within the chert adjacent to the gabbro. To the east this vein also enters the gabbro. The parts of the Kitchener and Eclipse veins within the gabbro do not carry gold. The chert bed is drag-folded and highly jointed west of the points where the shear zones and veins enter the gabbro. The largest bodies and best grade of ore are located within bay-like projections of the chert bed into the gabbro body. The drag-folding and jointing of the chert are the results of a slight movement of the south or hanging-wall side of the vein eastward and upward relative to the north or foot-wall side.

East of the Tene mineral claim, the gabbro contact swings south and the main fracture zone continues within the gabbro (Figure 3). The Tene 6 vein, and the Hope vein farther east, are along this main zone within the gabbro. The main fracture zone gradually crosses the gabbro body, and east of the Hope mineral claim the andesite along the north side of the gabbro is intensively sheared across widths of from 10 to 60 feet. The shear zones at the east end of the main fracture belt are larger and the rocks are more highly schistose than at the west end. In the highly schistose zones, the quartz is in small, lenticular bodies. The quartz at the west end of the main fracture zone is a dark, smoky variety, whereas on the Hope and to the east the quartz is a white, sugary-appearing variety. Both the Kitchener and Eclipse quartz bodies are of variable width and length on the levels explored, and the character of the deposit varies considerably from point to point along the same level. In places the whole width of the drift is in quartz, whereas in many other sections considerable chert is present in the quartz as long bands and angular fragments. On the 375-foot level the Kitchener quartz body is fairly continuous for 1,320 feet, but of this length only 550 feet was commercial ore. The average width of the ore lenses is about 4 feet, with some sections narrower, and others, especially where drag-folds are extensively developed, 20 feet or more in width. On the 250-foot level the average gold content was valued at $11.45 for a length of 900 feet and an average width of 5·1 feet. The quartz is the dark variety showing many joints and other, small, discontinuous cracks. No free gold was seen in the quartz, nor has free gold been found in the few thin sections of the ore examined microscopically. Some chalcopyrite and, locally, considerable pyrite are present in the quartz, also a little pyrrhotite. The results of tests show that most of the gold is free and in very small particles, only a very small proportion of the gold being associated with the sulphides. An analysis of an average sample of the Kitchener ore is as follows:[1] Gold, 0·78 ounce a ton; copper, 0·40 per cent; lead, nil; zinc, trace; iron, 1·67 per cent; nickel, 0·009 per cent; insoluble, 92·54 per cent. The small percentage of nickel in the ore probably is in the pyrrhotite, for in Oiseau River area to the south the pyrrhotite in sheared zones close to gabbro and peridotite is nickeliferous. Above the 375-foot level, the average dip

[1] Godard, J. S.: "Experimental Tests of Gold Ore from the Kitchener Mines, East Central Manitoba"; Invest. of Ore Dressing and Metallurgy, 1926, Mines Branch, Department of Mines, Ottawa, pp. 72-79.

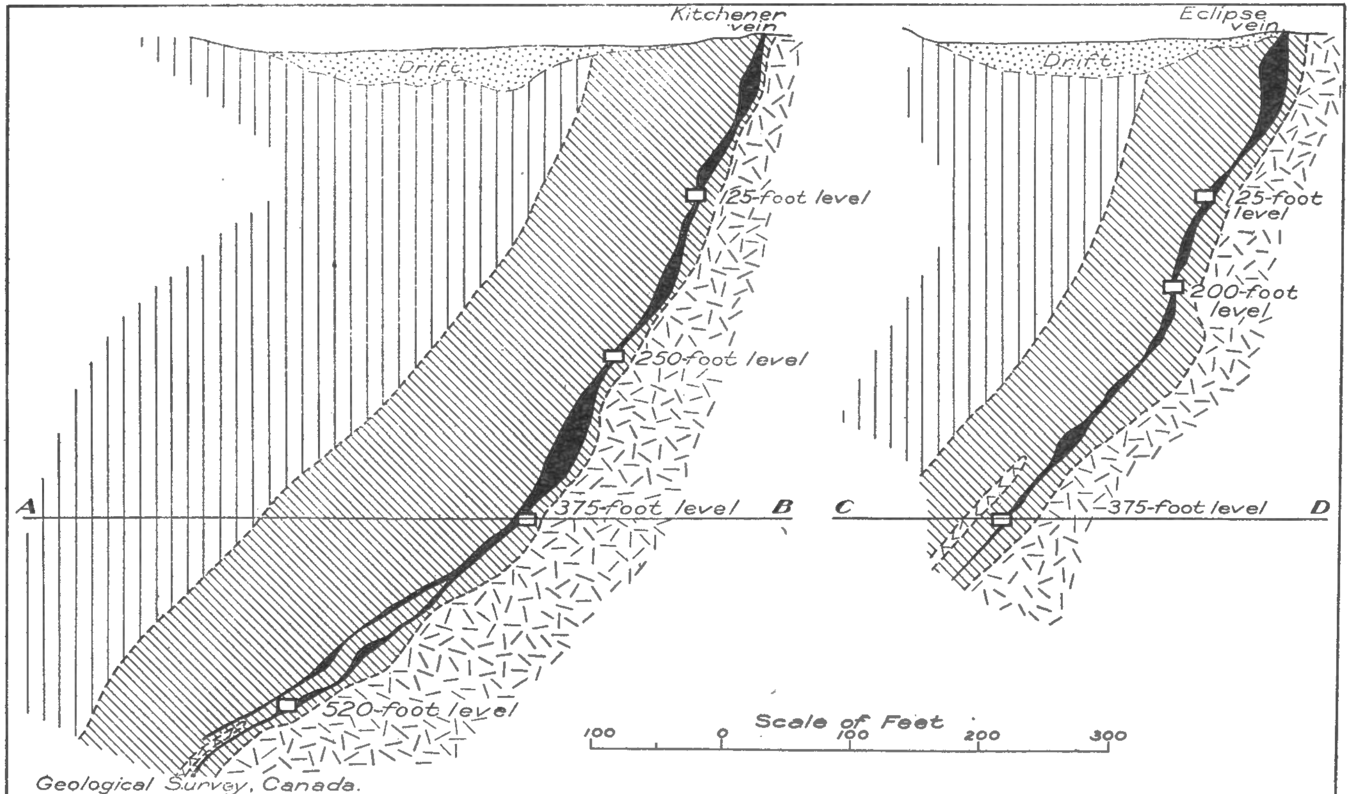

Figure 5. Vertical cross-sections along lines AB and CD of Figure 4, Kitchener and Eclipse veins, Central Manitoba Mines, Limited, Beresford-Rice Lakes area, Manitoba. Quartz veins shown by solid black; andesite by vertical ruling; chert and tuff by diagonal ruling; gabbro and diabase by irregular, pecked line pattern; granite porphyry by angle pattern.

of the Kitchener vein is approximately 62 degrees south, whereas between the 375- and 520-foot levels the dip flattened to nearly 38 to 40 degrees south (*See* Figure 5). Although the quartz vein is fairly continuous on the 520-foot level, the gold content is low in the flat-dipping section of the vein. Just below the 375-foot level, the gabbro contact bulged outward down the dip similar to the bulges along the strike. This contact might be expected in depth to again steepen, in which case another lens of ore might be present at some point below the 520-foot horizon.

The Eclipse vein has been explored on four levels down to the 375-foot horizon. The outline of the chert-gabbro contact is more irregular than along the Kitchener vein and the dip of the Eclipse vein varies from vertical to 75 degrees south. At the east end of the drift on the 200-foot level, the gabbro-chert contact dips 30 degrees north. The variations in the direction of the gabbro-chert contact are only local features, extending some 20 or 30 feet vertically, and about twice these distances horizontally. The Eclipse vein is 380 feet long on the 200-foot level and 320 feet long on the 375-foot level. This ore-shoot appears to plunge slightly to the east. The vein has not been developed below the 375-foot level. On the surface, east of the Eclipse vein, the chert has been slightly sheared adjacent to the gabbro content and to the andesite contact. In this section some surface work and diamond drilling to shallow depths have been done, but the quartz bodies so far outlined are small and of low grade.

The Tene 6 vein is about 3,500 feet east of the Kitchener and is near the middle of the gabbro body (Figure 3). The deposit at the surface is a lenticular body up to 19 feet wide and about 200 feet long, consisting of dark quartz carrying considerable chalcopyrite. This quartz body for a length of 155 feet and across an average width of 15·5 feet gave assays ranging from $13 to $20 a ton, with many assays much higher than these figures. The shear zone in the gabbro continues a considerable distance beyond the ends of the quartz lens. In depth the quartz body ended, but other small lenses of quartz were encountered in following the shear zone down the dip, and also along the strike. The quartz bodies and, hence, the ore-shoots in this shear zone are small and not closely spaced.

The Roger vein is 500 feet south of the Tene 6 deposit and is along the gabbro-chert contact (Figure 3). Some underground work was done on this vein from an inclined shaft 175 feet deep, but the deposit was found to be small and lenticular at depth.

The west end of the Hope deposit is 1,400 feet east of the Tene 6 shaft (Figure 4). The gabbro east of the Tene 6 is sheared, but there is no evidence that the Tene 6 and Hope shear zones are continuous across the large, intervening, drift-covered area. The Hope shear zone is in gabbro near the north side of the gabbro body. This zone is well exposed 700 feet along its strike, and across widths varying from 9 to 75 feet. The dip of the shear zone is from 80 to 85 degrees north. Along the shear zone the gabbro is in part altered to a chlorite-carbonate-quartz schist. Quartz in narrow, parallel veins and stringers is distributed throughout the schistose rock. Chalcopyrite, pyrite, and free gold are present in the quartz. No large, continuous body of quartz is exposed in the trenches. To the east along the projected strike of the Hope zone, several shear zones have been stripped. A number of fairly large quartz veins have been opened up by prospect pits in the area to the east and south of the Hope zone. The quartz is white and fine grained, and all the deposits so far sampled in this part of the area are barren or carry on the average low values in gold.

Some surface work has been done along schistified zones within andesitic and basaltic lava in the area surrounding the Central Manitoba group. On the New Hope mineral claim, a schist zone and a small quartz body are exposed along the trail leading north from the Kitchener at a point 3,000 feet north of the Kitchener shaft. To the west in the vicinity of Halfway lake, several schistified zones have been opened up by a few trenches, but the quartz bodies of this locality are all small. To the east and southeast some work has been done on the Dot, Heather, Hope No. 5, Success, Stovel, Anaconda, Dome, and Eureka mineral claims. At some of these localities wide shear zones are exposed. The quartz, however, is a white, barren-looking variety carrying little mineralization. These bodies are also of irregular outline and discontinuous along the strike. The average gold content of these deposits is unknown.

ELDORADO AREA

Within this area is grouped the gold deposits extending from southeast of the southwest end of Halfway lake to Bidou lake east of the northeast corner of Long lake. The bedrock around the southwest end of Halfway lake is massive, medium-grained granodiorite and granite cut by a few narrow dykes of pink aplite. North of the east end of Long lake, andesitic and basaltic lavas of the Rice Lake series and dykes of granite porphyry constitute the bedrock. The majority of the gold-bearing quartz deposits are along shear zones within the granitic intrusive mass.

Eldorado Claims

The main development work in this area was done on the Eldorado mineral claim. This and the group of fifteen surrounding mineral claims were staked in 1916 by Messrs. William Walton and Gilbert Labine. Surface work exposed a narrow shear zone trending north 40 degrees west for 2,400 feet, and perhaps continuing another 2,000 feet to the northwest, for a shear zone is exposed along the projected strike of the deposit to the northwest of the creek from Halfway lake. The shear zone varies in width from 1 foot to 5 feet and its contact with the massive granite is sharp. Within the zone the granitic rock is altered to a quartz-sericite schist containing, in places, rounded grains of feldspar that are remnants of the original, larger, feldspar crystals. Three small quartz lenses carrying abundant free gold were exposed at intervals along the shear zone and small lenses and veinlets of quartz were found erratically distributed throughout the belt of schist.

Early in 1926, Eldorado Gold Mines, Limited, was organized to develop the property. During the summer of 1926 surface work was carried on and two prospect shafts, each 50 feet deep, were sunk on the southwest and northeast quartz lenses respectively. In 1927 a mining plant was installed and a power line was built from the Central Manitoba property, approximately 2 miles to the east. The southeastern prospect shaft was deepened to the 520-foot level, and at the 125-foot level drifts were run along the shear zone for 527 feet west and 297 feet east of the shaft. Lenses of gold-bearing quartz from 2 to 3 feet wide were found along the shear zone west of the shaft, whereas to the east the shear zone narrowed and at the east end the drift was in fairly massive granite cut by aplite stringers. On the 250-foot level, a drift was run 1,071 feet west and another 490 feet east of the shaft. No ore was found west of the shaft, and east of the shaft, though the quartz was 7 feet wide at one point, only a few assays gave encouraging values in gold. No work was done at the 375-foot level. On the 500-foot level, 1,051 and 733 feet of drifting was done west and east, respectively, of the shaft. No ore was found, and the shear zone in places was narrow, the wall-rock a massive, pink, aplitic granite. The assays of samples from the surface and near the shaft on the 125-foot level indicate small shoots of good-grade ore. The results of the work on the lower levels, however, were very disappointing and there appeared to be no possibility of locating a large deposit of commercial ore above the 500-foot level, consequently, work was stopped in November, 1928.

Claims Southeast of the Eldorado

Southeast of the Eldorado, some prospecting has been done along shear zones on the Calumet, Orion, Rockland, and Ogama mineral claims controlled by William Walton and associates. The bedrock here is granite and granodiorite. The shear zones strike northwest. These deposits have been traced only a few hundred feet along the strike and all the quartz bodies are small. Free gold is present in some of the quartz.

Kingfisher Gold Mines, Limited

Kingfisher Gold Mines, Limited, control the Dardanelles, Elora, and some twelve surrounding mineral claims located northeast of the Ogama. The first work on this group was done by A. M. Steward in 1916 on the Dardanelles mineral claim. A shear zone in andesite was opened, but little quartz was found. In 1922 a two-stamp mill was built to the west on the Elora fractional mineral claim and a small, high-grade body of quartz was mined by open-cuts. Some 200 tons of this ore is reported to have yielded $2,300 in gold. Pockets of the quartz carrying arsenopyrite were high grade and free gold was abundant in some of the quartz. This deposit is in andesitic lava 300 feet east of the granite contact. In 1928 work was recommenced, this time on the Valley Vein mineral claim of this group. Some mining equipment was installed and a shaft was sunk to a depth of 34 feet. This deposit is in granite and the surface outcrops of quartz are small. Work was stopped late in 1928.

Blenn Claim

Some surface work has been done on the Blenn mineral claim just north of the Elora Fraction. This claim is controlled by Messrs. George Edmunds and William Walton. The bedrock is andesite lava and lies between a small outcrop of granite to the east and the main granite body to the west. The quartz body averages 4 feet in width for 100 feet along the strike. Free gold is abundant in the quartz at a few points. The deposit is drift covered to the north.

North Star and Rex Claims

Quartz bodies are also exposed along shear zones on the North Star, Rex, and Shuniah mineral claims, 3,000 feet along a trail northeast of the Blenn. The North Star deposit is in gabbro, the quartz bodies on the Rex are in a mass of granite and granite porphyry about 1,000 feet in diameter. No large, continuous, quartz bodies are exposed on these mineral claims.

Onondaga Claim

In 1924 a shaft was sunk to a depth of 100 feet on the Onondaga deposit controlled by Mr. V. S. A. Ripstein and associates of Winnipeg. This deposit is 2,000 feet southeast of the Ogama. The shear zone is within and along the contact of a dyke of granite porphyry with andesitic pillow lava just east of the granite mass extending southeast from the Eldorado. The quartz is distributed in small lenses and stringers through a belt of schistose rock averaging 6 feet wide and 800 feet long.

Mirage Group

Considerable surface work has been done on the Mirage group controlled by Mr. Cris. Hodgins and associates and located east of Bidou lake. The bedrock here is basaltic lava intruded by dykes of granite porphyry. Two main schist zones are exposed. They strike north 80 degrees west and dip from 40 to 70 degrees north. The northern zone is exposed for 1,000 feet along the strike and averages nearly 6 feet in width. The quartz is in small veinlets and lenses within the schist. Brownish iron carbonate is abundant in some of the quartz and in the chloritic wall-rock. Both white and smoky quartz are present. Free gold is abundant in some of the quartz, and a few specimens of crystalline gold have been collected from this deposit. An inclined prospect shaft was sunk 35 feet near the east end of the deposit. The quartz lens narrowed in depth and, for a part of the depth explored, was bounded on the hanging-wall by a sharp contact representing a joint plane which is slickensided. The southern shear zone is exposed for a length of 2,000 feet and in places is 20 feet wide, the average width being nearly 6 feet. Quartz is only sparingly present in this belt of schist. It occurs in veinlets and small lenses, and, at the west end, in one vein-like mass 2 feet wide and 75 feet long. Some free gold occurs in the large quartz body. The average gold content of mineable widths of schist impregnated by quartz is not known.

CRYDERMAN AREA

Cryderman

This area extends northwest from the north end of Moore lake to Bennett lake. The Cryderman is the only deposit that has been developed by underground work. This deposit was discovered in May, 1925, by R. Cryderman, and the Mining Corporation of Canada at once took over the exploration of the group of mining claims located at that time. The rock exposed on this property comprises basaltic and andesitic lavas of the Beresford Lake phase of the Rice Lake series and dykes of basalt and granite porphyry. Quartzose sediments outcrop on Moore, Palamar, and Bennett lakes. The deposit is in andesitic pillow lava and surface work exposed a shear zone following a general direction of north 40 degrees west and carrying quartz at five points. The deposit dips from 58 to 78 degrees southwest. At the southeast end, two nearly parallel shear zones lie 100 feet apart and are exposed for 425 feet along the strike. Small lenses of quartz are present along the northern shear. A body of white and smoky-coloured quartz, averaging nearly 4 feet in width, is exposed along the south zone. At one place the quartz is 20 feet wide. Coarse particles of free gold are present along cracks in some of this quartz. Underground work, done during the summer of 1926, includes a shaft 260 feet deep, and 656 and 232 feet of drifting and crosscutting on the 125- and 250-foot levels respectively. A wide, white, quartz body was exposed along the drifts on both the 125- and 250-foot levels, but the average gold content was very low. Some diamond drilling was done to the west of the shaft during the winter of 1927. The surface work to the northwest of the shaft exposed five zones of sheared rock up to 10 or 12 feet in width and carrying some quartz. The average gold content of these quartz bodies is low.

This property was purchased from the Mining Corporation of Canada by Winnipeg financiers, and in the winter of 1928, Cryderman Mines, Limited, was organized to continue the development of the deposit. Surface work was carried out during the summer of 1928 by this company, but no information is available regarding the results of this work. No work was in progress in the deposit during the summer of 1929.

Moore Lake Mines, Limited

A number of shear zones are exposed in the andesitic lava between the Cryderman and Moore lake and some surface work has been done on a few of them. Moore Lake Mines, Limited, during the summer of 1928 did surface work on a group of forty-seven mineral claims at this locality. On the Two Bits mineral claim a prospect shaft was sunk to a depth of 40 feet in a shear zone that is exposed for 1,500 feet along the strike and in places is 15 feet or more wide. Quartz in small stringers occurs throughout the wide belt of schist. Some of the quartz carries free gold, but the quartz is not abundant enough to give the whole zone a gold content high enough to make a large deposit of commercial value.

GOLD LAKE AREA

The mining activities from 1914 to 1923, in Beresford-Rice Lakes area, centred in the area south of Gold lake and northwest to Rice lake. Underground work was commenced on the Gold Pan, Moose, Gold Pan Extension, and Pendennis deposits, and in 1916 a mill was built on the Gold Pan where a small, high-grade ore-shoot was being developed. The early mining activities were more or less haphazard and consisted of sinking small shafts and pits without first having thoroughly explored and sampled the surface showings to determine the size and grade of the outcrops of the deposits. This area has received little attention in recent years. The prospect shafts are now full of water and little is known regarding what was found underground. The Gold Pan workings were last pumped out in the autumn of 1923 when an attempt was made to mine and mill the ore below the 200-foot level. The mill on this property has since been burned and the mining machinery has been purchased by other operators in the area.

Gold Lake area is underlain by volcanic rocks, including andesite and dacite with porphyritic and schistose phases. The lavas are cut by many porphyry dykes ranging in mineral composition from granite to diorite porphyry and by a few dykes of gabbro and diabase. The schistosity of the volcanic rocks strikes northwest and the dips are vertical to steeply northeast. About 1 mile east of Gold lake the lavas are cut off abruptly by a large area of granite extending eastward to near the east end of Long lake.

Gold Pan, Gold Pan Extension, and Gold Seal

The Gold Pan, Gold Pan Extension, and Gold Seal deposits are along the same shear zone. This zone strikes north 30 degrees west and is exposed for 2,500 feet, but is narrow, being at only a few places as much as 4 feet wide. The quartz is irregularly distributed, varying from 1 inch to 2 or 3 feet in width, and averaging less than 1 foot. The Gold Pan shaft was sunk where the shear zone crosses a gabbro dyke trending east of north. This dyke was displaced 20 feet along the fracture zone and the quartz adjacent to the north face of the dyke was very rich in gold. The quartz body, however, was only a chimney-shaped mass about 15 feet long and 4 to 5 feet wide. The quartz along the shear zone in the lava east and west of the intersection of the dyke was barren or of medium grade. The open spaces resulting from the fracturing of the brittle gabbro apparently made favourable conditions for the concentration and deposition of gold. In all, some 725 feet of underground work was completed on the 100- and 200-foot levels of the Gold Pan deposit. Several hundred feet of sinking and drifting were done on the Gold Seal and Gold Pan Extension deposits, but the results of the work are not known. These two deposits as revealed at the surface are considered to be far too small to be of value.

Moose Claim

The Moose and several other mineral claims to the northwest were staked along well-developed fracture and shear zones. Along the strike of the Moose shear, southwest of the shaft, the granite is fractured and impregnated with quartz for 50 feet from the granite-lava contact. In the lava near the granite contact, the shear zone is of irregular outline and trend. Three lenses of quartz, of which one is 100 feet long and 6 feet wide, are present along this shear. The Moose shaft was sunk on the largest of these, 200 feet away from the granite. The quartz carries some free gold and considerable pyrite and chalcopyrite. The northwest continuation of the Moose shear zone is drift covered.

Nevada Claim

Near the north side of the Nevada mineral claim, 6,000 feet northwest of the Moose, two wide shear zones are exposed but carry little quartz. A number of small quartz bodies are exposed north of the Moose deposit, both in granite and in the adjoining, fractured and baked, andesitic lava. The outcrops of all the known deposits are far too small to be of economic importance.

Pilot, Smuggler, and Canadian Girl Claims

To the southwest of the Gold Pan a well-developed, continuous shear zone crosses the Pilot, Smuggler, and Canadian Girl mineral claims. It strikes north 15 degrees west and appears to cut slightly across the general strike of the schistosity of the enclosing lava. For a part of its distance the shear zone follows the contact of a gabbro dyke with andesitic lava. Where exposed on the Canadian Girl, the quartz averages about 2 feet in width and the shear is 6 or 8 feet wide. The shaft on the Pilot claim showed considerable pyrite in the quartz and 30 feet from the surface, on the south wall of the shaft, there is a band of solid pyrite a foot wide. The shear zone is in places over 30 feet wide, but along the strike to the southeast the quartz is not so abundant. So far as is known this deposit and a number of others in this area have not been systematically sampled.

RICE LAKE AREA

Free gold was first discovered in Beresford-Rice Lakes area early in 1911, by a native of Manigotagan by the name of Trueheart, in a quartz body near the northwest corner of Rice lake. Capt. A. E. Pelletier staked the Gabrielle group of mineral claims at this locality in March, 1911; these were the first claims staked in the area. The San Antonio mineral claim was staked in May, 1911, by Mr. Alexander Desautels, who later transferred all interest in the deposit to Capt. Pelletier. Between 1911 and 1914, a number of groups of mining claims were staked north of Rice lake and prospect shafts were sunk on several deposits. This work, however, did not locate gold-bearing quartz bodies of promise and the prospectors gradually worked eastward to Gold, Long, and Beresford lakes. All the workings north of Rice lake were soon abandoned and little development has since been done in the area, except on the San Antonio deposit where work has been in progress since 1926.

The bedrock exposed in the vicinity of Rice lake comprises thick-bedded, quartzose sediments of the Wanipigow phase and basaltic and andesitic lavas of the Beresford Lake phase of the Rice Lake series. The strike of the bedding and schistosity of the sediments and lavas is from west to north 75 degrees west and the dip from 45 to 70 degrees north. In the underground workings of the San Antonio deposit, the sediments are followed to the north by basaltic lava with no apparent evidence of an erosional or structural break between the two types of rock. A roughly lens-shaped mass of porphyritic rock, 2 miles long and ½ mile wide, outcrops north of Rice lake. This body has a mineral composition near quartz diorite. A few narrow dykes of black, diabasic rock cut the sediments and quartz diorite.

San Antonio

The most important known deposit in this area is the San Antonio on the north shore of Rice lake, three-quarters of a mile east of the northwest corner of the lake. The outcrop of the San Antonio vein was located in 1911, but only a few prospect pits and trenches were dug on the property prior to 1922. In the summer of 1926 surface work was undertaken on the property by the Wanipigow Syndicate. This work indicated an area about 100 feet wide and extending 1,200 feet northwest from the point (formerly a small island) on the lake where No. 2 shaft (*See* Figure 6) was subsequently sunk, wherein several shear zones carrying quartz were present. In July, 1927, Wanipigow Mines, Limited, was incorporated and took over the property from the Wanipigow Syndicate. In September, 1927, the name of the company was changed to San Antonio Mines, Limited, and except for two short periods, this company continued underground work up to the end of 1929. In 1927, No. 1 shaft was sunk on top of a hill and near what was thought to be the largest shear zone within the belt of schistose rock. As the underground work, on the 125-foot level, did not disclose a well-defined shear zone and quartz body, this shaft was abandoned and No. 2 shaft was sunk at a point 950 feet to the southeast. According to a report by Mr. D. J. Kennedy, mine superintendent, in the twenty-eight months preceding the first of December, 1929, some 9,100 feet of underground work, including shaft and winze sinking, drifting, crosscutting, and station cutting, had been completed from No. 2 shaft. Underground work was continued during 1930 and the quartz bodies were explored at several points to the 900-foot levels. Early in 1931, 3,000 feet of diamond drilling was done from the various levels. A total of 61 feet of ore, averaging $9.80 a ton in gold, was reported in six drill intersections. The results of this work are reported to have doubled the ore reserves, and in August, 1931, the property was sold to San Antonio Gold Mines, Limited. This company is building a 150-ton mill and plans to commence production early in 1932. Power is to be supplied from Central Manitoba mine, 18 miles to the east.

The quartz bodies on the San Antonio mineral claim are along shear zones in greenish black basalt and diabase, probably representing a thick lava flow. In thin section under the microscope the feldspar of this rock is altered to saussurite, albite, quartz, and calcite, and the ferromagnesian minerals are uralite, hornblende, actinolite, and chlorite. Thick-bedded quartzite and arkose with conglomerate lenses outcrop in the large islands south of the property. The strike of the sediments is south 80 degrees east and they dip 40 to 60 degrees north. The No. 2 shaft passed from basalt

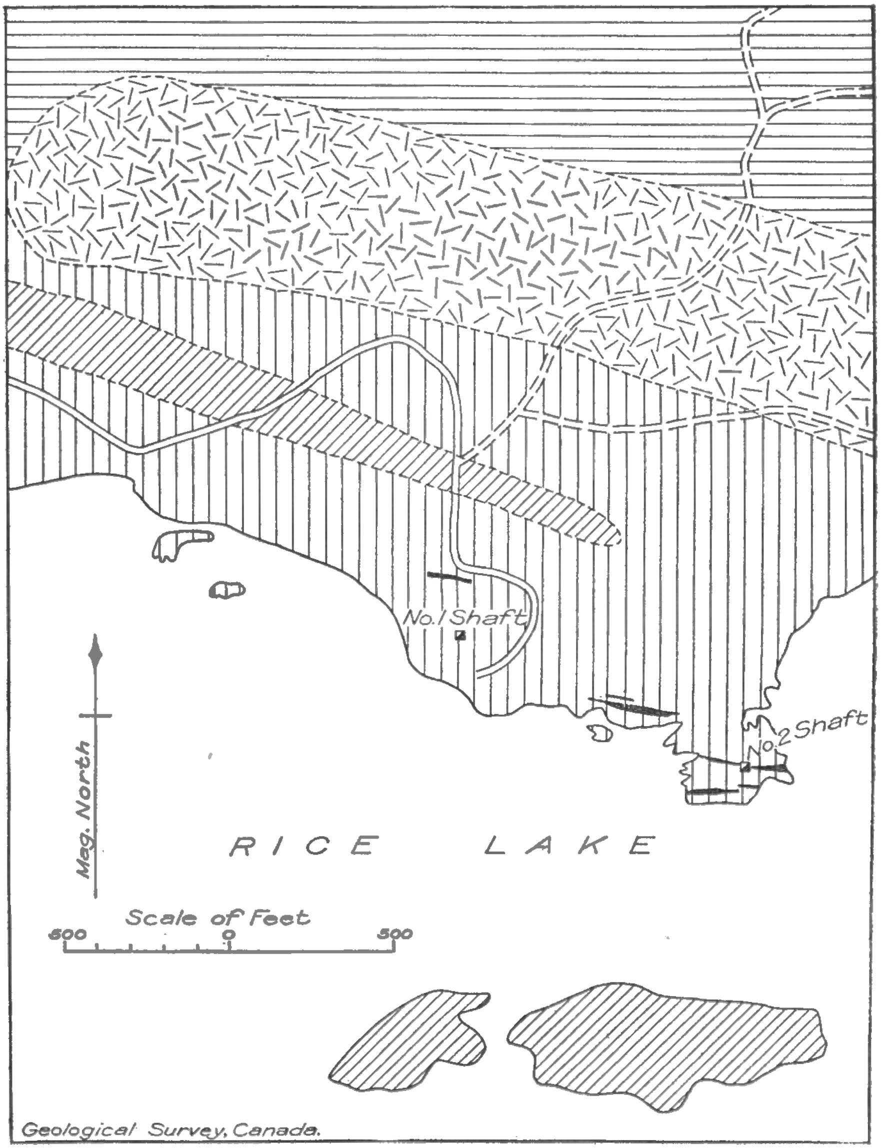

Figure 6. Plan showing geology in vicinity of San Antonio gold deposit, Beresford-Rice Lakes area, Manitoba. Quartz veins and shear zones shown by solid black; basalt and diabase by vertical ruling; quartzite, arkose, quartz-sericite schist by diagonal ruling; quartz diorite porphyry by irregular, pecked pattern; rhyolite and dacite by horizontal ruling.

into sediments at about the 300-foot level, hence the contact between basalt on the north and sediments on the south is under the lake about 300 feet south of the shaft. The sheared zone carrying the quartz bodies outcrops at intervals at the foot of and along the side of a ridge crossed by several north-south depressions and followed to the north by a wide drift depression. Pillow lava outcrops at a few places along the foot of the hill north of this drift depression and to the east along the north shore of Rice lake. The high ridges north of this drift depression are of a porphyritic rock, near quartz diorite in average mineral composition. Locally this igneous rock is sheared and the lava along its south contact is highly schistose and carries some vein quartz. Small inclusions and schlieren-like patches of lava are locally present in this porphyritic rock, and around the east end of the mass dykes of granite porphyry cut the schistose lava. The abundant phenocrysts of the body are oligoclase-andesine in crystals up to one-half inch across, the majority of the phenocrysts, however, being under one-quarter inch across. Some outcrops show grains of bluish quartz in addition to feldspar phenocrysts. The greyish groundmass is of untwinned feldspar, probably both orthoclase and albite, biotite, chlorite, and sericite and some calcite, epidote, zoisite, and magnetite. The body of porphyritic rock gradually narrows and ends just north of the west end of Rice lake. The mass is lenticular in outline, and is about 2 miles long and ½ mile wide at its widest point. The south contact dips north parallel the schistosity of the lava, and this mass of porphyritic rock perhaps is a sill or laccolith-like body. The arkosic sediments and the quartz-diorite porphyry are cut by narrow dykes of black diabase.

No large and continuous shear zone or vein was exposed on the surface, the best showing perhaps being the one just north of No. 2 shaft. Here, an open-cut on the north side of the hill exposed 3 feet of quartz and from 20 to 30 feet of sheared and massive basalt. The sheared basalt carries iron carbonate, quartz, and pyrite. Both east and west of the open-cut the quartz body branches and is irregular in outline. The quartz exposed at the surface was not encountered in the 150-foot level, although the basaltic rock was schistose and altered to secondary minerals along the short drifts and crosscuts. On the 300-foot level, considerable more drifting was done than on the 150-foot level, and in the drifts a few small quartz veins and stringers were found, also small bodies of grey carbonate rock. This grey carbonate rock passes outward, in some places through a narrow, brecciated zone and in others through a highly schistose zone, into only slightly schistose and altered basalt. In thin section under the microscope the grey carbonate rock consists of carbonates (ankerite, dolomite, and calcite) about 50 per cent, albite about 25 per cent, quartz 10 per cent, pyrite 10 per cent, leucoxene 3 per cent, and pyrrhotite 2 per cent. This rock is considered to represent diabase or basalt that has been highly altered by solutions carrying considerable iron and carbon dioxide. Most of the grey carbonate rock carries a little gold, and a few assays are reported to indicate the presence of commercial quantities of gold across narrow widths. The average, however, of a large body of this rock is low grade.

Most of the development work to date has been done on the 600- and 725-foot levels (Figure 7). On the 600-foot level the crosscut northeast

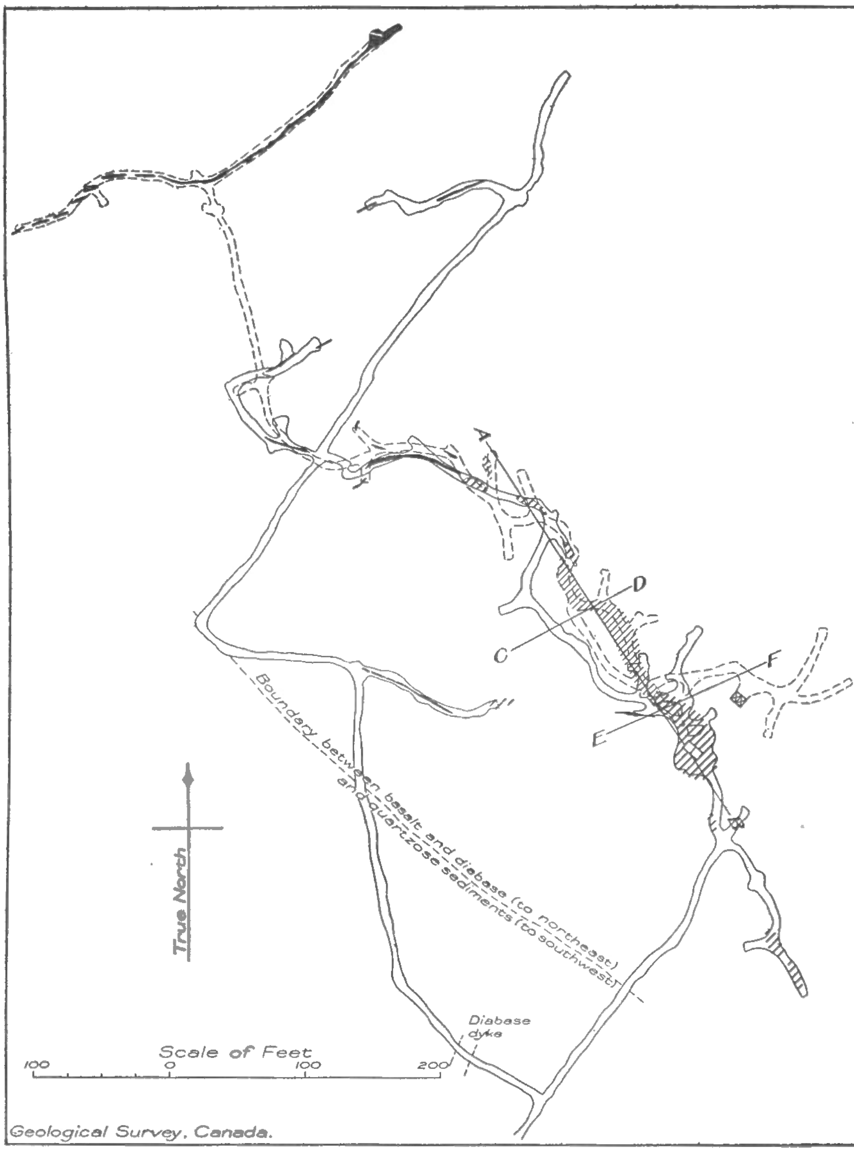

Figure 7. Plan of 600-foot and 725-foot levels, San Antonio mine, Beresford-Rice Lakes area, Manitoba. Quartz veins shown by solid black, irregular lines; 600-foot level shown by continuous line, 725-foot level by pecked lines; areas of carbonate on 600-foot level shown by heavy diagonal ruling; areas of carbonate on 725-foot level by light diagonal ruling.

from the shaft is, for the first 280 feet, in arkosic sediment, with highly schistose zones between the thick, massive beds. This crosscut continues northeast in slightly schistose basalt for 130 feet beyond the arkose-basalt contact. At this point a zone of highly schistose basalt was encountered, and this was drifted on to the north and south of the crosscut. About 40 feet northwest along the drift to the north, a body of grey carbonate rock was entered and found to be 39 feet wide at the widest point and 70 feet long. A winze from the 600- to 725-foot levels was commenced in this carbonate rock, and on the 725-foot level, just northwest of the winze, a long, narrow body of carbonate rock was outlined that may be the downward continuation of the body on the 600-foot level. If so, the body extends a greater distance vertically than horizontally, and may be roughly lenticular in outline. On the 600-foot level several smaller lenses of carbonate rock were found along the drift for a hundred feet or more both northwest and southeast of the main body. In the drift to the north, a quartz vein was followed for 80 feet from a point approximately 390 feet northwest of the crosscut. This vein dips from 20 to 30 degrees to the north, and its average trend is nearly east and west. The quartz carries free gold and the assays are reported to indicate a small body of good-grade ore. Considerable other work was done on the 600-foot level (*See* Figure 7). No large, continuous bodies of quartz were found, although the diabase and basalt are jointed, sheared, and altered to chlorite schist with narrow zones of rock completely altered to chlorite-carbonate schist carrying pyrite.

On the 725-foot level, a drift was run 450 feet northwest from the winze from the 600-foot level. The drift runs through a body of carbonate rock just northwest of the winze and previously mentioned as being perhaps the downward continuation of the body of similar rock on the 600-foot level (*See* Figure 8). No large quartz vein was found along this drift, although the basaltic lava for most of the distance was altered to a chlorite-carbonate schist. At 450 feet along the drift northwest of the winze, the direction of the workings was turned to nearly north, and 70 feet of schistose lava and 120 feet of black, fine-grained, hard rock were crossed. This hard rock, as seen under the microscope, is an aggregate of epidote, chlorite, and carbonate in a matrix of quartz. Needles of tourmaline are abundant in some areas of the thin sections. A characteristic feature of the thin sections is large grains of leucoxene, some of which are slightly brownish and appear to be slightly altered titanite. This rock may be either a basic dyke or an andesitic lava highly altered and silicified. The hard rock passes gradually to the north into sheared, chloritic lava, and about 30 feet north of the silicified, hard rock, a quartz vein was encountered in the sheared, chloritic lava. This vein trends approximately northeast and dips nearly 70 degrees northwest; its course is nearly at right angles to that of the schistose zones on the 600-foot level and near the winze on the 725-foot level. At the time the property was examined, near the end of September, 1929, the northeast-trending shear zone and vein on the 725-foot level had been explored for about 325 feet along its strike. A recently issued report of the company states that the average gold content is $12.94 a ton for a length of 329 feet, and across an average width of 3·8 feet. At one point the quartz is 11 feet wide; the average width northeast of where the vein

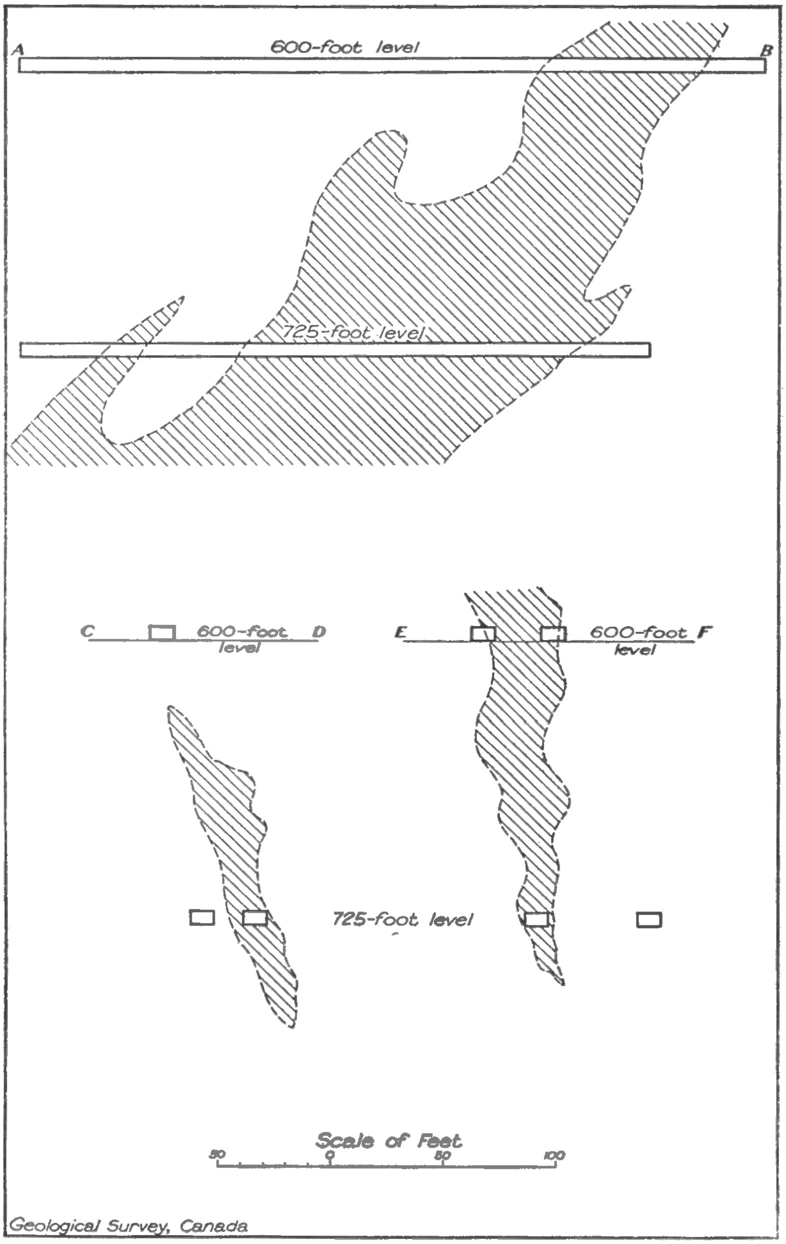

Figure 8. Diagrammatic vertical sections along lines AB, CD, and EF (*See* Figure 7), 600-foot and 725-foot levels, San Antonio mine; to show conjectured disposition of body of carbonate rock (by diagonal ruling).

was intersected is approximately 4½ feet. To the southwest the vein is discontinuous and on the average is nearly 2½ feet in width. Both light and dark-coloured quartz are present and seams of finely crystalline pyrite lie in the quartz adjacent to the foot-wall. This is the most promising vein on the property and this body of gold-bearing quartz has been intersected on the 600- and 925-foot levels.

Gabrielle Group

Some surface work was done on the Gabrielle group during the summers of 1911 and 1912. Two shear zones were located, one on the lake shore in basaltic rock and the other in quartz diorite porphyry 1,200 feet to the northeast. In 1919, Gabrielle Mines, Limited, was organized. Between 1919 and 1920 a prospect shaft 63 feet deep was sunk on the north deposit and another 54 feet deep on the south deposit. Considerable surface work was also done on the north deposit, and the shear zone is well exposed 2,000 feet along a strike of from north 80 to north 50 degrees west. A quartz body 250 feet long and averaging nearly 2 feet wide is exposed at the shaft near the northeast end of this deposit. The quartz and schist carry pyrite and iron carbonate but no free gold was seen. In 1928 the company did 1,000 feet of diamond drilling on the south deposit. No large quartz body is here exposed and no additional work had been done on these deposits to the end of 1929.

Scarab Group

The Scarab group of five mineral claims and two fractional claims adjoins the San Antonio on the north. This group is controlled by Scarab Mines, Limited. In 1931 the property was amalgamated with San Antonio. During 1929 surface work was done on two shear zones within quartz diorite porphyry. These shear zones are wide; in one place the porphyry is in part altered to a quartz-sericite carbonate schist across 100 feet. The quartz bodies, however, are all small, lenticular, and distributed erratically throughout the schist belts. No single body of the quartz is large enough to be of commercial value, and the average gold content of the small quartz bodies and mineralized schist is apparently too low to make a mineable shoot of gold ore.

RED RICE LAKE AREA

Considerable surface work has been done on groups of mineral claims between Red Rice lake and Turtle lake and on the Wolfe and other nearby claims northeast of Red Rice lake. The bedrock here is trachyte and dacite lavas, in part porphyritic, and dykes and large bodies of gabbro, granite, and granodiorite.

Montcalm Group; Tine Group

The Montcalm group southwest of Red Rice lake was staked by Mr. Frank Simard in July, 1917, and the adjoining Tine group to the south by Mr. S. Clifford in July, 1918. The Clappelou group to the east was staked by James Rathall. The quartz body on the Montcalm is of irregular outline and is 14 feet wide at one point. It is exposed on the side of a hill for 175 feet along a strike of south 50 degrees east. The quartz is white and carries some pink feldspar. Free gold occurs at a few points in this quartz. Shear zones on the Tine group, 750 feet to the south of the Montcalm, are exposed by some nineteen trenches along a distance of 1,200 feet. Near the west end of the south shear, the quartz averages 2 feet in width for 300 feet and is mineralized with pyrite, chalcopyrite, and some free gold. At the east end of this shear the quartz as exposed in the trenches is in small lenses.

Eva Group

On the Eva group, controlled by the Great West Gold Manufacturing Company, and located 3½ miles west of the Tine group, a shaft has been sunk to a depth of 58 feet. This deposit is within granite. The quartz body averages nearly 3 feet in width in the shaft. The shear zone has been traced 800 feet on the surface. The quartz is a dark variety without signs of mineralization, and its average gold content is low.

Several narrow shear zones are visible in grey, porphyritic lava and also within granite between the Tine group and Turtle lake. The small quartz bodies on some of the mineral claims covering these zones carry free gold. The deposits have been developed only by surface trenches and pits. No large, promising looking body of gold-bearing quartz was seen at this locality.

Wolfe Group

Surface work has been done along several schist zones on the Wolfe group north of the Manitoba government road east of Red Rice lake. The rock is trachyte and dacite porphyry showing pillow structure. The schist zones are crooked and discontinuous. All the quartz bodies are narrow and lenticular. A ton of quartz from a prospect pit near the foot of the hill at the north end of the Wolfe shear zone was treated by the Ore Testing Laboratory of the Department of Mines, Ottawa, and gave gold 1·07 ounces and silver 1·50 ounces a ton. This material also carried 1·43 per cent copper. Little work has been done on these deposits in recent years.

BEAVER LAKE AREA

Luleo Group

The most extensive mining operations in this area were carried on by the Selkirk Gold Mining Company between 1921 and 1928. This company controls the Luleo group and other claims to the east surrounding Beaver lake. In 1927, the Selkirk Canadian Mines, Limited, took over the property from the Selkirk Gold Mining Company. The Luleo group was staked in June, 1915, by Mr. Charles Andrews. In the succeeding years some work was done by the Bellevue Mining Company financed by New York capitalists. In 1922, work was commenced by the Selkirk Gold Mining Company, also financed in New York. Between 1922 and 1925, a shaft was sunk to the 325-foot level; on the 125-foot level 480 feet of drifting and 150 feet of crosscutting, on the 250-foot level 630 feet of drifting and 70 feet of crosscutting, and on the 325-foot level 720 feet of drifting and 150 feet of crosscutting were completed. A winze was extended from the 325-foot level to the 525-foot level, where 360 feet of drifting and 180 feet of crosscutting were done. In 1927, eight diamond drill holes, totalling 1,252 feet, were drilled from the drift on the 525-foot level to explore the deposit in depth and to locate, if present, parallel shear zones in the walls.

The deposit is along a shear zone in granite and granodiorite porphyry. The shear zone is well defined in the underground workings, and throughout most of the distance followed underground quartz was also present. Some of the ore from above the 250-foot level was run through a small mill, built in 1923. The value of the ore stoped from above the 125-foot level was reported as $6 in gold a ton over an average width of 5 feet and a length of 125 feet. Milled ore from between the 125- and 250-foot levels was stated to average $10 a ton in gold. Although the vein continued strong on the 300-foot level, the average gold content was stated to be only $2 a ton. On the 525-foot level, an ore-shoot 80 feet long averaged $8.45 a ton across an average width of 5 feet. The quartz from this level was both white and smoky, and was well mineralized with chalcopyrite and pyrite.

In 1927 and 1928, nearly 8,000 feet of diamond drilling was done by this company to the east of the Luleo deposit in the vicinity of Beaver lake. The bedrock here is quartzose sediments cut by dykes of gabbro and diabase. The drilling indicated that shear zones in the sediments adjacent to the gabbro and diabase dykes were mineralized with chalcopyrite and sphalerite. The average grade of the sulphide-bearing schist across mineable widths was low and work was discontinued.

Luana Group

Some surface work has been done on the Luana group lying southeast of Beaver lake and controlled by George Vanson and associates. On this group a shear zone in acidic rock is exposed for 700 feet along the strike. The quartz is in lenticular bodies and carries some pyrite, arsenopyrite, and chalcopyrite. The average value of mineable widths of combined quartz and mineralized schist is unknown.

Some work has also been done on several groups of mining claims still farther east up Wanipigow river, but no information is available regarding the size or gold content of the quartz bodies exposed.

SAXTON LAKE AREA

Clinton Group

Most of the work in this area has been done by Clinton Gold Mines, Limited, under the direction of Mr. W. K. Harding. This company controls the Clinton group comprising some forty whole and fractional mineral claims. Some of these claims were staked in 1911 by Mr. Charles Andrews. The bedrock is granite and granodiorite with inclusions of andesite schist and quartzose sediments. A small bed of impure limestone outcrops on the small island near the northwest end of Saxton lake. The gold-bearing quartz deposits are along shear zones within the granite and also in the included masses of schist. In 1928 a shaft was sunk to a depth of 100 feet on the deposit on the Clinton mineral claim. Some drifting and cross-cutting were done at the 100-foot level. A quartz body, at one point 17 feet wide, is reported to have been intersected in the workings. The quartz contains considerable chloritic material and is mineralized with pyrite, chalcopyrite, arsenopyrite, and some free gold. Small amounts of galena are present in the quartz at the surface. An adit was driven from the lake level for 126 feet northwest, to intersect a shear zone on the Clinton No. 2 mineral claim to the west of the shaft. Quartz bodies were reported at 38 and 96 feet from the entrance of the adit. These deposits were 14 and 7 feet wide, respectively; their average gold content is not known.

WANIPIGOW LAKE AREA

A number of gold-bearing quartz deposits have been discovered north of Wanipigow lake. The bedrock is massive granite and porphyritic granodiorite with long, narrow areas of included schist perhaps representing fragments of members of the Rice Lake series included within the granite magma. The quartz bodies are along shear zones in the granite and in the schist intrusions. The most work has been done on the Roderick group, controlled by Roderick Gold Mines, Limited. This group comprises thirty-two mineral claims. The main work has been done on the Roderick claim where a shear zone is exposed over a length of nearly 600 feet. The shear zone is from 2 to 5 feet wide, and traverses an inclusion of chloritic lava within the granite. The shear zone is mineralized with pyrite, chalcopyrite, and small lenses and stringers of quartz. Other shear zones on the Park mineral claim of this group have been stripped and trenched, but the average gold content of schist and quartz at these localities is not known.

On the Huronic claim a shear zone averages 4½ feet in width and in it lies a quartz body 2 feet wide and 200 feet long. This shear is in granite. The quartz carries pyrite, carbonate, chalcopyrite, and free gold. Narrow shear zones have been traced several hundred feet on the Bondholder and Bingo claims, but all the quartz bodies are small. Long shears and fairly large lenses of quartz are exposed on the Proctor and Amisk groups, but the assays show only low gold values. The gold is erratically distributed in the quartz of all these deposits, and although some very high assays can be got by selective sampling, the average grade of deposits large enough to work commercially is disappointingly low.

ENGLISH BROOK AREA

Some prospecting has been in progress along English brook for the past nine or ten years and free gold is known to occur in a number of quartz deposits in this area. The more important groups of mining claims include the Lotus, Ling, Betty, Bingo, Denver, Dominion, and St. Marys. The situation of the deposits of Saxton, Wanipigow, and English Brook areas is shown on mining claim maps prepared by the Mining Recorder of the Department of Mines, Winnipeg. The bedrock is granite and granodiorite with more basic phases and long, narrow inclusions of black schist considered to belong to the Rice Lake series, members of which outcrop to the south along Wanipigow river. The granite is coarse grained, massive, and evenly granular or porphyritic. Some outcrops show crystals of feldspar up to 1 inch long. The thin sections studied microscopically show a variation in mineral composition from that of a normal granite with abundant microcline to a granodiorite with oligoclase and hornblende as the abundant constituents. The areas of more basic rock, granodiorite, diorite, and quartz diorite, are small, and so far as can be determined the normal granite grades into the more basic types.

The gold-bearing quartz deposits lie in shear zones within the granitic rocks and along the contact of granite and included bodies of schist. The English Brook Gold Mining Company, Limited, developed the deposit on the Betty No. 6 mineral claim to the 250-foot level. On the surface no definite, continuous shear zone or vein is exposed, but a number of small shear zones striking in various directions are present within an area 150 feet wide and 1,200 feet long. The bedrock is granite, granite porphyry, and black schist. In the winter of 1927 a portable, gasoline-driven mining plant was installed, and a shaft was sunk near the west end of the exposed, sheared area. At the 50-foot level a crosscut was run north 11 feet and crossed a schist belt 7 feet wide and containing 3½ feet of well-mineralized quartz. A sample of a 50-pound shipment of this quartz was assayed by the Ore Testing Laboratories of the Mines Branch, Ottawa, and gave 0·14 ounce gold and 0·34 ounce silver a ton, also 0·49 per cent copper and 2·58 per cent arsenic. At the 125-foot level, a crosscut was run north 40 feet and a narrow schist zone was followed west for 25 feet, but only narrow quartz stringers were found; in a drift to the east, the quartz was 3 feet wide for 15 feet. A crosscut to the south intersected black schist at 60 feet, but only small amounts of quartz were found in the schist along the granite-schist contact. On the 250-foot level a crosscut was run north 200 feet through porphyry; a little sheared rock was found in the workings on this level.

The English Brook Gold Mining Company, Limited, also did surface work on a number of surrounding mineral claims, including the Betty about ½ mile southwest of the Betty No. 6, and the Oxford, and the Wanna, respectively, 2½ and 2 miles east of the Betty No. 6 shaft. At these localities shear zones carrying lenses of gold-bearing quartz were uncovered. The bedrock is granite, granite prophyry, gabbro, and a pink, aplitic granite. The average gold content of these deposits is not known.

Surface work has also been done on the Lotus, Ling, Denver, Dominion, St. Marys, and other groups in this area. Some of the quartz on these claims carries free gold. The quartz bodies, however, are all small. If even a few small lenses of high-grade ore could be cheaply outlined, a small company might, perhaps, successfully mine and mill the ore.

LITTLE BEAR LAKE AREA

In the winter of 1924 free gold was discovered by Messrs. E. Anson and F. Zeemel in quartz near Little Bear lake, in the northeast part of township 18, range 14, east of the principal meridian. The area was examined in the summer of 1924. The bedrock is granite, granite porphyry, and granite-gneiss containing long, narrow belts of black, massive, and schistose rock. The gold-bearing quartz is within narrow shear zones in the granite and in the enclosed schist. Most of the work has been done on the Silver Fox mineral claim, which, with surrounding mineral claims, is controlled by Bear Lake Mines, Limited. Information supplied by this company indicates that the deposit on the Silver Fox mineral claim has been opened up over a length of 1,100 feet by some nineteen trenches. The shear zone strikes south 85 degrees east and dips 80 degrees north. The quartz is, for the most part, in stringers, although one body near the west end varies in width from 6 inches to 2 feet for 190 feet along the strike. The quartz and schistose, granitic wall-rock carry pyrite, galena, chalcopyrite, and sphalerite. Assays of samples representing widths of from 1 foot to 7 feet are stated to range from 40 cents to $28 in gold a ton. Samples of selected specimens assay much higher than the figures given above. Some surface work has been done on several nearby mineral claims, but the quartz bodies are all small.

COPPER-NICKEL DEPOSITS OF OISEAU AND MASKWA RIVERS AREAS

HISTORY

Late in 1917 a deposit of copper and nickel sulphides was staked in the northeast part of township 19, range 14, east of principal meridian, in what is now known as Maskwa River area. Considerable prospecting and surface stripping were done in this area during the succeeding summers, but the Mayville or original discovery was the only deposit whose surface exposures appeared promising enough to warrant further work, and here, in the spring of 1923, the Devlin Mining and Development Company put down seven shallow diamond drill holes. No further work was undertaken until the winter of 1928, when the Consolidated Mining and Smelting Company optioned some mineral claims in this area and commenced diamond drilling.

In Oiseau River area deposits of copper-nickel sulphides were discovered in the autumn of 1920 north of Oiseau river, about 3 miles west of the west end of Oiseau lake. These deposits are of a type similar to the Maskwa River deposits. The more important known occurrences include the Chance, Devlin, Wento, and Cup Anderson. Prior to 1923 the Devlin Mining and Development Company did surface work on the Chance and Devlin deposits. In 1923, the Manitoba Copper Company was organized to explore the Wento and Cup Anderson deposits, and this company did surface work and diamond drilling at intervals until the early winter of 1925. In the autumn of 1928, Ventures, Limited, and associates optioned the holdings of both companies and commenced development work, which included a Radiore survey followed by trenching and diamond drilling. This work was discontinued in the summer of 1929.

GEOLOGICAL FEATURES

The geological features of the Maskwa River and Oiseau River copper-nickel sulphide bodies are very similar. The rocks outcropping in the vicinity of the deposits are andesitic pillow lavas and associated, quartzose, tuff beds folded to almost vertical positions. The rocks are in part altered to an aggregate of chlorite, carbonate, and sericite, and are cut by dykes and boss-shaped bodies of peridotite and gabbro and by large and small bodies of granite. The sulphide bodies lie along sheared zones in the volcanic rocks close to the edges of bodies of peridotite, gabbro, and granite. Locally, sulphides are also present in the marginal rock of bodies of peridotite and gabbro. Some bodies of peridotite and gabbro are cut by granite which, where in contact with sulphide bodies as in the case of the Chance and Devlin deposits, is also penetrated by a few small veinlets of pyrrhotite and chalcopyrite. These veinlets, however, extend only a few inches within the chilled margin of the granite and no sheared zones in the granite were seen that carry pyrrhotite and chalcopyrite. The minerals of the granite are fresh as compared with those of some nearby outcrops of peridotite, gabbro, and volcanic rocks.

Some of the sulphide bodies contain both nickel and copper; a few lack nickel. The Chance and Devlin deposits, which are adjacent to bodies of peridotite, carry both copper and nickel; the Wento and Cup Anderson, only a short distance from outcrops of peridotite, are not known to contain nickel in addition to copper. Pentlandite has been recognized in the Chance sulphide body; the pyrrhotite of the Devlin body is nickeliferous; an analysis of a specimen of this sulphide showed 0·27 per cent nickel. Some chalcopyrite and white iron sulphide are associated with the pentlandite and nickeliferous pyrrhotite. In the Wento and Cup Anderson deposits, chalcopyrite, chalmersite, pyrrhotite, and pyrite are the abundant sulphides. Titaniferous magnetite is also present in the Wento deposit. In the Mayville deposit, pentlandite is present in addition to pyrrhotite and chalcopyrite. Of the sulphides, the pyrrhotite was deposited first; it was followed by pentlandite and then by chalcopyrite. The sulphide bodies carry only very small quantities of gold and silver; the available results of assays show only from a trace up to 3 or 4 ounces of silver and from a trace up to 0·06 ounce of gold a ton. Galena and sphalerite are present only sparingly in the district, and have not been noted in the sulphide bodies referred to above.

The microscopic study of thin sections of the sulphide-bearing rock shows the sulphides to penetrate and to include grains of the silicate minerals, including the secondary minerals chlorite and sericite and, therefore, the sulphides were deposited after the lavas were sheared and after the bodies of peridotite and gabbro had crystallized. At the Cup Anderson, chalcopyrite penetrates crystals of garnet and, therefore, mineralization here followed the regional metamorphism of the tuffaceous beds to a garnet-bearing schist. In the peridotite that carries sulphides, the ferromagnesian minerals adjoining veinlets and blebs of sulphides have been bleached and altered to chloritic material.

There is little evidence of the sulphide bodies having been severely deformed since they were deposited. The Wento and Cup Anderson deposits apparently are crossed, transverse to the long direction of the deposit, by one or more faults along which the beds appear to have been displaced from 3 to 25 feet.

The sulphides are in part weathered from the upper few feet of the deposit, leaving a limonite-stained capping.

The deposits are clearly replacements. Direct evidence of the source of the mineralization is meagre. The nickel content of some deposits lying close to or within bodies of peridotite and gabbro suggests that such deposits and these intrusive rocks are related in origin. As some pyrrhotite and chalcopyrite were deposited later than the crystallization of the granite magma, and since the granite intrudes the basic rocks, and no basic intrusives are known that are younger than the granite, it is concluded that perhaps two periods of mineralization are represented, the first being associated with the intrusion and consolidation of the basic magma, and being characterized by the presence of nickel in addition to copper, and the second following or accompanying the granitic intrusion and being distinguished by the presence of copper without nickel. The presence of veinlets and blebs of quartz in the Cup Anderson sulphide body also suggests an acidic magma as the source of the mineralization at this locality.

The development work done to date on these deposits is not extensive, but is sufficient to suggest that the sulphide bodies are lenticular. The ore lenses are not known to extend more than 300 feet in depth.

It appears from the available information that the areas worthy of intensive prospecting are those wherein andesitic lava flows and tuff beds alternate, as they do in the area, $\frac{1}{4}$ to $\frac{3}{4}$ mile wide, extending from the Wento deposit westward to the east end of lac du Bonnet. Drift deposits are widespread in this area. A few outcrops of schistose lava in this area exhibit small quantities of chalcopyrite and other sulphides.

DESCRIPTION OF DEPOSITS

Wento

This sulphide body is in the middle of the west part of section 28, township 17, range 15. The bedrock exposed by the prospect pits is andesite lava and quartzose tuff. Granite outcrops immediately northwest of the pits and gabbro to the southwest. Small stringers of granite cut the gabbro; inclusions of andesite lie in the granite. The sulphide body appears to be in a small mass of lava and interbedded tuff occupying a bay-like area on the border of a gabbro body and lying between the gabbro and the end of a tongue of granite extending southeast from the large granite mass to the north. The sulphide body consists of schistified andesite lava and tuff carrying lens-shaped masses of solid sulphides and small stringers and bunches of sulphide. Along the gabbro-andesite contact at the east end of the deposit, there are a number of small masses of titaniferous magnetite and massive chalcopyrite and pyrrhotite. The metallic minerals are younger than the gangue minerals. The pyrrhotite, chalmersite, and chalcopyrite are intimately intermixed and appear to have crystallized together.

The development work on this sulphide deposit consists of some fifteen test pits and trenches, a shaft 25 feet deep with about 20 feet of drifting, and three diamond drill holes inclined from north to south and reaching depths of from 150 to 200 feet below the surface. The drill holes intersected alternating beds of andesite and quartzose tuff, cut by granite and gabbro dykes. The gabbro has been sheared and impregnated with quartz carrying some chalcopyrite. The seams of chalcopyrite-bearing rock intersected by the drill cores were narrow. As exposed by the trenches the area of mineralized rock is 300 feet long and the width averages nearly 40 feet, with a greatest width of 100 feet. Within this area two small lenses of copper ore are present. The prospect shaft was sunk on the larger of these lenses; assays of samples across a width of 17 feet at the bottom of the shaft are reported to average 5·2 per cent copper. The second outcropping sulphide-bearing body is just east of the shaft and is reported to average 14 per cent copper across an average width of 7 feet and for 30 feet along the strike. These sulphide lenses are apparently shallow, as at a depth of 200 feet, as revealed by diamond drilling, dykes of gabbro and granite appear to be much more numerous than at the surface, and the sulphides are only sparingly present in narrow zones of schistose rock.

Beaver

Some surface work and diamond drilling have been done on the Beaver and Diabase mineral claims adjoining the Wento on the west. Here five shear zones in andesite are exposed. Two of these carry some chalcopyrite and one bears some galena and sphalerite. The largest exposed shear zone is just south of the granite contact and about 1,600 feet northwest of the Wento workings. This zone is 250 feet long and averages about 12 feet in width. Specks of chalcopyrite are distributed through the schistose rock and, more abundantly, in small lenses of more highly sheared rock erratically distributed throughout the zone of schistose rock. The average grade of the deposit was estimated to be less than 2 per cent copper. A sample of the galena and sphalerite-bearing rock from a small shear zone east of the main zone assayed 2·50 per cent lead, 6·10 per cent zinc, 0·20 per cent copper, and 3·40 and 0·06 ounces of silver and gold, respectively, a ton of 2,000 pounds.

Cup Anderson

The Cup Anderson sulphide body is near the middle of the north side of section 28, township 17, range 15, and approximately 2,900 feet northwest of the Wento. The bedrock exposed in the prospect trenches is a grey, schistose tuff, locally showing bedding. Some beds carry round to subangular grains of smoky quartz up to ¼ inch in diameter. Other beds are black, fine-grained, chloritic rocks that may be highly altered, andesitic lava, and others are a black, slaty schist carrying red garnet. Granite outcrops about 300 feet north of the prospect pits and a small mass of pegmatitic quartz and granite outcrops just south of the south end of the central trenches. Small masses of peridotite are exposed just east of the surface workings; andesitic pillow lava and gabbro form the country rock exposed south and west of the deposit.

The abundant sulphide of the Cup Anderson deposit is chalcopyrite; pyrite and pyrrhotite occur only sparingly. The chalcopyrite is distributed through the dark-coloured, highly schistose, chloritic beds in specks, blebs, and veinlets. The thick, more massive beds are only sparingly mineralized with chalcopyrite along joint planes and along layers containing abundant sericitic and chloritic materials. The deposit has been traced by a series of six trenches for 300 feet along an east-west direction and across a width varying from 6 to 100 feet. The strike of the bedding and schistosity of the enclosing tuff is from north 70 to 80 degrees west and the dip is vertical to 80 degrees north. The trenches were sunk through drift and the walls are now slumped so that little can be seen of the deposit. Considerable careful sampling was done by the Manitoba Copper Company during the summer of 1923, and according to information supplied by this company, the materials revealed in the east long trench averaged 4·1 per cent copper across 94 feet, and another section in a trench west of this averaged 3·8 per cent copper across 28·5 feet. The average of considerable areas of slightly schistose tuff was less than 1·5 per cent copper. Zones varying from 6 to 12 feet in width, wherein the rocks were highly schistose, averaged from 6 to 7 per cent copper. Diamond drill holes in the heavily drift-covered area to the east of the surface exposures failed to locate a continuation eastward of this sulphide body beyond a point 200 feet from its last exposure, and also failed to intersect at depth ore of the grade and size indicated by the surface trenching.

Devlin

This deposit is in the north-central part of section 27, township 17, range 15, 5,500 feet east and a little south of the Cup Anderson. The country rock is andesite pillow lava with a thin chert bed, and granite. The strike of the schistosity of the lava is south 70 degrees west, and the dip 75 degrees south. The drilling indicates that the dip flattens some in depth. A large mass of peridotite outcrops just west of the west end of the mineralized zone. The sulphide bodies are within the andesite just a few feet south of the granite contact.

The prospecting work at this locality has exposed three main bodies of sheared rock carrying sulphides. In the case of the farthest west body, fourteen trenches cross a mineralized zone 800 feet long and averaging nearly 12 feet in width. In one trench the sheared, mineralized rock is 75 feet wide. Three diamond drill holes were put down on this deposit in the spring of 1929. In the mineralized zone the andesite and a discontinuous cherty bed, up to 4 feet in thickness, is schistified and jointed and the sulphides occur in small lenses and as disseminated grains and specks. The sulphides noted are pyrrhotite, chalcopyrite, and white iron sulphide. The pyrrhotite carries some nickel but no pentlandite was recognized. The bodies wherein the sulphides are abundant vary from 2 inches to 2 or 3 feet in width and from 15 to 100 feet in length. Only two such sulphide-bearing lenses were noted; the schistified rock for distances up to 5 feet from these sulphide lenses carries considerable disseminated pyrrhotite and some chalcopyrite. Assays of channel samples cut at intervals of about 75 feet throughout the length, 800 feet, of the mineralized zone and across an average width of 4½ feet are reported to average 1·0 per cent copper and 0·5 per cent nickel.

A second locality where prospecting work had been done is approximately 500 feet east of the east end of the deposit described in the foregoing paragraph. Here two shear zones are exposed in andesite around the end of a small body of granite projecting east from the main granite body, the contact of which here trends northeast at an angle to the strike of the schistosity of the lava. The northern of these two shear zones is exposed for 100 feet along its strike, which is east-west, the dip being 70 degrees south. The width of the sulphide-bearing rock varies from 2 to 8 feet. A shallow shaft has been sunk on this deposit, but, judging from an examination of the walls of the shaft and the material in the dump, the deposit is low grade, as chalcopyrite is abundant only in a few small patches of schistose rock. The southern shear zone lies 200 feet south of the northern zone, is exposed for 250 feet along the strike, and varies in width from 2 to 15 feet. A shallow prospect shaft has been sunk in it. Samples cut across the more heavily mineralized part of this zone are reported to assay 2 to 3 per cent copper. The surface work, however, failed to locate a continuous body of copper ore of this grade. The chalcopyrite is mainly confined in small patches distributed throughout the sheared rock, the large, intervening areas being only sparingly mineralized with chalcopyrite and pyrrhotite.

Chance

This deposit is on the west end of the line between sections 26 and 35, township 17, range 15, and about 1,800 feet east of the occurrence last described. The rocks exposed in the prospect pits are peridotite, basalt, andesite, and granite. The sulphide lenses are in the peridotite and andesite adjacent to their contacts with granite. The mineralized zone trends east and west and has been traced by trenches for 1,600 feet. Most of the work has been done near the west end and here two shafts, about 150 feet apart and 20 to 30 feet deep, have been sunk. The rock on the dumps is fine-grained andesite and peridotite cut by veinlets of crystals of hornblende up to 1½ inches long. Small veinlets and specks of pyrrhotite, pentlandite, and chalmersite are present in the hornblende veinlets and also in the adjacent peridotite and lava. Where the sulphides are abundant the black hornblende is bleached to a pale green or nearly colourless amphibole. The assays of channel samples from the walls of the shafts averaged 1·95 per cent nickel and 0·15 per cent copper. On the surface the sulphide bodies on which the shafts were sunk are exposed for only 25 feet along their strike and the average width is less than 4 feet. To the east of this point there is little definite information regarding the size and grade of this mineralized zone. At a few places the trenches show widths of 15 feet of limonite-stained capping. Pyrrhotite is abundant in the trench farthest east. East of this the drift cover is thick.

Mayville

The Mayville deposit in Maskwa River area is approximately 16 miles north and west of the Wento. In 1923 a trail was cut between these two deposits. Lavas and sediments of the Rice Lake series occur for 2 miles along the north end of the trail and for 3½ miles along the south end; the intervening 10½ miles are across granite. The bedrock exposed near the Mayville is coarse-grained gabbro and andesite lava. Granite outcrops approximately 4,000 feet north of the deposit. The gabbro intrudes the lavas as a long, tongue-shaped body and as dyke-like masses. Both the gabbro and andesite are cut by the surrounding granite.

The Mayville sulphide body is along the south side and foot of a hill of andesite and gabbro. This hill is surrounded by swamp, and the westward continuation of the sulphide body is under the swamp. The mineralized zone is exposed for 200 feet along a general trend of north 60 degrees east magnetic. In the spring of 1923, the Devlin Mining and Development Company drilled seven holes to intersect the sulphide zone at depths of from 200 to 350 feet. In 1929, Consolidated Mining and Smelting Company of Canada, Limited, drilled five holes, three of which are vertical and reach depths of 530, 506, and 508 feet, respectively, and two are steeply inclined from the southeast towards the outcrop and are 1,501 and 1,401 feet long respectively. The diamond drill intersections indicate that the dip of the deposit is to the south. The deposit as exposed in the trenches consists of two bodies of schistose andesite and gabbro carrying pyrrhotite, pentlandite, and chalcopyrite. These bodies are 4 and 7 feet wide, respectively, in the middle trench. The cores of the diamond drill holes made in 1923, showed alternating gabbro dykes and andesite. One of the dykes intersected in the drilling consists almost entirely of labradorite crystals from ½ to 2 inches long; other dykes hold large hornblende crystals. The large feldspar and hornblende crystals are cut by veinlets of sulphides following cracks and cleavage planes. The andesite adjacent to such gabbro dykes carries sulphides only sparingly. Although short sections of the trenches and drill cores assayed over 4 per cent combined nickel and copper, the average of a body of mineralized rock of commercial tonnage is much lower in copper and nickel than these sections.

Hititrite

Another body of sulphide-bearing rock is exposed on the Hititrite mineral claim approximately 4,500 feet south of the Mayville. Here three small outcrops of gabbro carry pyrrhotite, pentlandite, and chalcopyrite. The sulphide-bearing rock, as exposed by five test pits, measures 125 feet along the strike and has an average width of 15 feet. Small, included masses of andesite and one body of grey, quartz-diorite schist are present in the gabbro along the sulphide-bearing zone. The sulphides occur along joint planes and in slightly schistose zones within the gabbro adjacent to the bodies of included andesite, and also in the andesite inclusions. A few specks of chalcopyrite are also present in what appears to be massive gabbro. Assays of channel samples from the trenches showed from 0·27 to 3·23 per cent copper and from 0·19 to 1·68 per cent nickel. One sample assayed 0·02 per cent platinum. So far as is known the body of sulphide-bearing rock at this locality is small.

Other Copper Prospects

Surface trenching and stripping have been done at a dozen or more localities in Oiseau and Maskwa areas in addition to those already described. These places were visited during 1923 and 1924, and some were re-examined during 1929. Since 1924 some surface work has been done on a few of the deposits, including the Osis, Rex, Hunter, Regal, National, Anson, and Gilmore-Hall. The prospect pits on these groups of mineral claims expose jointed and schistified lava, tuff, or gabbro, carrying some pyrite, pyrrhotite, and chalcopyrite. So far as is known the work already done has not exposed bodies of commercial size and grade. The deposits are exposed for only short distances, and are, as a rule, along the contacts of rocky ridges and swamp where surface work necessary to thoroughly explore the deposits is expensive.

COBALT DEPOSIT, WEST OF WERNER LAKE, ONTARIO

In the spring of 1921, cobalt bloom (erythrite) and cobaltite were discovered on a hillside west of Werner lake, 8 miles east of mileage 75 on the Manitoba-Ontario boundary and one mile east of the east side of Oiseau Lake area. Some surface work was done at this locality in the summers of 1922 and 1923. Cobalt-bearing minerals were also discovered, over a length of 3,000 feet, west of the original discovery, on the other side of a depression. The deposit is now known as the Belmont group and during the summer of 1929 Kenora Prospectors, Limited, did considerable surface work on it. The deposit was visited in October, 1922, and in June, 1929. It can be reached by canoe in one and a half days from either Minaki or Lac du Bonnet. If a load be carried, the route from Minaki is the easier.

Bedrock is well exposed in the vicinity of the deposit and comprises black and grey gneisses intruded by pink and grey granite and white pegmatite. The minerals of the granite are fresh and include quartz, orthoclase, microcline, oligoclase, hornblende, and biotite. Some outcrops of the granite are gneissic. The belt of banded gneiss trends nearly east and west and is from 200 to 500 feet wide. In a few prospect trenches the gneiss shows evidence of the original bedded character, and some of it is a highly granitized, quartzose sediment. Some beds are dark grey and carry abundant red garnet. Other layers are black and in these hornblende is abundant; such beds perhaps represent altered, basic, igneous rock, perhaps dykes. Grey granite and small dykes of pegmatite intrude along the foliation planes of the gneiss. Masses of similar-appearing gneiss are abundant in the granite along the canoe route west from the deposit to Oiseau lake.

Cobaltite and other sulphides occur within the gneiss along both its north and south contacts with the granite. The prospect trenches exposed a zone of sheared and jointed gneiss from 2 feet to 60 feet in width. In the trenches beds of garnet gneiss, laminated quartzite-gneiss, hornblende gneiss, biotite gneiss, and dykes of granite and pegmatite alternate. The beds strike south 80 degrees west, and dip from 70 to 90 degrees north. Some beds of the garnet gneiss, the mica gneiss, and the hornblende gneiss are schistose and carry sulphides. It is estimated that in some trenches the sulphide-bearing rock comprises one-quarter of the whole section exposed. The prospecting has exposed this sulphide-bearing zone for 2,800 feet along the strike from the west side of the hill west of the original cabin. North of the cabin a prospect shaft has been sunk in the sulphide zone.

All the minerals of the sulphide-bearing gneiss are in part altered, and include quartz, hornblende, biotite, garnet, feldspar, and abundant chloritic material. The sulphides are in small grains distributed throughout the chloritic material, and also form veinlets following cracks in the quartz and feldspar. The sulphides were introduced after the gneiss was foliated, as the grains are comparatively unfractured. The abundant sulphides are cobaltite, pyrite, pyrrhotite, and chalcopyrite. Most of the cobaltite, to depths of at least 2 feet from the surface, is altered to cobalt bloom. Nickel bloom and arsenopyrite bloom are also present in some of the weathered, sulphide-bearing rock. The cobaltite is in crystals up to one-quarter inch in diameter, and these crystals are penetrated by veinlets of pyrite and chalcopyrite. The nickel-bearing mineral has not been identified. Assays indicate that gold and silver are absent or only very sparingly present. The average content of cobalt across mineable widths is not known, but it is estimated to be less than 1 per cent in most of the trenches. There appears to be a large body of sulphide-bearing rock, but the average cobalt and copper content of the material is estimated to be low.

TIN DEPOSITS OF SHATFORD–BERNIC LAKES AREA

HISTORY

The occurrence of tin in southeast Manitoba has been known since 1920[1] when a deposit of pyrrhotite and pyrite in schist south of West Hawk lake was reported to carry tin. The tin here is thought to be present in a sulphide between chalcopyrite and stannite in chemical composition. When the area about Shatford lake was being geologically examined in the summer of 1924, a few black grains of a mineral, later identified as cassiterite, were collected from a pegmatite outcropping on the small island, now known as Tin island, near the east end of the lake. Mr. K. E. Miller in the autumn of 1924 also discovered cassiterite in this pegmatite and staked a group of mineral claims. The occurrence was then investigated in a preliminary way, under the direction of Mr. H. A. Wentworth, but it was decided that the deposit was too small to work further unless other nearby deposits of tin ore could be located. No further attempt to exploit this deposit was made until the autumn of 1928, when the Manitoba Tin Company commenced work. A staking rush followed in the area and by the early summer of 1929, cassiterite had been discovered at three additional localities and development work was in progress on two of these deposits, adjacent to Bernic and Rush lakes respectively. Considerable prospecting of some of the mineral claims staked during the winter of 1928-29 was in progress during the summer of 1929 but, so far as is known, no deposits of tin ore of a commercially promising type were uncovered.

GEOLOGY

The bedrock as known in the vicinity of Shatford and Bernic lakes consists of lava flows and associated sediments intruded by batholithic bodies of quartz diorite, granodiorite, and granite, and by dykes of pegmatite. The lavas and sediments are in places altered to schists, whereas

[1] DeLury, J. S.: "An Occurrence of Tin near the Manitoba-Ontario Boundary"; Can. Min. Jour., vol. 41, pp. 520-31 (1920).

the intrusive rocks are massive and unaltered except locally where a faint gneissic structure is developed. The assemblages of volcanic and sedimentary strata, lithologically and structurally, are very like members of the Rice Lake series of Beresford-Rice Lakes area to the north. The bedrock formations in the vicinity of Shatford and Bernic lakes are grouped, for purposes of description, as follows: (1) White and pinkish grey, pegmatitic albite granite and albite pegmatite and aplite (some bodies tin-bearing); (2) Pinkish microcline pegmatite; (3) Pink and pinkish grey microcline granite; (4) Porphyritic and non-porphyritic quartz diorite, granodiorite, and granite; (5) Garnet beds; (6) Basalt, andesite, greywacke, and tuff.

Basalt, Andesite, Greywacke, and Tuff

Black lava, showing excellent pillow structure, outcrops along the south shore of Shatford lake, and on the north shore of Bernic lake and north to Rush lake. The more massive lavas are fine to medium-grained rocks consisting of plagioclase, abundant hornblende, and, in some specimens, biotite. In a few specimens the plagioclase is labradorite and these rocks are basalts; in most specimens the feldspar is basic andesine, hence these rocks are andesites, and they generally contain some biotite in addition to hornblende. Most specimens carry chlorite, carbonate, and small grains of quartz. The schistose varieties are aggregates of chlorite, carbonate, sericite, quartz, kaolinite, epidote, and magnetite.

On Shatford lake the lavas are followed to the north by greywacke with an intervening garnet bed. North of Bernic lake basalt and andesite alternate with bedded tuff and greywacke. At Rush lake quartzose sediments follow the lavas to the north and here some beds have been recrystallized to quartz-mica-garnet schists. The sediments associated with the lavas vary in texture from fine, almost cherty types to coarse-grained, arkosic varieties. In most outcrops bedding is distinct, due to alternating layers of dark, fine-grained and light-coloured, coarser grained types. The tuffs intercalated with the lava flows are bedded, grey rocks consisting of angular and subangular fragments of quartz, feldspar, hornblende, and light-coloured felsitic material.

The strike of the strata is approximately east. In the basin of Shatford lake the dip is 50 to 70 degrees north, and from Bernic to Rush lakes the dip is from 60 to 80 degrees south. The inward dip of the beds of the two areas suggests a synclinal structure, but as the area between the two lakes is occupied by a large mass of granodiorite porphyry, it cannot be definitely proved that these two areas of strata represent the south and north limbs, respectively, of a syncline.

Garnet Beds

A few beds carrying abundant red garnets are interbedded with the lavas and sediments previously described. One garnet bed outcrops along the north shore and adjacent islands of Shatford lake and for more than a mile east of the lake. Other similar, garnet-bearing beds outcrop along Winnipeg river, east of Lamprey falls, associated with pillow lava, and along the south shore of Oiseau lake interbedded with quartzose sediments, and laminated cherty and carbonate-magnetite beds. These beds locally carry considerable magnetite, pyrrhotite, pyrite, and some chalcopyrite. Samples of garnet rock carrying vein quartz are reported to assay a trace of tin.

The garnet bed on Shatford lake was exposed by prospect pits at four points east of Shatford lake. In some outcrops garnet is estimated to form over half the rock, and is distributed in zones varying in width from 2 inches to 3½ feet, and estimated to be 90 per cent garnet. Such garnet-rich beds alternate with other beds or layers of black rock carrying only a small quantity of garnet, the mineral occurring in irregularly scattered clusters of crystals. Red to pink and black almandite is the abundant garnet. The garnet crystals include fragments of quartz, feldspar, and other minerals of the matrix. The garnet beds have been described in more detail in a preceding section of this report, where it is suggested that they represent recrystallized sedimentary beds of unusual composition, perhaps ash beds.

Porphyritic and Non-porphyritic Quartz Diorite, Granodiorite, and Granite

Two bodies of light grey to black, medium-grained, equigranular and porphyritic, intrusive rocks outcrop in the vicinity of Bernic lake. The intrusives vary considerably in texture and composition from outcrop to outcrop. A few, small inclusions of lavas and sediments are present. One of the intrusive bodies lies just west of the west end of Bernic lake and is of equigranular quartz diorite and granodiorite. The second, larger body is situated just south of Bernic lake and is, on the average, slightly more acidic than the body west of the lake; granodiorite porphyry forms the marginal part and areas of inequigranular granite are distributed throughout the central part of the mass. A very characteristic feature of large areas of this granitic mass is the abundant, well-developed phenocrysts of oligoclase and orthoclase in a fine-grained, greenish grey groundmass of quartz, feldspar, hornblende, and biotite. In many outcrops of granitic phases phenocrysts and eye-shaped grains of quartz and microcline are present. At several places in sec. 25, tp. 16, range 16, the grey porphyritic rock contains areas wherein quartz lenses up to a foot long are abundant. This is the only intrusive body known in the district that shows such excellent porphyritic texture. The rocks of these small intrusive bodies are massive, their minerals are only slightly altered—the plagioclase to calcite, epidote, and white mica—and they show little evidence of severe deformation since they crystallized.

Pink and Pinkish Grey Microcline Granite

A large mass of pinkish, medium-grained granite underlies the area south of Shatford lake, as far as Winnipeg river. This is part of a large granite body that widens westward from just east of Lamprey falls on Winnipeg river and extends from there westward to Lac du Bonnet and, perhaps, 10 or 15 miles beyond to where the early Palæozoic strata overlap the Precambrian. Within this large area of granite are many outcrops of grey and black schists, older than the granite, and, so far as is known, occupying areas not more than 2,000 feet wide and 2 miles long, the majority being much smaller. Another very large body of microcline granite outcrops south of the large body of grey oligoclase-granite and granodiorite passing through Pointe du Bois.

The essential minerals of the pink granite are quartz, microcline, orthoclase, and albite-oligoclase. In the average type dark minerals are not abundant, only a few flakes of biotite, partly altered to chlorite, being present. In some specimens magnetite is an abundant accessory mineral. A greyish pink to white phase of this granite carries abundant plagioclase and hornblende, as well as biotite. Along Winnipeg river in the vicinity of Pointe du Bois, a grey oligoclase granite or granodiorite outcrops along the south side of the batholith of pink granite. This grey granite is cut by dykes of pink pegmatite, whereas the pinkish microcline-granite lying between Winnipeg river and Shatford lake is not known to be cut by pegmatite, although small areas of this granite are pegmatitic in texture. The pink microcline-granite is characteristically massive, being slightly gneissic only locally along its contact with the sediments and lavas or near some of the large bodies of included schists.

Pinkish Microcline Pegmatite

Dyke-like bodies of microcline pegmatite are abundant locally in the lavas south of Shatford lake and east and northeast of Bernic lake. No pegmatites were noted along the borders of the body of granodiorite porphyry just south of Bernic lake, although this granitic body, towards its east end, is cut by pegmatite. All the bodies of pegmatite examined are irregular in width and discontinuous along their strike. Some bodies cross the schistosity and bedding of the enclosed rocks, but the majority follow closely the structure of the older rocks. The microcline pegmatites are characteristically red to pinkish and microcline and quartz are the abundant constituents, only small amounts of microperthite, albite-oligoclase, micropegmatite, biotite, and muscovite being present. A few of the microcline crystals are up to a foot across, the majority, however, are less than an inch across. In many of the dykes the microcline and quartz are intermixed. The microcline pegmatite is massive and the mineral grains show little evidence of severe deformation.

Albite Pegmatite and Aplite and Pegmatitic Granite

A few, small, boss-shaped and dyke-like bodies of pegmatite, aplite, and pegmatitic granite carrying abundant albite are present in the area. As cassiterite, beryl, tourmaline, and other accessory minerals are present in some of these pegmatites, they have been prospected for commercial deposits of tin ore. These pegmatitic rocks have a characteristic pinkish white to light red colour and their texture varies from that of a fine, almost aplitic, pegmatitic granite to a coarse-grained pegmatite. In thin section under the microscope, they consist of long, lath-shaped crystals of albite-oligoclase with crenated sides, triangular areas of platy crystals of albite, probably of the variety cleavelandite, some quartz, muscovite, biotite, tourmaline, and magnetite. A few bodies also carry cassiterite, beryl, lepidolite, spodumene, fluorite, triphylite, paragonite, sphalerite, arsenopyrite, and epidote as accessory minerals. An albite pegmatite on the Huron mineral claim, contains uraninite and this mineral has been analysed by H. V. Ellsworth and found to have a ratio of lead to uranium and thorium of from 0·260 to 0·265.[1] The age of this uraninite as calculated by using the generally accepted formula is nearly two thousand millions of years, and according to Mr. Ellsworth the uraninite from the Huron deposit is the oldest known. The uraninite here is in a pegmatite believed to be the youngest phase of the granitic intrusives and the pegmatite cuts members of the Rice Lake series.

The accessory minerals are for the most part localized in patches wherein quartz and muscovite are abundant and microcline and orthoclase are lacking or only sparingly present. The platy albite and some quartz grains with crenated outlines, penetrate crystals of albite-oligoclase and a few of the microcline crystals. Along the margins of some of the pegmatite bodies, the tourmaline and some of the albite crystals are oriented with their long axes at right angles to the walls. Small cavities lined with crystals of quartz and albite occur in a few bodies of albite pegmatite.

The relative ages of the albite pegmatites and the microcline-rich pegmatites are unknown, as the two types were nowhere found in contact. The albite-rich pegmatites may be connected in origin with the intrusives of the area that carry abundant plagioclase feldspar and are represented by the large mass of porphyritic granodiorite north of Winnipeg river, or they may represent an end phase of the magma that produced the large body of microcline granite of the area, or they may belong to a period of igneous activity younger than, and distinct from, that represented by the granodiorite and microcline granite of the area. It has recently been suggested[2] that albite pegmatites carrying abundant accessory minerals are replacements of already consolidated or nearly consolidated microcline pegmatite, by soda-rich materials carrying lithium, tin, boron, beryllium, fluorine, phosphorus, and other constituents. The Manitoba pegmatites, especially those carrying cassiterite, show little evidence of such an origin; they are thought to represent the end phase of the crystallization of the magma that gave rise to the large bodies of microcline granite in the vicinity of Shatford lake. The tin-bearing and the lithium-bearing pegmatites are alike in their general features; some cassiterite has been recognized in deposits wherein lithium minerals predominate, and a few crystals of lithia mica are present in the tin-bearing pegmatites.

DESCRIPTION OF PROPERTIES

Manitoba Tin Company, Limited

In the autumn of 1928 this company commenced work on the original tin discovery on a small island in the east end of Shatford lake, and also did considerable surface work on the mainland both west and east of this locality. In the winter of 1929 good camps were built, and before June

[1] Ellsworth, H. V., and DeLury, J. S.: "Uraninite from the Huron Claim, Winnipeg River, Southeast Manitoba"; Am. Min. (in press).

[2] Hess, F. L.: "The Natural History of the Pegmatites"; Min. Jour. Press, vol. 120, No. 8, pp. 289-298 (Aug., 1925).

Schaller, W. T.: "The Genesis of Lithium Pegmatites"; Am. Jour. Sci., vol. 10, 5th ser., pp. 269-79 (Nov., 1925).

a shaft had been sunk 110 feet on the north side of a large island just east of the small island on which the original tin discovery had been made. At the 100-foot level a crosscut was run northwest to the tin-bearing pegmatite, and this was followed 60 feet by drifts.

Andesitic pillow lava is exposed along the south shore of Shatford lake and the majority of the pegmatites are within this formation just north of its contact with a large body of microcline granite. The andesite is followed to the north by a garnet-bearing bed and quartzose sediments. Only a few pegmatite bodies are present in the sediments. Northeast of Shatford lake, the sediments are intruded by a body of porphyritic granodiorite and granite, which extends northward to near the south shore of Bernic lake. The bedding of the sediments and the schistosity of the lava strike approximately east and west, and their dip is from 50 to 80 degrees north. The long direction of the pegmatite bodies appears to parallel the trend of the bedding and schistosity of the enclosing rocks.

The only pegmatite in this locality known to carry cassiterite is the original discovery on the small island near the east end of Shatford lake. This island is roughly lenticular in outline and, at a time of medium high water, is approximately 60 feet long and 40 feet across at the widest part. The tin-bearing pegmatite outcrops just above water-level on the south side of the island and lies between a garnet bed on the north and pillow lava on the south. This pegmatite body cannot be more than 12 feet wide and it does not extend eastward 100 feet, for at that distance a trench on the west end of the larger island on which the shaft was sunk crosses the projected strike of the tin-bearing pegmatite and shows only lava and garnet rock. The westward extent of the dyke under the lake is unknown.

In June, 1929, only a few square feet of the pegmatite was visible at the top of a small prospect shaft nearly full of water. Specimens in the dump are of a pinkish, albite pegmatite. Within the pegmatite a zone, approximately 2½ feet wide at the top of the shaft, contains abundant quartz and muscovite. The cassiterite occurs in this quartz-muscovite phase, in crystals up to ¼ inch long and in small grains lying either along the edges of bands or streaks wherein either quartz or muscovite are abundant, or between grains of quartz and pinkish feldspar. The pink feldspar in the quartz-muscovite phase occurs in areas with irregular outlines and lying between large grains or areas of quartz. In thin section under the microscope the pegmatite is seen to carry abundant quartz and muscovite with some albite-oligoclase, cleavelandite, microcline, cassiterite, and fluorite. Grains of quartz, muscovite, and cleavelandite penetrate the albite-oligoclase and microcline crystals, and this relationship perhaps indicates two generations of crystallization during the consolidation of the pegmatite magma. The fluorite is in small, irregular patches between large quartz and feldspar grains, suggesting a cavity filling.

The extent of the tin-bearing, quartz-muscovite phase of the pegmatite body is unknown. It is reported that on the 100-foot level, cassiterite was present in the normal feldspar pegmatite and that the quartz-muscovite phase, as developed at the surface, was not encountered underground.

On the point on the south shore of Shatford lake, several pegmatite bodies are exposed in prospect trenches from 1,600 to 3,000 feet southwest of the main shaft. A few of these pegmatite bodies are large, up to several hundred feet in length and 60 to 100 feet in width, but these larger masses are not known to carry cassiterite or other valuable minerals, although locally the quartz and mica are segregated in pockets or irregular-outlined areas. In some of these pegmatites, cavities are lined with crystals of albite stained brownish by circulating waters. One pegmatite contains crystals, up to a foot across, of a muscovite-like mica reported to carry some lithium. This mica splits into curved, saucer-shaped flakes. Two pegmatites contain areas wherein beryl crystals, from ½ inch to 2 feet long and ¼ inch to 3 inches in diameter, are abundant. A number of other masses of the area carry a few crystals of beryl.

The andesitic lava 2,000 feet southwest of the shaft has been sheared and the shear zone locally impregnated with sulphides. Pegmatite bodies are present nearby, but no pegmatite was recognized within the shear zones. In other parts of the area the pegmatites carry sulphides. A prospect shaft was sunk 30 feet on one of these shear zones. The schistose lava on the dump contains pyrrhotite, and some pyrite, arsenopyrite, chalcopyrite, molybdenite, galena, and sphalerite. The molybdenite is in quartz veinlets cutting the schistose lava. Several other rusty zones of schistose lava were exposed by surface trenches in the area west of this propect shaft, but at all these localities no indications were found of a large deposit of sulphide-bearing rock of commercial grade.

The garnet bed exposed at the main shaft has been traced eastward at intervals for approximately 3,500 feet. At a point 2,200 feet east of the main shaft, a small prospect shaft was sunk 10 feet on a zone within the garnet bed carrying chalcopyrite, but not of commercial grade across mineable widths. Some chalcopyrite was also found in several other trenches crossing the garnet bed, and samples of sheared sulphide-bearing rock from a few of these prospect pits are reported to carry a trace of tin. The garnet of certain beds of this rock might be suitable for use as a powdered abrasive, if there were a demand for this product. At most points the chalcopyrite was present only sparingly in schistose phases of the garnet bed, and at the end of June, 1929, the development work completed had not indicated any possibility of their being commercial bodies carrying copper, and possibly tin and garnet.

Jack Nutt Mines, Limited

Late in 1928, Jack Nutt Mines, Limited, was organized to develop a pegmatite body carrying cassiterite, and exposed on the south end of a point on the north shore of Bernic lake, in the southern half of sec. 15, tp. 17, range 15, E. of prin. mer. Surface work completed in the winter of 1929 exposed five, small, irregular-shaped, pegmatite bodies.

A shaft was sunk 140 feet and some crosscutting was done on the 100-foot level in an effort to locate the pegmatite bodies underground. A small pilot mill was built, but was operated only a very short time. In May, 1930, the name of this company was changed to Consolidated Tin Mining Company, Limited.

The country rock exposed at this locality is basalt cut by pegmatite. The long direction of the pegmatite bodies trends approximately north 10 degrees east, nearly at right angles to the direction of the schistosity of the basaltic lava flows. The pegmatite bodies appear to dip eastward at angles varying from 5 to 60 degrees. About 700 feet north of the pegmatite bodies the medium-grained, black, basaltic lava is followed by finer-grained, black, andesitic pillow lavas. To the south, basalt and andesitic flows and tuff beds are interbedded. Granite and granodiorite outcrop on the large island and on the mainland 2,200 and 2,500 feet, respectively, southwest and west of the point where the surface work was done.

The pegmatite exposed by the workings is a medium-grained, albite-oligoclase variety grading into fine-grained, pegmatitic, albite granite. The pegmatite body farthest north from the south end of the point extends 275 feet along the strike and is 60 feet wide at one point. The next body to the south is 275 feet long and averages nearly 25 feet in thickness. At its south end this pegmatite body curves sharply east and ends. Three smaller pegmatite bodies to the east are apparently not over 4 feet in thickness and 100 feet in length. These smaller bodies dip at low angles so that their surface outcrops are large. Cassiterite was noted in a quartz-mica phase in a small projection along the east contact or hanging-wall side of the southern of the two large pegmatite bodies, and also in a small area of pink pegmatitic granite along the east margin of the northern large body. Black tourmaline in crystals up to 2 inches in diameter is an abundant constituent of all the pegmatite exposed at this locality, and it is only after some experience that without careful tests the tourmaline can be distinguished from the black cassiterite. In one of the smaller pegmatite masses, the tourmaline crystals lie with their long axis at right angles to the wall of the pegmatitic body. Some of the mica of the cassiterite-bearing, quartz-mica phase of the pegmatite is a white to yellowish green variety, with optical properties near those of paragonite. A microscopic study of three thin sections of this pegmatite suggests that the minerals commenced to crystallize in the following order: tourmaline, beryl, muscovite, albite, cassiterite, microline, quartz, white mica, and cleavelandite. The thin sections afforded little evidence of replacement of one mineral by another, though there may be two generations of mica and quartz. As far as could be determined from a careful surface examination, the tin-bearing pegmatite forms only a small fraction of the whole mass. For this reason, and considering the flat dip and apparently irregular shape of the pegmatite bodies, it would seem advisable to explore such deposits by open-cuts and inclined prospect shafts before commencing extensive underground work.

Rush and Stannite Groups

Two pegmatite bodies occur approximately 2,200 feet west and north, respectively, of the west end of Rush lake, in sections 19 and 20, township 17, range 16. The pegmatite west of the lake lies on the Rush group of claims controlled by Jack Nutt Mines, Limited. The other pegmatite body is on the Stannite group owned by K. E. Miller and associates. Only a small amount of surface work had been done on these pegmatites up to the middle of June, 1929.

The country rock on the Rush group is andesite lava and beds of quartzose tuff and of mica schist carrying red garnets. The pegmatite body probably is continuous 1,600 feet along its strike and at two points is 100 feet wide. The average strike of the pegmatite is nearly east and west and the dip appears to be 75 degrees south. Small bodies of andesite lava are included in the pegmatite body. The pegmatite varies from a fine-grained pegmatitic granite with lath-shaped crystals of albite-oligoclase and areas of cleavelandite as the main constituents, to a type of irregular grain and consisting of large crystals of quartz, feldspar, and muscovite. Some outcrops show excellent graphic intergrowths of quartz and pink and white feldspar. The coarser grained phases form small, irregular areas erratically distributed throughout the pegmatite body. Some of these areas of coarse pegmatite are less than 3 feet across. The accessory minerals of the pegmatite include beryl, tourmaline, cassiterite, tripylite, lepidolite, fluorite, epidote, arsenopyrite, sphalerite, magnetite, and perhaps others not recognized. Only a few crystals of cassiterite were recognized in the trenches.

The pegmatite body on the Stannite group was exposed at intervals for a distance of 450 feet along the strike. The country rock is quartzose sediments and small blocks of these rocks lie in the marginal part of the pegmatite mass. This pegmatite is coarse grained, with some crystals of feldspar and muscovite up to a foot across. The only exposure noted that shows cassiterite is approximately 430 feet west of the No. 1 post of the Stannite No. 1 mineral claim. Here coarse-grained pegmatite in contact with cherty sediments is exposed over an area of 4 square feet. The contact here dips north. In addition to cassiterite this outcrop carries beryl and muscovite. The cassiterite crystals are up to one-half inch long, and are in small bunches distributed erratically throughout the small outcrop. A fine-grained, aplitic pegmatite outcrops 1,000 feet south of the cassiterite-bearing pegmatite. This second body carries considerable pinkish to purplish, lepidolite-like mica, beryl, a green to bluish tourmaline, and a yellowish green muscovite, but no cassiterite was recognized.

Oiseau Lake Prospect

On the south shore of Oiseau lake, at a point about 2 miles east of the west end, Jack Nutt Mines, Limited, did considerable trenching and some diamond drilling during the summer of 1929. The small point on which the work was done is an island when the water in the lake is high. Here, the bedrock is a series of alternating beds of greywacke, cherty-quartzite, garnet-rich rock, and magnetite-carbonate rock. The strike of the beds is nearly east-west and their dip 68 degrees south. The garnet-rich and magnetite beds were exposed by trenches for 200 feet along their strike, and in both directions pass under the water of the lake. These beds vary in width from 6 to 12 feet, and the whole exposed zone of alternating beds is from 90 to 130 feet wide. The rocks along the contacts of the alternating beds are sheared, and in these zones a few small stringers of quartz and pegmatite are present. The sheared rock also carries some pyrrhotite and pyrite. Samples from this deposit are reported to assay a trace of tin, but no indication could be seen of the possible existence of a promising deposit of tin ore.

SUMMARY REGARDING TIN DEPOSITS

Cassiterite occurs in a few pegmatites in the vicinity of Shatford and Bernic lakes. The few tin-bearing pegmatites are characterized by an abundance of soda feldspar in contrast with the pink, potash feldspar pegmatites so abundant in the area. The cassiterite is confined within the pegmatite to either coarse or fine-grained phases that form pockets either irregularly distributed throughout the whole body or confined to the hanging-wall side of flat-dipping bodies. So far as could be determined the bodies of tin-bearing pegmatite are small. The microscopic study of thin sections of the pegmatite indicates that the cassiterite and other accessory minerals crystallized early from the pegmatitic magma; there is little evidence of a replacement of earlier-formed minerals by those crystallizing later, except where quartz-muscovite phases are developed. No typical greisen has been recognized in the area, the tin-bearing, quartz-muscovite rock being a phase of the pegmatite.

Pegmatites of the important tin fields of the world have not been large producers of tin ore. Of the various types of lode tin deposits, the most promising commercially are veins which, in addition to cassiterite, carry abundant quartz and such characteristic minerals as topaz, fluorite, and tourmaline. The country rock bordering cassiterite veins is altered to a quartz-muscovite aggregate known as greisen and typically formed by the pneumatolytic alteration of granite. In Manitoba area, the granites are not traversed by shear zones and show no evidence of alteration to greisen. Bodies of greisen are in most cases developed near the top of granite batholiths or within and around cupolas projecting above the general level of the roof of the batholith. In Manitoba, the present surface intersects the batholiths considerably below the roof, that is, below the level where greisen is typically developed. Cassiterite-quartz veins and greisen-like zones, however, may occur within members of the Rice Lake series along the sides of the granite batholiths. No quartz veins carrying cassiterite and bordered by greisen are known in the vicinity of Shatford and Bernic lakes.

LITHIUM DEPOSITS

By C. H. Stockwell

INTRODUCTION

Although a lithium deposit had been known at West Hawk lake since about 1916, it was not until the discovery, in 1924, of a larger and better grade deposit on the Bear mineral claim near Winnipeg river that the possible economic value of lithium minerals in Manitoba attracted attention. During the following two years other deposits were discovered at Bernic lake, Cat lake, and Winnipeg river. During the summers of 1926 and 1927 the writer made a detailed study of the deposits and, in order to aid further prospecting, made a reconnaissance survey of a large, rectangular area including the country between Bernic and West Hawk lakes and extending westward a few miles beyond the longitude of Pointe du Bois, Manitoba, and eastward into Ontario for a few miles beyond Separation lake and Minaki.

SUMMARY OF GENERAL GEOLOGY

The oldest rocks in the district are sediments and volcanics. Their distribution in Manitoba is shown in index map (Figure 1). In Ontario the Winnipeg River belt extends as far as Sturgeon river and Separation lake. The sediments include a variety of types such as mica and hornblende schists, greywacke, quartzite, slate, conglomerate, and iron formation. A large part of the sediments in Ontario are intimately associated with granite, forming an injection gneiss. The volcanics are chiefly hornblende basalt. The sediments and volcanics are intruded by a few small masses of gabbro and basalt. The next youngest rocks are granite, aplite, and pegmatite which may be divided into major intrusives and minor intrusives.

The *major intrusives* comprise large masses of granite of three main types, oligoclase granite, microcline granite, and albite granite. The microcline granite is the most widely distributed and occurs chiefly as a large mass extending eastward across the middle of the district for a length of 60 miles. It is 27 miles wide in Manitoba near the Interprovincial Boundary. To the east it narrows gradually and comes to an end just west of Separation lake. Its western limit is not known. This large mass is in contact with volcanics as its east end and is in contact with oligoclase granite along its north, south, and southeast sides. Oligoclase granite occurs over most of the remaining territory, but its continuity is interrupted by many large and small areas of microcline granite, the largest of which extends across the east end of the district from Separation lake nearly to Minaki. The albite granite forms only small masses, the largest being 2½ miles long and ½ mile wide; it occurs in a belt of volcanics on the south side of Winnipeg river 4 miles east of Lamprey falls. Two smaller masses occur in the same volcanic belt 7½ and 8½ miles, respectively, east of the same point. North of Winnipeg river and about 6 miles easterly from Lamprey falls five smaller masses were observed in oligoclase granite. Nine small areas of the same rock are present in sediments and volcanics between Birse and Ryerson lakes. Another mass occurs in volcanics on the islands and shores of English river 2½ miles south of Upper Kettle falls.

The oligoclase granite varies in composition, colour, texture, and structure over short distances. The colours are commonly grey varying from light to dark and almost black; some types are pinkish grey. The texture is fine grained to coarse grained and the rock is usually non-porphyritic, although in some areas well-developed phenocrysts of feldspar and quartz are present. The structure is commonly somewhat gneissic and in many places the rock is a well-banded gneiss. Less commonly it is massive. Plagioclase is usually the dominant constituent. It varies in different specimens from albite to andesine, but oligoclase is by far the most common kind. Biotite is present in all types and in most cases is accompanied by hornblende which, on the average, is more abundant than biotite. Other constituents are quartz, microcline, orthoclase, magnetite, apatite, titanite, and epidote.

The microcline granite is generally uniform over great distances and is characteristically massive, although in places it is gneissic. The rock is commonly medium grained, but in the central part of the large mass which extends across the middle of the district microcline crystals are up to 2 inches long. Most commonly the rock is non-porphyritic, but at several places large masses have phenocrysts of microcline and oligoclase. The characteristic colour is pink, but several masses near the sediments and volcanics in Ontario are white. Microcline is an important constituent and is generally accompanied by an approximately equal amount of oligoclase, but in some types is accompanied by albite, in which case microcline predominates. Quartz is more abundant than in the oligoclase granite, biotite is characteristic, and hornblende is rare. Muscovite, magnetite, garnet, apatite, epidote, and titanite occur in small amounts.

The albite granite is massive, medium to coarse grained, and varies from white to pink. Two main types are discernible, an albite-muscovite granite and an albite-tourmaline granite. The albite-muscovite granite generally has a small amount of biotite. The muscovite is uniformly distributed as in ordinary granites and occurs in coarsely crystalline, cone-shaped, radiating aggregates up to 5 inches long. The tourmaline of the albite-tourmaline granite is black and forms small crystals distributed irregularly throughout and in places constituting as much as 25 per cent of the rock. Small amounts of biotite and muscovite are present at some localities. Both types have a predominance of albite over microcline, contain scattered garnets, and have a higher quartz content than the microcline granite. The albite-muscovite granite is best developed on the south side of Winnipeg river and the albite-tourmaline granite occurs between Birse and Ryerson lakes. A less common type contains microcline and albite-oligoclase in about equal amounts and does not differ greatly from some phases of the microcline granite described above.

The contact between the oligoclase granite and the microcline granite is indefinite and both types occur in a mixed zone from ½ to 3 miles or more wide. Within the mixed zone the microcline granite either grades into the oligoclase granite or, more commonly, cuts it and holds numerous inclusions of it. The albite granite intrudes oligoclase granite at one locality, but is nowhere in contact with microcline granite. All three types of granite are probably results of a single period of magmatic activity. The oligoclase granite solidified before the microcline granite and the albite granite probably formed in upper cupola-like parts of the microcline granite and most of it has now been eroded away.

The *minor intrusives* include dykes of granite, aplite, and pegmatite, irregular-shaped bodies of aplite and pegmatite, and lenticular bodies of pegmatite. The dykes vary greatly in size up to 60 feet wide and 1,500 feet or more long. Commonly they are from 2 to 10 feet wide. They usually have straight parallel walls. A few have angular outlines due to filling by the dyke rock of spaces between broken blocks of country rocks. Others are branching or have a pinch and swell outline. The ends of the dykes were not often seen, but a few were observed to round off and end abruptly and others gradually narrowed down and finally pinched out. In schistose and gneissic rocks the dykes commonly parallel the structure, but many cross it at all angles and frequently cut one another. Most of the dykes dip vertically or nearly so, but a few dip at angles of 45 degrees or less. The lenticular bodies vary in size from 1 foot by 6 inches to 10 feet by 5 feet. Some of the irregular-shaped bodies are only a few feet across, but most of them form indefinitely bordered, broad masses up to several hundred feet across.

The major intrusives of oligoclase granite and the volcanics south of Winnipeg river are cut by a few oligoclase granite dykes. These dyke rocks resemble the oligoclase granite of the major intrusives and are probably derived from them.

Close to the edges of major intrusives of microcline granite, either in the large bodies of oligoclase granite or in sediments or volcanics, are many dykes of microcline granite, microcline aplite, and microcline pegmatite and a few dykes of microcline pegmatite mixed with microcline granite and microcline aplite. Dykes of microcline pegmatite are also numerous nearly everywhere throughout the large bodies of oligoclase granite, but are much rarer within the major intrusives of microcline granite. A few lenticular and irregular microcline pegmatite bodies occur in, and grade into, the surrounding microcline granite. All these dykes and other minor bodies of microcline granite, microcline aplite, and microcline pegmatite are, no doubt, derived from the main bodies of microcline granite.

The microcline granite of the minor intrusives is like the microcline granite of the major intrusives. The microcline aplite is similar except that it is finer grained, contains less biotite, and in places more magnetite and garnet. The microcline pegmatite is coarser grained than the granite. Microcline predominates over albite or oligoclase and quartz is abundant. In some bodies microcline and quartz are the only constituents, but commonly a small amount of biotite and, less commonly, muscovite is also present. More rarely one or more of the following constituents occur: cleavelandite, magnetite, beryl, tourmaline, garnet, titantite, apatite, molybdenite, pyrite, and arsenopyrite. Many of the microcline crystals are a foot or more across. They are generally perthitically intergrown with acid plagioclase and many are graphically intergrown with quartz. In some bodies the minerals have a uniform grain and are uniformly mixed, in others large microcline crystals are scattered through finer-grained pegmatite or occur on the borders of scattered quartz pockets. Some dykes have quartz along the middle and the borders are of microcline pegmatite. In dykes composed of more than one component, microcline granite is irregularly mixed with microcline aplite and grades into it, and microcline pegmatite occurs either as segregations in the granite or aplite, or forms a middle zone between granite and aplite on the sides.

Close to the borders of the larger masses of albite granite, either in volcanics and sediments or in oligoclase granite, are a few dykes of albite granite, albite aplite, albite pegmatite, and microcline pegmatite and many dykes that are a mixture of microcline pegmatite with one or more of the types just mentioned. A few dykes composed of a mixture of quartz-muscovite rock with microcline pegmatite, albite aplite, or albite granite also occur in the vicinity of the larger bodies of albite granite. Within the bodies of albite granite are numerous lenticular masses of microcline pegmatite and very many irregular bodies of various mixtures of the dyke rocks mentioned above. All these dykes and the other small masses that are so closely associated with the larger bodies of albite granite, are probably derived from the albite granite.

Though, in general, the dykes of albite granite, albite aplite, albite pegmatite, etc., appear to have been derived from the larger bodies of albite granite this may not have been the case at West Hawk lake. At this locality a body of sediments and volcanics is bordered by microcline granite. Dykes of microcline granite, aplite, etc., are common in the volcanic-sedimentary assemblage near the granite contact, but farther away from the contact, dykes of albite aplite, pegmatite, etc., predominate and there are indications that as the edge of the microcline granite is left the dyke rocks gradually change from those of the microcline family to those of the albite family. In this area, therefore, the dykes of albite granite, pegmatite, etc., appear to have been derived from the microcline granite.

The albite granite of the minor intrusives is almost identical with that of the major intrusives. The albite aplite is similar except that it is finer grained, contains less muscovite and more garnet, contains quartz phenocrysts, apatite, beryl, or green tourmaline and in some places has many bands of garnet and biotite. The albite pegmatite is coarser grained than the albite granite and has a predominance of acid plagioclase, usually albite, or cleavelandite, over microcline. Quartz and commonly muscovite or black tourmaline are important constituents. Garnet, apatite, beryl, and biotite are present in some bodies. Green tourmaline and purpurite are minor constituents at one locality and uraninite, monazite, tantalite, and zoisite occur at another. The minerals of albite pegmatite are generally uniformly mixed and rather fine grained, crystals of feldspar usually not exceeding 1 to 5 inches in cross-section. Cone-shaped aggregates of coarsely crystalline muscovite and pockets and veins of finely crystalline muscovite are present in some albite pegmatite and microcline pegmatite bodies. The quartz-muscovite rock is composed of quartz and muscovite generally uniformly mixed in about equal amounts and, in some places, in graphic-like intergrowth with one another. The quartz-muscovite rock generally carries small amounts of albite or cleavelandite and in some places small amounts of microcline, apatite, beryl, or garnet. In bodies composed of more than one component it is common to find large microcline crystals up to 1 to 2 feet across scattered through albite granite, albite aplite, albite pegmatite, or quartz-muscovite rock. In other such bodies scattered quartz pockets bordered by microcline crystals are present in albite granite, aplite, or pegmatite. Quartz-muscovite rock occurs in a few bodies of albite aplite as roughly circular or vein-like masses.

What appear to be phases of the albite pegmatites are the lithium-bearing bodies, of which twenty-nine are known. These occur in the same areas as do the albite pegmatites, except in two instances, namely, in oligoclase granite north of Winnipeg river and in volcanics on English river. Possibly lithium-bearing bodies are present in these two areas, but have not yet been found. On the whole the main difference between the albite pegmatites and the lithium-bearing bodies is the presence in the latter of lithium minerals. Four of the lithium-bearing bodies occur in Winnipeg River area, two within bodies of albite granite and two near the edges of bodies of albite granite, but in one case in volcanics and in the other in oligoclase granite. Nine occur in volcanics at the east end of Bernic lake, no mass of albite granite is visible at this locality, but the lithium-bearing bodies are probably derived from an underlying, cupola-like intrusion of the albite granite. Five occur at Cat lake and lie in volcanics or oligoclase granite. Here, too, no body of albite granite is present at the surface, but may occur at depth and has been the source of the lithium-bearing bodies. Three lithium-bearing bodies occur in volcanics at West Hawk lake. They lie still farther away from the microcline granite contact than do the albite pegmatites referred to on page 112 and like them may have been derived from the microcline granite. The West Hawk Lake deposits are wholly of lithium pegmatite, whereas the other lithium-bearing deposits are mixtures of lithium pegmatite and one or more of the following: microcline granite, microcline pegmatite, albite granite, albite aplite, albite pegmatite, and quartz-muscovite rock.

In lithium pegmatite albite predominates over microcline and the albite is usually the cleavelandite variety. Quartz and muscovite are important constituents; biotite is lacking. Coloured tourmaline, garnet, apatite, beryl, topaz, fluorite, purpurite, tantalite-columbite, monazite, podolite, and calcite are locally present. Lithium minerals, including spodumene, lepidolite, zinnwaldite, a variety of other lithium-bearing micas, montebrasite, and lithiophilite are present in large or small amounts.

Prospectors in search of lithium deposits in the district should keep in mind the relation of lithium pegmatite to the major granite intrusives as outlined. Search should be made in areas of sediments, volcanics, and oligoclase granite close to the edges of intrusions of albite granite. In some areas albite granite is not exposed at the surface, but its presence close beneath may be indicated by a group of albite-bearing dykes. Lithium deposits may also be found at considerable distances from the edges of microcline granite intrusives, as in the West Hawk Lake district. They are quite unlikely to occur within intrusions of microcline granite or in the areas of oligoclase granite, sediments, or volcanics which contain numerous dykes of microcline granite, microcline aplite, or microcline pegmatite.

The subject of the genesis of pegmatites presents many interesting and complex problems which will be only touched on here. The commonly accepted conclusion has been that though replacement phenomena are recognizable, essentially all minerals of pegmatites formed as the result of solidification of injected magma. Recently Schaller[1] has concluded that many pegmatites are the result of two processes: the cooling of a magma (a closed system) resulting in the production of an original formation and, later, a flow of hydrothermal solutions (an open system) resulting in a more or less complete replacement. The first process yielded a mass of rock solid from wall to wall and consisting essentially only of potassium feldspar with perhaps small amounts of sodium feldspar and quartz; all other minerals are the result of later replacement by the hydrothermal solutions. Other writers have come to somewhat similar conclusions. The pegmatites of Manitoba, with their associated granite and aplite components, show many mineral relationships which are of doubtful interpretation, but it seems most probable that almost all their minerals formed by solidification of injected magma, possibly in some bodies of more than one injected

[1] Schaller, W. T.: "Mineral Replacements in Pegmatites"; Am. Min., vol. 12, pp. 59-63 (1927). "The Genesis of Lithium Pegmatites"; Am. Jour. Sci., vol. X, pp. 269-279 (1925).

magma. A considerable amount of replacement took place in some albite-bearing and all lithium-bearing bodies by reaction between earlier crystallized minerals and still liquid magma. Some volatile constituents probably escaped, but no large amount of material was brought in by a flow of solutions from outside sources. It was essentially a closed system. The evidences used to reach this conclusion are based chiefly on mineral relations and structures observed in the field. An account of them would be long and involved and will not be given here.

BEAR MINERAL CLAIM

The Bear mineral claim is 3 miles slightly south of east from Lamprey falls on Winnipeg river. A winter road and pole tramway each 3½ miles long have been constructed from the property westward to a point on Winnipeg river 1 mile south of Lamprey falls. From the end of the road it is 6½ miles southwest along the river to Pointe du Bois where railway connexions are made. A shorter overland route into the property is by way of a trail, 1½ miles long, which extends from the property northwest to Winnipeg river, but motor boats going from Pointe du Bois to the end of this trail must pass Lamprey falls, which is possible only at certain times. Camps have been erected at the property and on the bank of the river at the end of the road.

The deposit (*See* Figure 9) was discovered in July, 1924, by F. B. Evans and R. G. O. Johnston. They did a small amount of stripping and trenching on the deposit and it was then taken over by the Silver Leaf Mining Syndicate (Canada), Limited. The syndicate has since done a considerable amount of development work. Some stripping, quarrying, and open-cutting have been done on a hillside where part of the deposit outcrops. The larger part of the deposit is covered by swamp into which six pits have been sunk and the deposit exposed in four of them. In addition, 1,000 feet of trenching has been carried out in the swamp for the purpose of draining it, the plan being to drain it to a depth of 10 feet so that further stripping and test pitting in the swamp can be carried on without interference from water. During 1926 and 1927 about 75 tons of lepidolite and spodumene were shipped to various countries, including the United States, England, and Germany, for the purposes of quantity sampling and experimental work. The deposit was not worked during the summer of 1929 or since that time.

The deposit is a lithium-bearing dyke which cuts volcanics. Exclusive of a broad granite phase on its north side, the dyke strikes slightly north of west, has been traced at intervals along the strike for a distance of 525 feet, and has a maximum exposed horizontal width of about 100 feet. Of the total length, 175 feet is well exposed at the east end on the side of a hill, 40 feet in height, where the dyke rounds off and comes to an end; the remainder lies to the west under a swamp and has been exposed at four localities by means of open-cuts. On the hillside the dyke is cut by a fault which strikes slightly north of east and dips 65 degrees north. The part of the dyke that lies on the south side of the fault is displaced about 75 feet horizontally to the east of the part that lies on the north side.

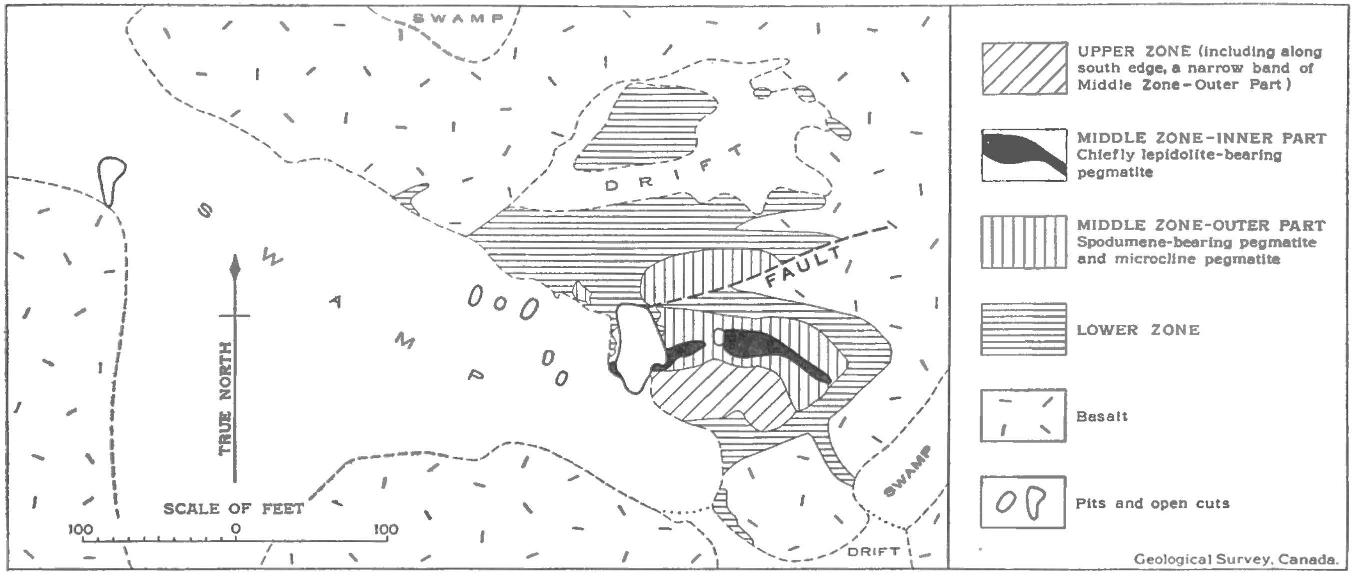

Figure 9. Pegmatite dyke on Bear mineral claim, lot 17, range 16 (east of principal meridian), Manitoba—by C. H. Stockwell.

The dyke is a complex body comprising three zones, a lower zone, a middle zone, and an upper zone. On the hillside, on the south side of the fault, the lower zone outcrops as a crescent-shaped band, about 20 feet in horizontal width, that extends along the south side, around the east end, and along the north side of the dyke. Its lower, outer surface is in contact with volcanics and dips from all sides toward the middle of the dyke. Its upper surface is curved and consequently has irregular dips, but, in general, also dips toward the middle. The dips of both surfaces suggest that this eastern portion of the dyke is trough-shaped and may not extend to any great depth. In the southern portion of the trough is an area of the upper zone forming a nearly flat-lying sheet 100 feet long and 30 feet wide. The middle zone fills the remainder of the trough, probably underlying the flat-lying sheet of the upper zone. It outcrops as a very narrow band between the flat-lying sheet of the upper zone and the south arm of the crescent-shaped band of the lower zone and it also outcrops as a large area 150 feet long and with a horizontal width of 30 to 40 feet between the flat-lying, upper zone and the northern arm and eastern end of the crescent-shaped band of the lower zone. Along the middle of the large northern area of the middle zone are several masses, up to 75 feet long and 20 feet wide, forming a subzone. The under surfaces of several of these masses are almost horizontal.

On the hillside on the north side of the fault the lower zone covers a broad, nearly circular area 150 to 200 feet across and the middle zone forms small patches on the south side of this broad area.

In the swamp, a short distance west of the main area, the lower zone is exposed in a test pit. The middle zone shows in a second pit, and the upper zone in two other pits. All three zones are exposed in an open-cut several hundred feet farther west. In this open-cut the lower zone occurs on the north side, the upper zone occurs on the south side, and the middle zone occurs between the two and has a horizontal width of 10 feet. The part of the dyke in the swamp apparently dips south.

The lower zone is composed chiefly of albite granite, overlain by banded albite aplite with a layer of cleavelandite rock. Small amounts of lepidolite, zinnwaldite, and spodumene occur in the aplite. The upper zone is composed chiefly of quartz-muscovite rock underlain by a narrow band of cleavelandite rock. Lithium-bearing minerals are present chiefly in the middle zone.

The outer part of the middle zone is composed chiefly of large microcline and quartz-spodumene crystals. The microcline occurs as scattered crystals up to 2 feet across chiefly in an area 75 feet long and 5 to 15 feet wide in the northeast portion of the large outcrops on the hillside south of the fault. A few quartz-spodumene crystals are associated with the microcline, but are most abundant outside of the microcline area where they are scattered or are closely packed together and make up the major portion of the outer part of the middle zone. The microcline and quartz-spodumene crystals lie in a groundmass of, or have the interstices filled with, various mixtures of quartz, cleavelandite, lepidolite, radiating lithia mica, and curvilamellar lithia mica. The two last-mentioned minerals contain only small percentages of lithia, are not abundant, and are of no economic value. These materials in some places simply fill spaces between or surround the microcline or quartz-spodumene crystals, in other places they form veinlets cutting them and, quite commonly, they form masses partly or almost completely replacing them. Other minerals noted in the outer part of the middle zone include bluish green curvilamellar lithia mica, zinnwaldite, pale lilac lithia mica, garnet, fluorite, and calcite.

The inner part of the middle zone is composed chiefly of lepidolite which is associated with cleavelandite and quartz and locally with pale lilac lithia mica, spodumene, or beryl. A chemical analysis of the pale lilac lithia mica shows that it contains only a small percentage of lithia and is of no economic value. It can be distinguished in the field from the lepidolite by its paler colour. One area from 5 to 10 feet across in the inner part is of quartz and cleavelandite with smaller amounts of spodumene, topaz, beryl, purple muscovite, montebrasite, and lithiophilite. The purple muscovite can be distinguished from lepidolite by its paler colour, transparency, and absence of lithia as shown by a blow-pipe test. The montebrasite contains a satisfactory percentage of lithia (8·20 per cent) for commercial purposes, but only a few masses up to a foot across are exposed. The presence of this mineral is interesting and further work on the property may result in finding amounts large enough to be of economic value. The topaz is generally greyish, bluish, or greenish and turbid and occurs as crystals from 1 to 5 inches in cross-section. Jacob Papish[1] succeeded in extracting 0·019 gms. of germanium dioxide from 18·3 gms. of this topaz. A very small amount of clear sky-blue topaz, probably of gem quality, was found and a search for more of this or similar material should be made. The beryl is present in only small quantity and is usually milky-white. A small amount of it is pale pink and transparent, but the crystals are considerably fractured and too pale in colour to be valuable gem material.

The minerals of chief economic interest are the spodumene of the outer part, and the lepidolite of the inner part, of the middle zone. The spodumene is intimately associated with quartz and a mixture of the two forms quartz-spodumene crystals. The crystals are tabular-shaped and usually measure from 1 foot to the side and 2 to 3 inches thick to a maximum observed size of 3 feet by 7 inches. The spodumene in these crystals is of two types, an earlier spodumene and a later spodumene. The earlier spodumene is white and forms plates ½ to 1 inch in length lying in the quartz and oriented, for the most part, with their vertical crystallographic axes normal to the larger faces of the tablets. In a typical specimen the ratio by weight of spodumene to quartz is 55:45 and most of the material appears to have about this ratio. In some crystals the proportion of quartz to spodumene is much greater than the typical case given above. There are nowhere any masses of pure spodumene or even any with a ratio of spodumene to quartz any greater than about 50:50. The later spodumene occurs as an alteration of the earlier spodumene plates and of the associated quartz of many but not all of the quartz-spodumene crystals. In some cases the alteration is only partial and in other cases

[1] Econ. Geol., vol. XXIV, 1929, pp. 471-472.

is almost complete. The later spodumene is a very fine-grained, white rock almost identical in appearance with aplite. Quartz remnants are usually mixed with the later spodumene and are in variable proportions, but on the average the alteration product probably contains a greater proportion of spodumene than do the unaltered quartz-spodumene crystals.

The quartz-spodumene crystals constitute the major portion of the outer part. On the hillside south of the fault the crystals, exclusive of the microcline area, occur over an exposed area of 2,700 square feet. In some parts of this area they constitute about 90 per cent of the material and in other places constitute only about 50 per cent of the material. On the average they constitute roughly 75 per cent, the remaining 25 per cent being of the interstitial and groundmass materials. In the middle of the exposure similar proportions are locally exposed over vertical thicknesses up to 9 feet. The total thickness is probably considerably greater than this, but in estimating tonnage it should be borne in mind that this part of the dyke is probably trough-shaped and accordingly that the material may not extend to any great depth. Toward the edges of the trough the thickness apparently gradually thins to zero. Similar proportions likely occur beneath exposures of the inner part of the middle zone and beneath the exposure of the upper zone and an additional area of 3,300 square feet is thus probable. Quartz-spodumene crystals constitute about 90 per cent of the material exposed in one open-cut in the swamp, but in the most westerly open-cut they constitute only about 50 per cent of the material of the outer part of the middle zone and the outer part here is only a foot or two wide. A much larger tonnage of spodumene may be present beneath the swamp which covers the major portion of the deposit and here may extend to considerable depths. A considerable tonnage of quartz-spodumene crystals is thus indicated. The crystals could readily be hand-sorted from the interstitial or groundmass material, but the spodument of the quartz-spodumene crystals could not be separated in this way from the quartz of the quartz-spodumene crystals. No representative analysis of the quartz-spodumene rock has been made, but pure spodumene plates after careful separation from the intergrown quartz have been found to contain 6·47 per cent Li_2O. The quartz-spodumene crystals, as already stated, generally contain about 50 per cent of quartz and accordingly the Li_2O content would be about 3·2 per cent. Some of the quartz-spodumene crystals contain less, and others contain more, than 50 per cent of quartz and would accordingly contain correspondingly more or less than 3·2 per cent Li_2O. Spence[1] reports that a representative sample of "spodumene" was found to contain 4·0 per cent lithia. Wright[2] gives an analysis of a "hand-picked sample judged to represent approximately the spodumene-bearing rock after 50 per cent gangue has been removed." The analysis shows 4·76 per cent of Li_2O, but also shows considerable percentages of fluorine and phosphoric acid suggesting that the sample contained some montebrasite. Cole and Eardley-Wilmot[3] give an analysis of spodumene? (also probably a mixture of amblygonite and spodumene) showing 5·23 per cent of Li_2O. The grade of spodumene ore mined in the Black hills

[1] "Mineral Resources and the Mining Industry, 1926"; Mines Branch, Dept. of Mines, Canada, p. 16.

[2] Geol. Surv., Canada, Sum. Rept. 1924, pt. B, p. 103.

[3] "Mineral Resources and the Mining Industry, 1925"; Mines Branch, Dept. of Mines, Canada, p. 72.

or elsewhere is not known, but analyses of the spodumene crystals mined show a lithia content varying from 4·90 per cent to 6·78 per cent and these are apparently picked clean from gangue materials. It is probable that the quartz-spodumene crystals on the Bear mineral claim are too low in lithia content to be profitably used for extraction of lithia compounds, but if some cheap method could be developed for the separation of the spodumene from the closely associated quartz a profitable extraction of lithium compounds might be possible. The quartz-spodumene rock may possibly be used to advantage in glass work in place of lepidolite.[1]

The lepidolite of the inner part of the middle zone occurs on the hillside as three large masses elongated parallel to the strike of the dyke and as one mass in the most westerly open-cut. The largest of the masses on the hillside is near the east end of the dyke. It is 75 feet long and 20 feet in maximum horizontal width. The western end of the mass is exposed on the side of a short shaft where it is seen to be flat-lying and only about 3 feet thick. It probably thins to the east. This mass is composed of lepidolite mixed with quartz and cleavelandite, but 50 to 75 per cent of it is of pure lepidolite or of lepidolite mixed with small amounts of quartz or cleavelandite in rounded and irregular-shaped areas from 6 inches or less to 3 feet across. The pure or nearly pure lepidolite rock could be hand-sorted from the other materials, but apparently only a small tonnage is available. The second largest of the masses on the hillside lies close to the swamp, has been quarried out to a considerable extent, and is mostly covered. It is apparently about 40 feet long and is exposed at one place over a width of 12 feet. Its thickness is not known. The central and main portion of the mass is of pure lepidolite or, locally, is of lepidolite mixed with small amounts of quartz, cleavelandite, and tantalite-columbite. One specimen, apparently from this mass, is a fine-grained mixture of lepidolite, spodumene, and quartz. Near the north edge of the mass the lepidolite is intimately mixed with considerable quantities of cleavelandite and quartz. At its southern edge the pure lepidolite grades into a mass of pale lilac lithia mica which has only a low content of lithia. Most of the lepidolite ore which has been shipped from the deposit has been obtained from this mass, but apparently a considerable tonnage still remains. The third mass on the hillside lies between the two just described. It measures 18 feet by 11 feet on a horizontal plane. At its west end it is exposed on the face of a quarry where it is seen to be flat-lying and only about 2 feet thick. It is composed chiefly of pure lepidolite, but some of it is of lepidolite intimately mixed with small amounts of quartz and cleavelandite. Apparently only a small tonnage is available. The mass in the most westerly open-cut in the swamp is 6½ feet wide. It is composed chiefly of an intimate mixture of lepidolite and cleavelandite in approximately equal amounts. Within the middle part of this mixture and grading into it are a few masses of pure lepidolite measuring up to 1 foot by 3 feet. Here the dyke apparently dips south and the lepidolite-bearing rock probably continues to a considerable depth. A much larger tonnage of lepidolite may be present beneath the swamp which covers the major portion of the

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[1] Spence, H. S.: "Investigations of Mineral Resources and the Mining Industry, 1926"; Mines Branch, Dept. of Mines, Canada, p. 16.

deposit. An analysis of pure lepidolite from the deposit shows the following percentages of various constituents: Li_2O, 3·39; Fe_2O_3, 0·24; MnO, 0·90; Cs_2O, 0·21; F_2, 4·30. Rubidium and germanium are also present. Much of the lepidolite rock is pure or almost pure and may be expected to have about this composition. When lepidolite is mixed with cleavelandite or quartz the percentage of its constituents as given above would be proportionately decreased. Several analyses of lepidolite ore have been made with the following results:

—	I	II	III	IV	V	VI
Li_2O	3·87	3·98	4·02	2·9	3·5	
Fe_2O_3	0·10	0·64	....	0·3	0·4	
Iron oxide	....	....	....	....	....	0·25
Manganese	....	....	....	0·3	0·9	0·5
Fluorine	4·10	....	4·21	3·6	3·1	
AlF_3	....	8·40	....	....	....	

I. "Sample of compact crystalline lepidolite. M. F. Connor, analyst." Wright, J. F.: Geol. Surv., Canada, Sum. Rept. 1924, pt. B, p. 103.

II. "Analysis, furnished by Silver Leaf Syndicate, of lepidolite. Analysis by Daniel C. Griffith and Co., London, England." Cole, L. H., and Eardley-Wilmot, V. L.: "Investigations of Mineral Resources and the Mining Industry, 1925"; Mines Branch, Dept. of Mines, Canada, p. 72.

III. "General Sample of lepidolite mineral from the deposit. E. A. Thompson, analyst, Mines Branch, Ottawa." Cole and Eardley-Wilmot: Op. cit., p. 72.

IV. "Run of mine, lepidolite ore, Silver Leaf mine. Analysis furnished by Corning Glass Works, Corning, N.Y." Spence, H. S.: "Investigations of Mineral Resources and the Mining Industry, 1926"; Mines Branch, Dept. of Mines, Canada, p. 16.

V. "Run of mine, lepidolite ore, Silver Leaf mine. Analysis by E. A. Thompson and A. Sadler, Mines Branch." Spence, H. S.: Op. cit., p. 16.

VI. Spence, H. S.: Op. cit., p. 16.

The lithia content of the lepidolite compares favourably with the lithia content of lepidolites from California[1] and New Mexico[2] and the fluorine content is generally higher so far as known. The iron and manganese content is rather high, however, which may make the lepidolite objectionable for use in glass-making.[3] Should the lepidolite be used for extraction of lithia compounds the cæsium, rubidium, and germanium which it contains may possibly be valuable by-products, but it is doubtful if lithia compounds could be profitably extracted from material with such a low lithia content.

[1] Schaller, W. T.: U.S.G.S. Mineral Resources of the United States, pt. 2, 1916, p. 12.

[2] Roos, Alford: Eng. and Min. Jour., vol. 121, pp. 1037-1042 (1926).

[3] Spence, H. S.: Op. cit., p. 16.

Myers, W. M.: U. S. Bureau of Mines, Information Circular 6205, p. 31, states that the iron content should not exceed 0·05 per cent of ferric oxide.

ANNIE MINERAL CLAIM

The lithium-bearing body on the Annie mineral claim is in rocks of the albite granite group $\frac{3}{8}$ of a mile northeast of the dyke on the Bear claim. On the Annie claim lithium-bearing pegmatite mixed with granite and aplite occurs chiefly over an area measuring 50 feet across and was also observed easterly of this locality at distances of 60 and 300 feet. The lithium-bearing pegmatite contains scattered flakes of lilac lithia mica, lilac curvilamellar lithia mica, and grey curvilamellar lithia mica. A small amount of beryl occurs in crystals up to 1 inch across. The grey, curvilamellar, lithia mica contains only 0·90 per cent of lithia. The deposit is of no economic value.

GRAY MINERAL CLAIM

The lithium-bearing body on the Gray mineral claim is in rocks of the albite granite group $\frac{1}{4}$ of a mile northwest of the dyke on the Bear claim. On the Gray claim a small amount of grey curvilamellar lithia mica similar to that on the Annie claim is scattered through pegmatite and aplite over an area measuring 75 feet by 50 feet. A small amount of beryl is also present. The deposit is of no economic value.

CAPTAIN GROUP OF CLAIMS

The lithium-bearing body on the Captain group of claims is a dyke cutting rocks of the oligoclase granite group in the southern portion of sec. 14, tp. 16, range 16, 3 miles slightly south of east of the dyke on the Bear mineral claim. The deposit may be reached from Winnipeg river by a trail about a mile long. The dyke strikes north 20 degrees east, dips 35 degrees to the southeast, and is exposed for 200 feet along the strike. At its southwest end it is 24 feet wide and at its northeast end is 3 feet wide. Scattered flakes of lepidolite occur in small amount in the middle of the southwest portion of the dyke. A small amount of beryl is also present. The deposit is of no economic value.

BERNIC LAKE DEPOSITS

Nine lithium-bearing dykes occur over an area 500 feet wide and 3,000 feet long near the east end of Bernic lake. The deposits may be most easily reached from Lac du Bonnet, Man., by canoe along Oiseau river at Bernic lake, a distance of 36 miles. An ungraded road 4 miles long extends southward from the south shore of Bernic lake, 3 miles from the east end of the lake, to Winnipeg river about 2 miles west of Lamprey falls. From the end of the road to Winnipeg river it is 5 miles along the river to Pointe du Bois, Manitoba.

Two claims, the Buck and the Coe, were staked by K. E. Miller in 1926, the former on May 10 and the latter on July 9, and a third, the Brillant mineral claim, was staked on July 10 of the same year by P. Osis. The deposits have been prospected to a limited extent by stripping operations, small open-cuts, and trenches. The dykes have intruded volcanics which contain a few narrow belts of sediments. Dykes Nos. 1, 2, and 4 are fairly large and the others are small.

Dyke No. 1 is well exposed on the southern face of a small cliff into which it dips at an angle of 20 to 30 degrees. It is exposed along the strike, which is northeasterly for a length of 120 feet and at its eastern end is covered by a swamp which continues along the base of the cliff and covers the foot-wall of the dykes so that its thickness is unknown. The thickest exposed portion, measured normal to the dip, is about 15 feet. A zone 1 to 4 feet thick, extending along the hanging-wall of the dyke for a distance of 75 feet from the east end of the exposure, is composed, in its upper part, chiefly of large, black, tourmaline crystals mixed with albite and in its lower part is chiefly a coarse, granitic mixture of albite, quartz, and muscovite. The west end of the dyke over a length of 35 feet is chiefly of large microcline crystals. Albite aplite occurs in small amount in association with the microcline and also occurs along the lowest exposed portion of the dyke midway along its length. Lithium minerals occur in a middle zone, lying beneath the hanging-wall zone. The middle zone has a maximum exposed thickness of 7 feet and for the most part its thickness is unknown, for it is partly covered by swamp. The lithium minerals present are spodumene and montebrasite. The spodumene is intimately mixed with quartz, the mixture forming quartz-spodumene crystals generally from 6 inches to a foot long and about half as wide. Only twelve such crystals were noted distributed over a distance of 50 feet along the strike of the zone. Only three rounded masses of montebrasite from 6 inches to 1 foot across were noted. Both the quartz-spodumene crystals and the montebrasite masses lie in quartz which constitutes the major portion of the middle zone. Near the top of the dyke at its west end a quartz area measuring 6 feet by 3 feet contains fifteen or twenty scattered beryl crystals from 2 to 10 inches in basal section. A few crystals of beryl from 1 inch or less to 8 inches in basal section are scattered through the quartz of the middle zone, and a few an inch across occur in the coarse, granitic material of the hanging-wall zone.

Dyke No. 2 strikes north and has been traced intermittently along the strike for 220 feet. It is exposed on a cliff face across its southern end where it has a horizontal width of 45 feet. Here it dips 25 degrees to the east at its east side and is apparently horizontal at its west side. The maximum exposed thickness normal to the dip is about 9 feet. The easterly dipping hanging-wall of the dyke is well exposed on a dip slope for a distance of 150 feet from the south end. Midway along the strike the dyke outcrops in a few, small, natural exposures and is exposed in some trenches over a length of 45 feet and a width of about 25 feet. At the north end it is exposed on a low cliff face into which it dips at an angle of 55 degrees to the east. A hanging-wall zone of the dyke is about 3 feet thick and is composed chiefly of tourmaline and albite in its upper part and of a coarrse, granitic mixture of quartz, albite, and muscovite in its lower part. Nowhere is the foot-wall of the dyke exposed, but in the most westerly part of the trenches, apparently close to the foot-wall, the pegmatite, across a width of 10 feet, is composed chiefly of large microcline crystals. Lithium minerals are exposed chiefly in the trenches over a length of 45 feet and a width of 4 to 6 feet between the hanging-wall zone and the microcline. Here, the lithium minerals are spodumene and montebrasite. The spodumene is intimately mixed with quartz, the mixture forming spodumene-quartz crystals about 1 foot across and constituting about 60 per cent of the area in the trenches. The montebrasite forms masses 1 to 2 feet across and constitutes about 10 per cent of the area. The remaining 30 per cent of the area is chiefly of quartz. Lithium minerals are also exposed on the cliff face at the south end of the dyke west of the hanging-wall zone. Here, a few scattered flakes of lepidolite are scattered through cleavelandite and two or three mases of montebrasite up to a foot across occur in a large, open cavity. Beryl forms a few, small crystals in the trenches in associtiom with the lithium minerals.

Dyke No. 4 strikes slightly north of east. Its south wall dips vertically and its north wall is not exposed. At its east end the dyke is in irregular contact with broken blocks of the country rock, holds a few inclusions of the country rock, and breaks up sending many small branch dykes into the country rock. Near the east end the dyke is well exposed on a flat surface for a length along the south wall of 7 feet and over a width of 9 feet. At a distance of 20 feet to the west of this exposure the dyke has been uncovered in a cross trench over a width of 20 feet. At a distance of 30 feet farther to the west a small open-cut on the strike of the dyke shows country rock cut by small pegmatite stringers. A band of quartz muscovite rock 1 inch to 1 foot wide lies along the south wall and a narrow band of granitic pegmatite occurs along the east end. The flat surface near the east end of the dyke covers about 50 square feet and is composed almost entirely of closely packed quartz-spodumene crystals mostly from 1 to 2 feet long and with a maximum observed size of 2½ feet by 10 inches. Over a width of 19 feet in the trench the dyke is composed chiefly of a coarse-grained mixture of quartz-spodumene crystals, quartz, and a small amount of montebrasite.

In dykes Nos. 3, 5, 6, and 7 a few scattered masses of montebrasite lie in quartz. They are generally 6 inches to a foot across, but in dyke No. 7 one mass is 3 feet across. In dykes Nos. 3, 6, 8, and 9 there are small amounts of spodumene. In dyke No. 3 there is a 1-foot mass of massive lepidolite similar to the lepidolite on the Bear mineral claim. In dykes Nos. 3, 5, and 7 there are a few scattered beryl crystals, the largest of which is 6 inches in basal section.

Of chief economic interest in the Bernic Lake deposits are spodumene, montebrasite, and beryl. The spodumene is intimately intergrown with quartz, the mixture forming quartz-spodumene crystals similar to those on the Bear mineral claim and only about half spodumene. The quartz-spodumene crystals could be hand-sorted from other materials where necessary, but the spodumene could not be separated by this means from the intergrown quartz. Unless some cheap method of bringing about this separation is developed the spodumene is probably of too low a grade to be profitably used for the extraction of lithium compounds and even if such a method were developed a considerably larger tonnage would have to be proved before mining could be considered advisable. No analyses of the montebrasite have been made, but it is similar to that on the Bear mineral claim which is of commercial grade. There is more montebrasite in the Bernic Lake deposits than anywhere else in Canada as far as known. An amount large enough to warrant mining operations has not yet been proved, but the indications are encouraging enough to make a further search worth while. The beryl of the deposits is generally slightly turbid, but is transparent and all the crystals are minutely fractured. They are colourless to very pale sea green and pale yellowish, but the pale colouring and fracturing makes the material of no value as gem stone. The quantity, as indicated at present, is not large enough to be profitably mined for other purposes. The beryllium content (12·74 per cent BeO) of a specimen from dyke No. 1 is sufficient, however, for commercial purposes.

CAT LAKE DEPOSITS

Cat lake is in the central part of township 19, range 15, 12 miles north of the Bernic Lake deposits. At the time of the writer's visit it was rather difficult to reach. The first part of the trip was made by motor boat from Lac du Bonnet, Manitoba, to Peterson's farm on Oiseau river, a distance of 22 miles. From there a trail, about 13 miles long, was followed to a small cabin at the southern end of a lake in the northeast corner of township 18, range 14, supplies being taken in by horse and buckboard which were hired locally. The remainder of the journey is by way of a little travelled route, 6 to 8 miles long, over a chain of small lakes and long portages without well-defined trails. Dug-out canoes and boats were available on the lakes, but it would be preferable to take along a small, lightweight canoe. Five lithium-bearing dykes are present in the vicinity of the lake. They cut granodiorite and volcanics. One of the dykes, on the Irgan mineral claim, is about 1,500 feet north of the lake and another, on the Cat Lake mineral claim, is 1,000 feet south of the lake. Two are in an area of volcanics 500 feet south of the lake and ½ mile east of the dyke on the Cat Lake claim. The fifth is north of the lake and 1,400 feet slightly east of south of the east end of the dyke on the Irgan claim.

The dyke on the Irgan claim is well exposed on a glaciated surface. The dyke strikes north 80 degrees west and dips 87 degrees to the south. At its east end it is about 40 feet wide and strikes into a swamp. Toward the west it widens to a maximum width of 60 feet at a point 200 feet from the east end. Farther west it gradually narrows and, finally, apparently pinches out. Its total exposed length is 1,450 feet and its average thickness is about 20 feet.

Near the middle of its widest part over an area measuring 45 feet along the strike and 12 feet wide, the dyke is composed of large microcline crystals, from 6 inches to 2 feet along their edges, lying in a finer grained groundmass of a mixture of quartz and spodumene. The spodumene is in crystals usually about ¼ inch or less in length and diversely oriented in the quartz. The two minerals are present in about equal proportions. The microcline crystals constitute about one-third and the quartz-spodumene mixture about two-thirds of the area. The quartz spodumene mixture could be hand-sorted from the microcline, but the spodumene could not be separated from the quartz by this means. Elsewhere the dyke has a well-developed, banded structure parallel to the strike of the dyke. The banding is due chiefly to an alternation of bands or long lenses of spodumene-quartz mixture, with bands of coarse, granitic rock or albite aplite. The lenses vary from small ones 1 foot long and 1 inch to 6 inches wide to large ones 10 feet long and 6 inches wide. The bands vary in width from 1 inch to 2 feet. The coarse, granitic rock is composed of a mixture of albite, microcline, muscovite, and quartz with accessory garnet and apatite and is estimated to constitute over half of the dyke material. The albite aplite is much less abundant than the granitic rock. The spodumene of the spodumene-quartz mixture forms plates usually less than $\frac{1}{4}$ inch long and with a maximum observed length of 1 inch. They are usually diversely oriented in the quartz and constitute about one-half of the mixture.

A rough estimate in the field indicates that, across the strike of different parts of the dyke, the quantity of quartz-spodumene rock varies from 20 per cent to 50 per cent of the whole and the richest portion is estimated to contain 70 per cent of the quartz-spodumene rock over an area of about 500 square feet. Similar percentages are likely to continue to a great depth. It has been calculated that there are about 50,000 tons of quartz-spodumene rock or about 25,000 tons of spodumene in each 100 feet of depth. About half of this tonnage of spodumene is in rock composed of from about 15 per cent to about 30 per cent spodumene and about half is in rock composed of about 10 per cent spodumene. In the part of the dyke composed of large, microcline crystals in a ground of quartz-spodumene rock, the quartz-spodumene rock could be hand-sorted from the microcline, and in some parts of the banded part of the dyke the quartz-spodumene rock could be hand-sorted from the granitic material and aplite and a product of about 50 per cent spodumene obtained. In most of the dyke, however, the quartz-spodumene rock could not be separated from the granitic material and aplite by this means. All the spodumene is so intimately mixed with quartz that the two could not be separated by hand-picking.

The dyke on the Cat Lake claim is exposed along the face of a cliff into which it dips to the southwest at angles varying from 13 degrees to 25 degrees. It strikes north 25 degrees west and has been traced along the strike for 200 feet. It is covered by swamp at the southeast end and apparently breaks up at the northwest end. The hanging-wall contact with country rock is well exposed, but the foot-wall contact is covered. The maximum exposed thickness measured normal to the dip is about 15 feet. Albite granite forms a band from 1 to 2 inches thick along the hanging-wall contact and is underlain by a band of quartz-muscovite rock from 1 to 3 inches thick. A few beryl crystals occur in the quartz-muscovite rock. A band of albite aplite 3 to 5 feet thick constitutes the lowest exposed portion of the dyke. A lithium-bearing zone 10 feet thick occurs along the middle of the dyke and is exposed for a length of 160 feet along the strike. It is composed of large microcline crystals scattered through a groundmass of albite aplite and quartz-spodumene rock. The spodumene of the quartz-spodumene rock is in plates averaging from 1 to 2 inches long, which have a maximum observed size of 1 foot by 6 inches by $\frac{1}{2}$ inch. They generally lie with diverse orientations in the quartz and constitute about half of the quartz-spodumene rock.

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The percentage of quartz-spodumene rock varies greatly in different parts of the dyke. Rough estimates in the field indicate that, in some sections across the strike of the lithium-bearing zone of the dyke, the quartz-spodumene rock forms as much as 75 per cent of the whole. In other sections it forms only about 5 per cent of the whole. On the average the lithium-bearing zone consists of approximately 50 per cent quartz-spodumene rock, most of which could be hand-picked from the associated microcline and aplite. The spodumene could not be separated from the quartz-spodumene rock by this means.

Unless some cheap method of concentration of the spodumene on the Irgan and Cat Lake claims is developed the spodumene is too low grade, taking transportation and other factors into consideration, to be profitably used for the extraction of lithium compounds, and even if such a method were developed it is improbable that these deposits could be mined profitably under present conditions.

The three other dykes at Cat lake contain only small amounts of spodumene or beryl and are of no economic value.

WEST HAWK LAKE DEPOSITS

Of the three lithium-bearing dykes in the West Hawk Lake district, the largest is on the Deer mineral claim in the centre of sec. 16, tp. 19, range 17, 1,000 feet from the southwest shore of West Hawk lake. The two other dykes are small. One is 4,400 feet north 25 degrees west of the dyke on the Deer claim and the other is 1,200 feet south 30 degrees east of the same dyke. All three cut volcanics. West Hawk lake is easily reached from Ingolf, Ontario, on the Canadian Pacific railway. Ingolf is on Longpine lake and a portage trail, 44 chains long, leads from the west end of Longpine lake to West Hawk lake.

The dyke on the Deer mineral claim strikes north 30 degrees west and is exposed by natural exposures, stripping, and open-cuts at two localities, a southeast locality and a northwest locality. At the southeast locality it dips 75 degrees to the southwest and varies from 5 to 10 feet in thickness. At the northwest locality it varies from 2 to 8 feet wide, is in irregular contact with the country rock, sends a branch dyke into the country rock, and holds a large inclusion of the country rock. The length of the dyke, as indicated by the two exposures, is 260 feet. The dyke is composed chiefly of an intimate mixture of quartz, albite, lepidolite, and spodumene. A few small crystals of pink tourmaline are also present. They are somewhat turbid and are not of gem quality. The deposit is of no economic value at the present time.

The two other dykes are only from 6 inches to 1 foot wide. They are composed of albite and quartz with a small amount of lepidolite and, in one of them, a small amount of pink tourmaline which is not of gem quality. The dykes are of no economic value.

BERYLLIUM DEPOSITS

By C. H. Stockwell

A description and an account of the economic possibilities of beryl which occurs in lithium-bearing bodies has already been given. In lithium-bearing bodies it is most abundantly present in the Bernic Lake deposits, but also occurs in the Cat Lake deposits and on the Bear, Annie, and Gray mineral claims and on the Captain group of claims.

Beryl was also noted by the writer in eleven non-lithium-bearing bodies. Three of these are at Cat lake and consist chiefly of albite aplite in which are patches of quartz-muscovite rock. A few beryl crystals up to 1 inch in basal section are scattered through portions of each type of rock. On the Captain group of claims a dyke striking parallel to the lithium-bearing dyke is composed chiefly of microcline, but portions are of albite pegmatite which contains a few small beryl crystals and one large, milky white beryl crystal measuring 8 inches in basal section. Another dyke ¼ of a mile northeast of the lithium-bearing dyke on the Captain group of claims is composed chiefly of albite aplite, microcline pegmatite, and quartz-muscovite rock. Both the aplite and the microcline pegmatite contain pockets of quartz. Yellowish green beryl crystals up to 2 inches in basal section occur in some of the quartz pockets, but are chiefly present in the aplite close to quartz pockets. The beryl crystals are numerous over a length of 50 feet along the strike of the dyke; in one place fifteen beryl crystals were counted in an area of 1 square foot. Much smaller amounts of beryl were noted in a dyke 2 miles southwest of the Captain group of claims. On the south shore of Winnipeg river 3 miles east of Lamprey falls an albite pegmatite dyke contains a few green beryl crystals, about an inch in basal section, scattered through quartz-rich parts of the dyke. Two microcline pegmatite dykes in the northeast and northwest corners, respectively, of sec. 1, tp. 15, range 15, 6 miles slightly north of east from Pointe du Bois, Manitoba, contain a few small crystals of beryl. In Ontario, a few similar crystals were noted in a large pegmatite dyke cutting volcanics on the east shore of English river 2 miles northwest of Separation rapids and in a small dyke cutting sediments 3 miles west of Oneman lake. In none of these deposits is the beryl of gem quality, nor is it present in large enough quantity to be profitably mined for other purposes.

The outstanding discovery of beryl in the region is in a pegmatite dyke on the Huron claim owned by the Winnipeg River Tin Company. This claim is about half a mile inland from a point on the southeast shore of Winnipeg river, 9 or 10 miles above Pointe du Bois and in the immediate vicinity of the lithium-bearing dyke on the Bear mineral claim. The deposit has not been visited by the writer, but is described by J. S. DeLury[1] as follows:

"The pegmatite outcrops on the vertical face of small cliffs of andesite on either side of a narrow swamp. The attitude of the pegmatite, wherever seen, strongly suggests an anticlinal structure. On either side of the swamp the pegmatite dips away at low angles.

[1] "Beryl in Manitoba"; Can. Min. Jour., vol. LI, 1930, p. 1017.

The main constituent of the dyke is coarse feldspar. It is present in massive form with little or no quartz except in two or three places where masses of quartz resembling veins occupy thicknesses of 2 to 7 feet. In the trenches quartz is seen to be associated with beryl and the two appear to be in about equal quantity. Beryl is conspicuous in two places, one on either side of the swamp. On the north side beryl is exposed over a width of 15 feet. It occurs here in distinct crystals and crystalline masses. The more irregular masses have been fractured and the fractures are filled with veinlets of feldspar. The beryl is both green and golden in colour.

Across the swamp about 140 feet away is the other conspicuous beryl showing. The beryl is similar but less massive and with more good crystal outlines apparent. The mineral is closely associated with feldspar and quartz. The zone carrying beryl is about 20 feet wide and the richer portion with more massive beryl is 8 feet wide. Much of the beryl shows distinct alteration. Other interesting mineral occurrences in the same workings are tantalite, monazite, and pitch blende."

The same author in the same report mentions other beryl occurrences in the district as follows:

"The Winnipeg River Tin Company also has a pegmatite on the Annie claim (north of Huron) showing a small concentration of beryl, cassiterite, and lepidolite. The same company, on the Top of the World claim about ½ mile southeast of Greer lake, has a wide dyke of pegmatite showing zones of different composition more or less parallel to the walls. In one zone about 3 feet wide, small and well-formed beryl crystals are conspicuous. Other zones show less beryl and some of them lepidolite, the lithium mica.

Another interesting occurrence of beryl on the south side of Winnipeg river should be mentioned. At the water's edge on a claim about 9 miles above Pointe du Bois and owned by F. B. Evans, a pegmatite outcrops for a length of 60 feet along the shore. A 12-foot width is exposed in one place. Besides the usual minerals of pegmatites, this one shows rose-tinted and opalescent quartz and green and colourless beryl crystals. Some of the beryl is fairly transparent and in pleasing tints and has been used in a small way for gem material.

Beryl in small crystals and veinlets is also reported from a number of pegmatites near the shore of Winnipeg river, on the south side about 2½ miles above Pointe du Bois and on the north side 1½ and 4 miles above that place."

Other deposits of beryl occur at Shatford lake, at several places near Bernic lake, and at other localities. Regarding the deposits, J. F. Wright contributes the following account. "By hand-sorting perhaps several tons of beryllium ore could be mined from these pegmatites, but probably it would not be profitable to undertake to quarry and to market the beryl unless larger and higher grade deposits are found nearby." Regarding the economic possibilities of the deposits in Manitoba, DeLury says: "A great deal must be done still to prove that large tonnages of beryl can be shipped from Manitoba, but there is one deposit at least, and perhaps several more to be proved or found, that give high hopes that the province may be a producer when the time arrives for a large consumption of the metal beryllium."

Two beryl occurrences are in pegmatitic bodies on a point on the south shore of Shatford lake, 3,500 feet from the east end of the lake. These pegmatites are controlled by Manitoba Tin Company, Limited. A prospect pit in one pegmatite mass exposed an area of 2½ feet across carrying beryl crystals up to 24 inches long. In a nearby pegmatite, small beryl crystals are estimated to form half the area exposed in a pit 2 feet deep, 3 feet long, and 2 feet wide. Pink soda feldspar, white muscovite, and quartz are the only minerals noted with the beryl in the pegmatite. In June, 1929, sufficient work had not yet been done on these pegmatite bodies to determine the size of the beryl-bearing deposits that might be present, but apparently the beryl is localized within erratically distributed pockets.

Crystals of beryl are also present in the pegmatites opened up by Jack Nutt Mines, Limited, on the north shore of Bernic lake, and in the pegmatite in the Rush group. At these localities, however, beryl forms only a minor constituent of the pegmatite. A few tons of beryl perhaps could be obtained from the deposits south of Shatford lake.

FUCHSITE-BEARING ROCK SUITABLE FOR STUCCO MATERIAL

By C. H. Stockwell

Fuchsite (chromium mica) occurs in quartzite on the Vernon mineral claim in the southwest part of section 13, township 16, range 15. A road, ¾ mile long, has been constructed from the property to a point on Winnipeg river 1 mile south of Lamprey falls. From the end of the road it is 6½ miles southwest along the river to Pointe du Bois, where railway connections are made. In 1926 the Silver Leaf Mining Syndicate mined about 150 tons of fuchsite-bearing rock and shipped it to Winnipeg for use as stucco dash.[1]

The fuchsite is in a narrow band of quartzite that strikes east and dips at an angle of 70 degrees to the north. The quartzite is bordered on its south side by grey oligoclase granite and on its north side by basaltic lava. The deposit is exposed on the side of a hill in an open-cut about 20 feet wide and extending 50 feet along the strike. The quartzite is locally known as pearl rock. Pale green pearl rock composed chiefly of quartz with a few disseminated flakes of fuchsite occurs as a bed 3 feet wide along the middle of the open-cut. This bed is bordered on its south side by grey pearl rock and on its north side by white pearl rock containing a few narrow layers of fuchsite. In the bed of pale green pearl rock are about half a dozen lenses of fuchsite rock measuring up to 3 feet by 1 foot. The fuchsite rock has a bright green colour, is schistose, and is composed chiefly of fuchsite with small amounts of quartz and a black opaque mineral in miscroscopic grains. A larger proportion of fuchsite rock is said to have been present in the material mined. The fuchsite rock and pearl rock are cut by a few dykes and stringers of pegmatite. Analyses of "fuchsite ore" and of "a hard, green, compact material," probably the pearl rock, are given by Spence in the article referred to above. The fuchsite has probably been formed by metamorphism of original constituents of the quartzite. The pearl rock is exposed at intervals over a distance of 800 feet along the strike to the east. Over this distance the bedrock is largely covered and no fuchsite-bearing rock was seen, but it may be present.

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[1] Spence, Hugh S.: "Investigation of the Mineral Resources and the Mining Industry, 1926"; Mines Branch, Dept. of Mines, Ottawa, p. 18.

MOLYBDENITE NEAR FALCON LAKE

By E. L. Bruce[1]

"Recently claims have been staked for molybdenite in Manitoba near the Ontario boundary. The claims lie in tp. 9, range 16, W. 1st mer., Falcon lake, a body of water of considerable size, draining into Shoal lake and thence into Lake of the Woods, lies just south of the locations. In summer Falcon lake can be reached from Ingolf, a station on the Canadian Pacific railway just east of the Manitoba-Ontario boundary, by a canoe route that leads through Longpine and West Hawk lakes, and there is another good water route, by way of the Falcon river, from Shoal lake, where the Greater Winnipeg Water District railway terminates. In winter there is good connexion with the railway by road. Summer roads could be built without great expense.

The country has the typical, broken, lake-dotted character of the Precambrian, and has somewhat greater relief than most areas of similar rocks in Canada.

Three days were spent by the writer in the district, and although accompanied by Mr. W. J. Gordon, who is thoroughly acquainted with it, the time was altogether too short to make a satisfactory study of the geology. Moreover, work was very seriously hindered by snow, which left only cliff faces and hummocks exposed. The writer has, however, had access to a private report by Geo. Hanson, to the published reports of Parsons on the Lake of the Woods district, for the Ontario Bureau of Mines, and of R. Wallace, for the Public Utilities Commission of Manitoba. The latter report does not include Falcon lake, but deals with the Star Lake district just north of it.

GENERAL GEOLOGY

The following is a very brief summary of the geological relations. The oldest rocks consist of a volcanic complex of schists and ellipsoidal-weathering greenstones. Involved in these are certain areas of sedimentary rocks, which have not yet been separately mapped. The volcanics, and probably the sediments as well, are intruded by a fresh, reddish to grey granite-gneiss, which forms the country rock both to the northwest and southeast of the narrow belt of basic rocks between West Hawk and Falcon lakes. Parsons[2] says of the part of this belt crossed by the Manitoba-Ontario boundary: 'The Keewatin formation is here about 4 miles wide and consists of fine-grained, highly altered rocks, which show little trace in the field of their origin. The most abundant rock is biotite schist, but hornblende schist is common. Near the contact of this formation with the Laurentian on the north, the rock becomes coarser grained and is almost granitoid in texture, though much darker, than the Laurentian gneiss with which it is in contact.'

West of Finnel lake, which lies just north of Falcon lake, there are many areas of ellipsoidal-weathering greenstone. In fact, this greenstone seems to have a greater areal extent than any other Keewatin type; but, since this massive rock stands up in ridges and hence was bare at the time the district was visited, whereas the lower country, which is probably underlain by schists, was snow-covered, the predominance of the ellipsoidal lavas may have been only apparent.

On the northwest side of the basic belt, near the Keewatin-Laurentian contact, a large number of pegmatite dykes of all sizes cut the older formation. Most of these are entirely within the schist and greenstone, but the largest one seen may be the pegmatitic edge of the main body of gneiss. A wide muskeg-filled valley, however, separates it from the nearest outcrop of normal granite-gneiss. The pegmatites occur in a belt lying parallel to the approximate line of contact between the two formations, and, though not continuous, they form a zone about 2 miles in length north of Falcon lake. It is along this zone that claims have been staked for molybdenite.

The pegmatites consist mostly of a pink-weathering feldspar and quartz. Some of them are almost wholly feldspar, others seem to grade into typical quartz veins. In one place a pegmatite consisting of nearly equal amounts of quartz and feldspar gradually changes along its strike to a quartz vein with a feldspar border on each side, and farther along to an ordinary quartz vein. Muscovite is a fairly abundant constituent of the pegmatites and beryl is found, but is somewhat rare. Some molybdenite occurs in almost all the pegmatitic dykes of this zone. In one sample from the district native bismuth occurs associated with the molybdenite.

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[1] Reprinted from Sum. Rept. 1917, pt. D.

[2] Rept. Ont. Bureau of Mines, 1912, p. 201.

Although in all cases related to pegmatites, the molybdenite is found with the following physical characters:

(1) As a constituent of typical pegmatite dykes.
(2) In equigranular granitic dykes.
(3) In quartz veins.

In the typical pegmatite dykes the molybdenite occurs as crystals varying from a fraction of an inch up to 2 inches in diameter. The size of the larger individuals seems to vary according to the distance of the dyke from the parent granite mass, the larger crystals being found in the dykes close to the edge of the main granite area. In these dykes, however, the total amount of molybdenite present is not greater, and possibly is even less than in those farther from the intrusive.

In the equigranular dykes the molybdenite crystals are much smaller, occurring as small hexagonal plates rather than as the large almost equally dimensioned crystals found in the typical pegmatites.

In quartz veins molybdenite flakes are found in veinlets traversing the quartz. These veins lie near the typical pegmatites, and in some of them the veinlets are made up largely of molybdenite, with only very narrow borders of feldspar. The molybdenite does not seem to be secondary in any sense except that the veinlets are a little later in age than the quartz veins, which they cut. In type they are similar to the occurrences in the larger dykes.

The molybdenite-bearing quartz veins are not large and they contain too little of the mineral to make them workable, even if they were of sufficient size. The equigranular dykes carry more molybdenite than the other types, but all those seen were too small to be important. In the pegmatites it is very difficult to obtain an idea of the proportion of molybdenite. The crystals are scattered irregularly through the quartz and feldspar, so that a face showing no crystals may show several when a thin layer has been broken off. Ordinary sampling under such conditions is worse than useless. The only method of arriving at an accurate estimate of the content of a vein is to take out and mill a fairly large quantity. Judging from dyke material broken from the face of a small open-cut the molybdenite content is less than one-quarter of 1 per cent of molybdenite. This is in the only opening of any size made in the dykes. At this place the dyke is from 2½ to 3 feet wide and has been open-cut for 20 feet to a depth of 3 feet. The pegmatitic material breaks easily and a small quantity of almost pure molybdenite could no doubt be produced by cobbing such material, but it is doubtful if this could be done economically with so low grade a product as this seems to be. However, the accessibility of the district, the large number of well exposed dykes varying from 2 feet to 12 feet in width, and the ease with which a considerable quantity of the material could be taken out, without expensive mining machinery, make it possible that this prospect might be commercially worked at the present time.

The molybdenite content may be expected to continue fairly constant, but the depth to which the dykes extend cannot be foretold. Since they undoubtedly join the parent mass of granite below, the depth from the surface to which they reach depends upon the attitude of the granite. This can be ascertained only by drilling or by underground work."

OCCURRENCES OF GOLD AND SCHEELITE, STAR AND FALCON LAKES AREA

By E. L. Bruce[1]

"The area of Precambrian rocks in the southeastern corner of Manitoba received considerable attention from prospectors during the gold excitement in the Lake of the Woods district some years ago. Many test pits and shafts were sunk on quartz veins or shear zones impregnated with sulphides. At the Penniac group of claims just south of Star lake, mining and milling equipment was installed, but no production of any consequence resulted and for some years there has been little activity. In 1917 some of the old workings were sampled by J. R. Marshall of the Geological

[1] Reprinted from Sum. Rept. 1918, pt. D.

Survey[1] and assays of the samples showed appreciable amounts of platinum. Owing to the demand for this metal, a more thorough sampling of the veins from which the platinum-bearing specimens came, was considered advisable. Also some discoveries of scheelite had recently been made in the same district and these required examination. During July, 1918, a week was spent in the vicinity of Falcon and Star lakes and samples were obtained from practically all the old workings.

POSITION AND MEANS OF ACCESS

The district lies between the main line of the Canadian Pacific railway and the Greater Winnipeg Water District railway and is easily reached by canoe from either of these lines. Winter roads have been made and there are no serious obstacles to the construction of summer roads should the development of mining warrant it.

GENERAL GEOLOGY

No thorough study of the geology of the district has yet been made. A review of previous work and opinions is given in the Summary Report for 1917.[2] The oldest rocks of the district are volcanic in origin and consist of ellipsoidal weathering lavas and derived schists which are probably referable to the Keewatin. Areas of conglomerate occur folded in with the Keewatin rocks, but the conglomerate contains pebbles of the volcanics as well as fragments of various other rock types among which are relatively large oval pebbles of a reddish, rather friable rock which has the appearance of an arkose but may prove to be a somewhat abnormal granite.

The volcanic rocks and the conglomerate occur as a narrow belt between great areas of red granite which is intrusive into them. An isolated boss of granitic rock occurs south of Star lake. It intrudes both volcanics and conglomerates. In composition it is rather different from the red granite bounding the belt and it may have been intruded at a different period. It is variable in character; in places it has the appearance of a hornblende syenite, and in other places it is a very acidic binary granite. The binary granite occurs as relatively small elliptical areas without any very marked line of contact between it and the normal basic variety.

QUARTZ VEINS

The gold-quartz veins from which platinum has been reported occur both in the granite and in the basic rocks intruded by the granite. Many of them are shear zones impregnated with quartz and sulphides. In such deposits the central part commonly consists of quartz of fine texture. Outwards the zone consists of silicified country rock impregnated with sulphides which may also form veinlets of solid mineral. The assays given below show that the greater part of the gold content is associated with the sulphides rather than with the quartzose part of the zone. In the granite, fissures are more definite and there is less impregnation of the walls by vein material. The deposits occurring in the basic rocks seem to be arranged as a sort of aureole about the boss of granite, and this, together with the occurrence of visible gold and other metallic minerals in the differentiated parts of the intrusive, seems to be rather conclusive evidence that the vein material was derived from the granite.[3]

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[1] Geol. Surv., Canada, Sum. Rept. 1917, pt. D, p. 21.

[2] Geol. Surv., Canada, Sum. Rept. 1917, pt. D, p. 22.

[3] Wallace, R. C., and DeLury, J. S.: "Rice Lake District, Mineral Belt North of The Pas, Star Lake District in Eastern Manitoba"; Manitoba Public Utilities Commission.

The results of the assays of the various samples taken are as follows:

Sample No.	Claim	Width sampled		Method of sampling	Ounces troy per ton of 2,000 pounds	
					Gold	Platinum
		Feet	Inches			
5	Magpie	7	..	Channel	None	None
6	Jewel	4	..	"	"	"
7	"	5	..	"	0·16	"
8	Georgius	4	..	"	None	"
9	"	4	..	"	"	"
10	"	..	..	From dump	"	"
11	Enterprise	..	..	"	0·08	"
12	"	..	..	"	1·64	"
13	Hall	..	..	"	0·13	"
14	Boyes	..	..	"	2·42	"
15	Gold Coin	..	18	Channel fr. quartz	0·08	"
16	"	..	53	" " rock	None	"
19	Sunbeam	22	..	"	Trace	"
20	"	8	..	"	"	"
23	Waverley	1	..	" sheared rock	1·48	"
24	"	..	6	" quartz	Trace	"
25	Penniac	..	8	" face of drift	0·14	"
26	"	..	..	Ore from pocket	Trace	"
28	"	..	..	Tailings from mill	0·08	"
35		..	..	West side of Hawk lake, grab sample	None	"
36		..	..	Northwest side of Hawk lake, grab sample from pit	None	"

Assayer: H. A. Leverin, Mines Branch, Dept. of Mines, Ottawa.

Mineral Claims

Magpie. On the Magpie claim a shaft 8 feet by 8 feet has been sunk to a depth of 8 feet in a rusty-weathering, silicified zone. The strike of the zone is northeast and the dip is vertical. A little white iron is visible in the altered rock.

Jewel. Two shafts, 60 feet apart, have been sunk on a mineralized zone on the Jewel claim. The country rock is a dense, dark, hornblendic rock which is fairly massive. A zone one foot in width contains considerable sulphide.

Georgius. On the Georgius claim two shafts have been sunk, one along the hanging-wall, the other along the foot-wall of a sulphide-impregnated zone which at the shafts is 30 feet in width. Pyrite or marcasite seems to be the most abundant mineral, but some quartz also occurs in the altered country rock.

Enterprise. A shaft has been sunk to a depth of 20 feet at the point where the main vein divides. Open-cuts have also been made along the vein. The material on the dump contains a considerable amount of pyrite and in the open-cut small pockets of chalcopyrite were observed.

Hall. The deposit examined on this claim is a lens of quartz 15 feet in length with a maximum width of 2 feet. It occurs in a dense, dark grey, dioritic rock which is somewhat schistose. The quartz lens cuts across the structure. Besides the quartz some molybdenite is present along with molybdite, its alteration product.

Boyes. On this claim is a shaft 25 feet in depth, as well as a small open-cut. The deposit in the shaft consists of two veins of quartz, each averaging about 4 inches in width, separated by 8 inches of altered rock. The vein dips very steeply and along its hanging-wall side arsenopyrite and other sulphides form a selvage at most an inch in width. This seems to be the part of the zone in which the highest values occur, but in choosing the sample only enough of this material was taken to form approximately an average of the mineralized zone.

Gold Coin. The country rock of the Gold Coin claim is a coarse-grained granodiorite or hornblende syenite with some biotite. In the pit there are two veins of quartz, 3 inches and 15 inches in width respectively. Along the foot-wall of the narrower vein which dips beneath the wider one, the rock is fractured slightly and is impregnated with arsenopyrite. The quartz is glassy and has dark zones which roughly parallel the walls. It contains arsenopyrite and smaller amounts of pyrite, the alteration of which has stained the quartz.

Sunbeam. The sunbeam claim is also in the granitic boss. Several shallow pits have been sunk in a fine-grained, acidic mass of granite roughly oval in outline, 100 feet long by 75 feet wide. In places along the edge the normal syenite or granodiorite is distinctly banded parallel to the contact, but around the greater part of the border the acidic rock grades into the more basic normal facies. Apparently the acidic rock is a differentiate from the intrusive mass. The acidic granite itself is not homogeneous, but certain parts of it are so acidic and the rock is so fine grained that it is practically an aplite. Gash veins filled with quartz occur in the granite mass, but no metallic minerals were seen in them. Grains of pyrite and small bunches of galena and zinc blende occur scattered through the unfractured granite and seem without doubt to be a part of that rock.

Waverley. The Waverley claim lies east of the Sunbeam in the granodiorite area. In this a pronounced shear zone strikes northeast and dips 50 degrees southeast. Along the foot-wall side is a band of quartz 6 inches in width. A shaft has been sunk to some depth along the shear zone and a shallow open-cut has been carried along the vein for a distance of 200 feet. Judging from material on the dump, quartz formed only a small part of the material taken out.

Penniac. More development work has been done on the Penniac group of claims than at any other point in the district. An inclined shaft has been sunk to a depth of 60 feet, the upper 35 feet of which has an angle of 60 degrees and the lower 25 feet, an angle of 40 degrees. From the bottom of the shaft drifts were carried northeast and southwest. The northeast drift is 70 feet long and the southwest drift is said to be of about the same length. Besides the shaft there are several large open-cuts. A mill was installed to treat the ore, but the mechanical arrangements were not as convenient as they might have been and the process used was an experimental one. Possibly this may have been a factor in the failure of the mine.

The country rocks of this group are more varied than those on any other claims examined. Keewatin volcanics form part of the surface rock and a belt of conglomerate extends from Star lake at least as far south as the workings. These rocks are intruded by the granodiorite boss referred to above. Much of the rock on the dump at the shaft seems to be a basic intrusive rock which possibly bordered the granodiorite, the main mass of which outcrops just east of the shaft. A large part of the solid rock northeast of the workings is covered by a sand-plain.

Mineralization occurs at the Penniac in the shear zones in the conglomerate and lavas. Pyrite is apparently the most common mineral. The shaft follows a quartz vein that is fairly constant, but is in places broken into stringers. A quartz vein 8 inches in width is exposed in the face of the northeast drift.

SCHEELITE DEPOSITS

Northwest of Falcon lake, which lies south of Star lake, several claims have been staked for scheelite and some work has been done on them. Development was still in progress when the deposits were visited and since that time a small shipment of the material has been received for treatment at Ottawa at the Mines Branch, Department of Mines.

Most of the work has been done on the Empress claim and the deposits there are typical of the other occurrences. The deposits lie a short distance southeast of the main granite-greenstone contact. The scheelite occurs in a fine-grained, hornblendic rock, fairly massive, but with a roughly sheeted structure. Along the planes of sheeting quartz veinlets 15 to 20 feet in length and ¼ to ½ inch in width have been formed. The scheelite occupies vuggy lenses not associated with the quartz veinlets and not in all cases parallel to the sheeting. It occurs with relatively large amounts of epidote, smaller amounts of calcite, and occasionally garnet. The scheelite is in small white or reddish crystals and the association with calcite makes certain determination of its presence in a hand specimen rather difficult. The lenses which carry the scheelite are irregularly spaced, and usually only 2 to 4 inches in width and only a few inches to a few feet in length. They are probably of contact metamorphic origin and result from the intrusion of the neighbouring granite.

W. B. Timm of the Ore Dressing Laboratory, Mines Branch, Department of Mines, has kindly furnished a report on the milling tests of scheelite-bearing material from this district. The following is an extract from his report:

'*Summary*. The following is a summary of the results of this shipment of scheelite ore:

	Crude Ore	Concentrates	Tailings
Weight in pounds..............	7,921	177	7,744
Analysis WO_3	1·65%	70·63%	0·073%
Content WO_3 in pounds........	130·7	125·01	5·69

Conclusions. By the above test a high-grade tungsten concentrate of grade 70·63 per cent was made with a recovery of 95·7 per cent of the tungsten values in the ore. These results are very satisfactory for a low-grade ore considering the comparatively coarse crushing necessary to obtain the separation.'

As this shipment apparently consisted of cobbed material the return from the mill test is not encouraging."

SILICA DEPOSITS ON BLACK ISLAND, LAKE WINNIPEG

Certain beds of early Palæozoic sandstone on Black island and nearby islands and the shore of lake Winnipeg to the northwest are exceptionally pure and loosely cemented, consequently they are valuable as a source of silica. These deposits were examined recently by L. H. Cole and the following data regarding the silica deposits have been taken from his report.[1] In June, 1929, The Mid-West Glass Company of Winnipeg commenced to use silica, from the deposit on Black island, to manufacture bottle glass. The deposit at present being worked is on the southeast shore of Black island near the northeast end. The sand is loaded in barges and towed to Winnipeg 100 miles to the south. Other similar deposits of silica are exposed on the northeast shore of Punk island, 7 miles northwest of Black island, and on Grindstone and Anderson points on the west shore of lake Winnipeg, 10 and 15 miles, respectively, northwest of Black island.

On Black island the sandstone outcrops in cliffs, in one place 70 feet high, for about 7,000 feet on the southeast shore and 1,200 feet on the northwest shore. The deposit is a part of the Winnipeg sandstone considered to be of Trenton age. Grey, basaltic lavas showing pillow structure outcrop on the north end of Black island, and this horizon must, therefore, be near the base of the Palæozoic as developed at this locality. The beds appear to dip slightly southwest and to be thicker in that direction. In places the sand is pure white; other beds at some localities are iron-stained giving reddish brown to deep chocolate-coloured bands. The different coloured sands grade into each other. One deep chocolate bed, however,

[1] "Silica in Canada, Part II, Western Canada"; Mines Branch, Dept. of Mines, Canada, Rept. 688 (1928).

is of definite outline and is also considerably harder than the rest of the beds. The following two representative sections of the deposit are given by Mr. Cole:

Section in descending order, northeast end of deposit.

	Feet
Sandy loam and sand (Recent)	27
Blue, sandy clay	3
White sandstone with few iron stains	25
Golden brown, iron-stained, soft sandstone, lake-level	5
	60

Section in descending order, 500 feet south of foregoing locality.

	Feet
Fine-grained, angular, yellowish, quartz sand, with ocasional grains of tourmaline and feldspar	18
Smooth brown clay, highly plastic in thin beds or layers in sand	1
Fine-grained sand, same as top 18 feet	6
Clayey silt	1
Sandy, blue clay, becoming stiffer at depth with small pebbles of white sandstone embedded in it	3
White sandstone with occasional iron stains	30
Lake-level	59

The quartz grains of the white beds of commercial value are fairly well rounded and only loosely bonded. The sand can easily be shovelled, but it is hard enough to prevent vertical faces from slumping for some time, and for this reason the face has to be broken down to form a talus to load on the barges by means of scrapers. Where iron is present, it seems to be a stain on the grains or in the bonding material, as no iron-bearing minerals have been found included in the sand grains. In fact, very few grains of other minerals appear to be present in the sand. The following chemical analyses of representative samples of the sand indicate its high purity.

	Per cent	Per cent
SiO_2	95·52	97·48
Fe_2O_3	0·192	0·096
Al_2O_3	2·20	1·36
CaO	0·27	0·14
MgO	0·16	0·10
Loss on ignition	0·91	0·53
	99·25	99·71

The results of a number of screening, washing, and other tests of the sand are tabulated in Mr. Cole's report wherein it is concluded that the sand is of good quality and that the development of the deposit should not be a great problem. The other deposits to the northwest are similar in their general features to the deposit described above and a summary of a few tests of material from these deposits is also given in Mr. Cole's report.

CLAY DEPOSITS ON PUNK ISLAND, LAKE WINNIPEG

A deposit of kaolin has been reported, for a number of years, to occur on Punk island, lake Winnipeg. In the late autumn of 1922 this island was visited, but at that time the water-level of the lake was high and the white kaolin clays were not found. Other deposits of clay, however, were examined, and a report on these was published.[1] Mr. L. H. Cole visited this locality during the summer of 1926, at a time when the water-level of lake Winnipeg was low, and a deposit of kaolin-like clay was found and studied in some detail.[2] This deposit is on the north end of Punk island. At this locality greenish grey schists of Precambrian age are exposed at a time of low water of the lake. The rocks exposed above water-level are early Palæozoic sandstone, shale, and a few beds of limestone. Two main types of clay were recognized between the Precambrian and Palæozoic strata. The upper of these clays is white when dried and the lower is green. The contact between white and green clay is not sharp. The green clay contains lumps of greenish rock and this clay passes downward gradually into schistose bedrock. It is concluded that the white and green clays were formed in situ by an alteration of the Precambrian schist, the green clay being an intermediate stage between the schist and the white clay. In this respect, therefore, this deposit resembles a deposit of kaolinized syenite in a depression on Mattagami river, northern Ontario.[3] The clays on the Mattagami are of pre-Glacial age, and in all probability the clays on Punk island, lake Winnipeg, are also pre-Glacial, perhaps they represent a part of a regolith of early Palæozoic age. Brownish blue, stoneless clay, regarded by Mr. Cole as probably of Pleistocene age, outcrops in this area, and near the southwest end of the island soft clays are interbedded with the early Palæozoic strata.

Following are four chemical analyses of the clays as given in Mr. Cole's report:

—	I	II	III	IV
SiO_2	65·60	63·30	54·57	58·06
Fe_2O_3 (total iron)	0·97	1·08	6·07	6·02
Al_2O_3	23·93	24·76	23·97	20·90
CaO	0·09	Trace	None	None
MgO	0·49	0·89	5·10	6·26
K_2O	n.d.	1·33	n.d.	n.d.
Na_2O	n.d.	0·19	n.d.	n.d.
Loss on ignition	8·79	8·56	9·99	8·63
Total	99·87	100·11	99·70	99·87

Nos. I and II are of white clay.
Nos. III and IV are of green clay, in all cases unwashed material being used for analyses.

It is concluded that the chemical analyses of the white clays indicate that they are kaolins, also their fusibility (3101°F.) is near that of kaolin. This white clay is suitable for the manufacture of products requiring kaolin. The areal extent, so far as is known, of the deposit is small; in no place

[1] Geol. Surv., Canada, Sum. Rept. 1922, pt. C, pp. 76-79.

[2] Cole, L. H., and McMahon, J. F.: "Kaolin and Associated Clays of Punk Island"; Investigations in Ceramics and Road Materials, Mines Branch, Dept. of Mines, Canada, No. 690, pp. 25-35 (1926).

[3] Cross, J. G.: "Precambrian Rocks and Iron Ore Deposits of Abitibi and Mattagami Rivers"; Ont. Dept. of Mines, vol. 29, pt. 2, p. 17 (1920), and

Keele, Joseph: "Clay and Shale Deposits of the Abitibi and Mattagami Rivers"; Ont. Dept. of Mines, vol. 29, pt. 2, pp. 41-49 (1920).

is the thickness over 40 inches, and it is estimated that the average is nearly a foot. The green clays are not considered to be of economic value in the manufacture of clay products. The bluish grey clays considered to be of Palæozoic age are not vitrifying clays, and the greenish clays have practically no vitrification range. Both these types of clays may be of value in the future, the former for the manufacture of hard structural wares or rough surface face-brick and the latter clays could be used to manufacture building brick.

SERPENTINE AT GOLDEYE LAKE

Basic rocks carrying short fibres of asbestos have been known for some time in the vicinity of Goldeye lake. Recently these occurrences were investigated by Manitoba Marble Company, and in the summer of 1929 this company opened up one of the masses of basic rock as a source of serpentine for an interior decorating stone. The deposit is east of Goldeye lake, 2 miles from the mouth of Wanipigow river, in the northern part of township 25, range 9, east of the principal meridian. At a time of high water, fairly large barges and tugs can run from the wharf on Goldeye lake to Winnipeg, 105 miles to the south. A tramline, approximately 2,200 feet long, has been built from the wharf to the quarry.

The bedrock exposed in the vicinity of the deposit is serpentine, amphibole peridotite, and coarse-grained syenite and granite. Across the drift depression from ½ to 1 mile north of the serpentine, ridges of granite with included blocks of basic rock outcrop over a considerable area to the north. Granite also outcrops along the east shore of Goldeye lake southwest of the deposit. The contact of the granitic rocks with the black, basic rocks is not exposed in the vicinity. The syenitic rock outcropping south of the ridge of basic rock west of the deposit is coarse grained and contains many small bits of basic rock of similar appearance to that outcropping to the north. In thin section the grey, acidic rock has the mineral composition of a syenite or syenodiorite, the essential minerals being oligoclase, orthoclase, hornblende, and small amounts of quartz. The minerals are slightly altered, the orthoclase to kaolinite, the oligoclase to calcite, zoisite, chloritic material, and white mica, and the hornblende to uralite and chlorite. In contrast with this comparatively unaltered rock, the minerals of the basic rock 200 feet to the north are for the most part altered to secondary products, and this altered rock also carries considerable more quartz than the granitic-appearing rock. Some of the quartz is clear and has the appearance of vein quartz. Considerable areas of the secondary minerals have a bluish interference colour and probably represent a variety of serpentine. The feldspar is untwinned and apparently is albite. Calcite, zoisite, magnetite, leucoxene, and chlorite are fairly abundant. Except for the abundance of quartz the thin section of this rock is similar in appearance to those of the amphibole peridotite outcropping in Oiseau and Beresford-Rice Lakes areas. A few small seams of asbestos up to one-quarter inch wide cross the black basic rock at the east end of the outcrop south of the tramline from the serpentine quarry to the lake.

Serpentine is exposed in two places, namely, at the quarry and in a cut along the tramline to the west. The serpentine in the cut is a pale apple-green rock. It is weathered brownish for a foot beneath the glacial drift, which is also about a foot thick at this place. In thin section the green serpentine shows an irregular pattern of areas of muddy-appearing material crossed in every direction by seams of serpentine with the fibres oriented in some cases at right angles to the walls of the veinlet. A few bits of carbonate and epidote are the other minerals recognizable in the thin section. No evidence was noted of the outline of the original minerals of this rock.

The serpentine exposed in the quarry is bluish and greyish in colour, the grey variety being developed at the north side of the quarry. The rock beneath the glacial drift is weathered, to an average depth of 3 feet, to a rusty-coloured material, which shows horizontal joints, giving this material a bedded appearance. In thin section the bluish rock is composed of plates and fibres of colourless serpentine, with flakes and needles of a colourless, amphibole-like mineral. Some of the serpentine shows a mesh structure and magnetite is distributed along cracks that may be original cracks and cleavage directions of olivine. Chlorite and carbonate are present in the blue serpentine. In the grey serpentine, the fibrous serpentine is arranged in streaks with the longer axes of the plates and fibres parallel, and in this rock carbonate is abundant in bands and lenses parallel the streaks of serpentine. Some of the carbonate is calcite, as the grey carbonate locally effervesces under cold hydrochloric acid. Considerable magnetite and some ilmenite are present in small grains and crystals in the grey serpentine. Some of the grey serpentine breaks along smooth, irregular-outlined surfaces, perhaps representing planes of schistosity. Both the blue and grey serpentine are crossed by many joint planes. The joints strike in various directions and some are continuous only a few feet, others are more persistent, and the walls of some joint planes are slickensided. A prominent set strikes south 45 degrees west and dips 65 degrees southeast. Other prominent joints trend east, south 35 degrees east, and south 25 degrees west. Though fairly large blocks of serpentine are free of major joints, polished surfaces of slabs of the apparently unfractured rock are crossed by cracks of irregular trend, along some of which are veinlets of carbonate. The serpentine near some of the wider carbonate veinlets is a lighter green than the adjoining material, and the irregular pattern of the veinlets of white carbonate bordered by a fringe of light green serpentine gives a striking pattern to polished surfaces of the rock. The stone cannot be quarried by blasting on account of the fractured character of the rock. Some of the grey serpentine appeared to be a good grade soapstone.

In September, 1929, the main quarry was 110 feet long, 80 feet wide, and about 10 feet in average depth. The quarry is near the top of a low ridge sloping north and here the overburden of drift was only about 2 feet and the mantle of rusty weathered serpentine about 3 feet in thickness. The quarry had been opened by blasting methods, though near the end of the summer of 1929 the company had purchased machinery for sawing the stone. No rock is exposed for at least one-half mile south of the quarry.

To the west, serpentine may be continuous between the quarry and the exposure of green serpentine in the cut along the tramline, 900 feet to the west. The serpentine body undoubtedly is a part of a mass of basic intrusive rock, very probably ranging in mineral composition from a dunite to a peridotite. This intrusive mass is older than the surrounding granite, which, to the west of the deposit is a dark basic type that may have resulted through reactions of the granite magma and the older basic rocks. The serpentine body is similar in its general character and origin to serpentine deposits in Vermont, some of which have been quarried intermittently for about seventy-five years.[1]

Serpentine is a complex magnesium silicate, containing about 12 per cent water, and is always a secondary mineral resulting from the alteration of magnesium-rich silicates such as olivine, and some pyroxenes and amphiboles. The characteristic colour is green, though serpentine rock always contains some impurities, such as iron, and the different colours of the stone depend upon the quantity of such substances. This is a variable factor from point to point within the mass, depending on the variation in mineral content of the original rock, thus the different colours of the stone may be intermingled to give attractive patterns. In some of the Manitoba serpentine, various tints of green, blue, and grey are intermixed, and this, combined with the irregular markings of white carbonate veins and joints, makes a particularly attractive polished surface. The alteration of the magnesium silicates is brought about by the addition of water, although the exact nature of the process is not fully understood. Some authors believe that the serpentine was formed by ascending waters and soon after the basic rock consolidated.[2] The solutions that altered the Manitoba body of dunite and peridotite to serpentine may have ascended from the magma that consolidated to form the granitic rocks of the surrounding area. Some serpentine bodies are known to extend to depths of 2,000 or 3,000 feet. The size of the Manitoba deposit, therefore, depends upon the extent of the body of original rock carrying magnesian-rich minerals, and whether or not the alteration of the rock to serpentine is widespread or local. No definite information is available regarding these features, as bedrock is not exposed immediately surrounding the deposit, and no work has been done to expose the extent of the mass.

Serpentine,[3] apparently similar to that at Goldeye lake, also outcrops on a group of islands, known as the Pipestone Island group, near the east shore of lake Winnipeg, 15 miles northwest of Goldeye lake. Pipestone island and its body of serpentine are described by Dowling as follows:

"Pipestone island is small and partly wooded. At the northwest end are abrupt cliffs 15 feet high, whereas at the southeast end the shore slopes to near water-level. The middle of the island is about 25 feet high. The northwest side is composed of bluish, moderately thin-bedded serpentine, through which run a number of veins of fibrous serpentine mixed with magnetic iron oxide. Some of the veins are almost

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[1] Jacobs, E. C.: "The Talc and Serpentine Deposits of Vermont"; Rept. of the Vermont State Geologist, 1915-16, pp. 246-64, and

Wigglesworth, Edward: "The Serpentines of Vermont"; Rept. of the Vermont State Geologist, pp. 281-291.

[2] Lindgren, Waldemar; "Mineral Deposits"; 3rd ed., 1928, p. 429.

[3] Tyrrell, J. B., and Dowling, D. B.: "East Shore of Lake Winnipeg"; Geol. Surv., Canada, Ann. Rept., N.S., vol. XI, pt. G, p. 54 (1900).

entirely metallic. The east side is composed of a light greenish grey serpentine, some of which is calcareous; that which appears to compose the greater part of the island is much mottled with red. Through it are some veins of calcite and dolomite, or barite."

The rocks on the remaining islands of the group are reported as "massive, dark green, partly decomposed eruptive, ... green, porphyritic gneiss dipping vertically . . . . . light green, porphyritic schist." The massive, dark green eruptive is crossed by a little band of green schist and dolomite. The green gneiss and schist are cut by dykes of granite.

HEMATITE DEPOSIT ON THE SOUTH SIDE OF BLACK ISLAND, LAKE WINNIPEG

A deposit of hematite has been known for many years, on the south shore of Black island about 5½ miles from the southwest end of the island. In 1888 the deposit was explored by the International Mining and Smelting Company of Winnipeg. Some ore was mined and shipped to Winnipeg by sailboat. The workings are caved so that little can be seen regarding the geology of the deposit, as bedrock is exposed only near water-level of the lake. The interior of the island is heavily drift covered.

The deposit was examined in 1888 by J. B. Tyrrell, and the information quoted below is extracted from his report.[1]

The southern part of Black island "is overlain by horizontally stratified sandstone and limestone" of early Palæozoic age. Pillow lava and quartz-sericite and chloritic schists, probably belonging to the Rice Lake series, outcrop at a few localities on the northeast end of the island and on the small, nearby islands. Quartzose sediments of the same series also outcrop on the south shore near the hematite deposit. These latter rocks are described as follows:

"They consist of light green sericitic schists and quartzites, ... which are often externally reddened by oxide of iron. When first met they strike north 15 degrees east and dip at angles varying from 60 to 75 degrees. These schists outcrop along the shore for a distance of 450 paces, forming generally a rough, irregular beach which slopes gradually into the water."

The hematite deposit is near the northeast end of this exposure where the section of rocks is described as follows:

"The hematite is underlain at the water's edge by a green, quartzitic schist, and is overlain by a greenish white, argillaceous breccia from 1 to 2 feet in thickness. Overlying this is a mixture of quartzite (or infiltrated quartz) and rather hard green schist, containing a considerable quantity of hematite. This quartzose band is again overlain by light green, argillaceous or sericitic schists, very much crumpled, but generally dipping at an angle of 60 degrees and striking on the west side of the ore north 50 degrees east. Beyond this is 12 feet of light green, soft, sericitic schist, and this in turn runs into the harder and more quartzitic schists, which comprise the rest of the whole exposure . . . . . (of bedrock) along this part of the shore."

The main exposure of hematite is in the face of a cliff rising above and behind the sloping beach.

"This cliff is found to consist in the centre of a mass of hematite, which extends along the shore for a distance of 100 paces and rises to the height of 7 feet above the water. As shown in sections running back from the shore, it dips away from the

[1] Geol. Surv., Canada, Ann. Rept., vol. IV, N.S., pt. A, pp. 16-18 (1891).

lake at an angle of 30 degrees, and in the vicinity of the mass of ore the bedding of the schist is almost entirely obliterated.

The ore is a more or less pure hematite, not very compact on any of the exposed surfaces, and with numerous little seams and particles of crystalline calcite scattered throughout the mass, along with which are a number of small lenticules and crystals of quartz. In some places, especially near the outside of the mass, the hematite assumes quite a pisolitic or botryoidal structure, the spherules being often arranged in very well defined rows, the interspaces of which are filled with calcite.

Towards the outside of the mass in places the ore has been converted for from a few inches to a foot into an hydrated oxide of iron or limonite."

The available analyses of the hemotite,

"show an amount of metallic iron ranging from 53·99 per cent downwards. None was found to contain more than a trace of phosphorus. One specimen gave on analysis 2·026 per cent sulphur, the sulphur being present in the ore as finely disseminated iron pyrites; three other specimens show, respectively, 0·07, 0·12, and 0·032 per cent of this impurity. No iron pyrites was seen in the general run of the ore, but indications of decayed nodules could be traced in a very few places as yellow incrustations on the surface of the rock, and two or three small nodules were seen lying loose at the bottom of the cliff.

. . . . . The deposit extends for about 300 feet along the shore, ... rises to a height of 7 feet in the centre of the exposure, and dips back from the shore at an angle of 30 degrees."

The strike appears to be about parallel the shore, or north 70 degrees east. If this is the true strike it

"differs very materially from that obtained for the schists at the southwest end of the exposure, but in the immediate vicinity of the ore itself the bedding was entirely obliterated, so that it was impossible to determine in the short time at my disposal whether it was a true bedded deposit, or a lenticular inclusion in the schists."

The hematite deposit on Black island is similar in its general features to deposits of hematite in southeast Ontario.[1] The Ontario deposits have been explored extensively, and are in the Precambrian formations or the younger Palæozoic strata directly overlying the rocks of Precambrian age. Many of the deposits, however, as in the case of the Black Island deposit, are near the present margin of areas of flat-lying Palæozoic strata. The deposits are considered to be oxidation products resulting from pre-Palæozoic weathering of rocks rich in iron-bearing minerals and concentrated in cavities and brecciated and schistose zones extending below the pre-Palæozoic surface. Some hematite was also concentrated along joint planes and cavities in the early Palæozoic strata, the source of the iron of such deposits may have been certain beds of Palæozoic strata carrying a small percentage of iron. All the hematite deposits explored in southeastern Ontario are shallow and pass downward either into brecciated rock carrying only small quantities of hematite or pyrite-rich rock.[2] The pyrite in some of the hematite and the adjoining rock of the Black Island deposit suggests that the hematite may have formed from the weathering of a body of pyrite-

[1] Ingall, E. D.: "Iron Ore Deposits along the Kingston and Pembroke Railway in Eastern Ontario"; Geol. Surv., Canada, 1899, pt. I, pp. 69-80.

[2] Wilson, M. E.: "Arnprior-Quyon and Maniwaki Areas, Ontario and Quebec"; Geol. Surv., Canada, Mem. 136, p. 114 (1924).

bearing schist. If so, the deposit would not be expected to continue in depth over several hundred feet. The vein calcite and specularite[1] in some deposits suggest that the hematite might have been formed by hot, ascending solutions. The localized distribution of the deposits, to areas close to the contact of strata of early Palæozoic and Precambrian age, however, is a strong argument against a hydrothermal origin of the hematite deposits. They are situated where oxidation deposits might be preserved if they were present originally.

[1] "Delta Hematite Deposits"; Geol. Surv., Canada, Sum. Rept. 1920, pt. D, p. 33.

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