CANADA
DEPARTMENT OF MINES

HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

BUREAU OF ECONOMIC GEOLOGY

GEOLOGICAL SURVEY

MEMOIR 180

Mudjatik-Haultain Area, Saskatchewan

BY

F. J. Alcock

OTTAWA
J. O. PATENAUDE, I.S.O.
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1935

Price, 10 cents No. 2393

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CONTENTS

Illustrations

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INTRODUCTION

The area described in the present report lies in the northern part of Saskatchewan. Its southern boundary is the 56th parallel of latitude, or approximately Churchill river for a distance of some 40 miles as the crow flies from the point where it makes its eastward swing on leaving Ile-à-la-Crosse lake. The western boundary is roughly Mudjatik river and the eastern the Haultain, streams that flow southward into the Churchill. The area investigated by ground observations includes some 1,600 square miles and observations from the air extended this to include some 2,000 square miles. The region is one concerning which no geological information was available except some notes of traverses along the two main streams. In 1933 the Mudjatik topographic sheet, prepared from air photographs, was issued. The drainage pattern of the lakes and streams in the part of the map-area between Mudjatik and Haultain rivers suggested the probability that the region might be underlain by sedimentary or volcanic rocks cut by granite masses, conditions that offer favourable prospecting possibilities. The region is also one that lies within easy access of Ile-à-la-Crosse lake where the Provincial Department of Natural Resources maintains a station and to which there is ready means of communication and access. It was felt, therefore, that this was a region that should be investigated geologically. The Provincial Department of Natural Resources requested the assistance of the Federal Department of Mines in carrying out such an exploration, and a plan of co-operation was worked out. The Federal Government agreed to supply a geologist to take charge, geological assistants, their expenses to and from the end of steel, wages of a cook, and all surveying and camp equipment. The Provincial Department in turn supplied a " Vedette " flying boat and a pilot, a camp helper, all transportation from end of steel to the field of operations and return to end of steel, one collapsible and two freight canoes, and all provisions while the party was in camp.

The writer wishes to express his appreciation to the officers of the Department of Natural Resources, who did everything in their power to facilitate the work. He would like to mention particularly Major John Barnett, Deputy Minister, who was largely responsible for the undertaking of the exploration and who took a keen interest in it. The pilot of the "Vedette," Mr. G. C. Upson, performed his services in a most satisfactory way. Geological assistance was rendered efficiently by A. R. Byers and C. A. L. Hogg. Two other members of the party, Alexander Sutherland and Oscar Brownfield, contributed greatly to the success of the work.

ACCESS

The area is reached from Prince Albert either by way of Big river or Meadow lake. The route from end of steel at Big river is the older and the one by which most of the freight for the Lake Ile-à-la-Crosse region is taken in. It follows along Cowan lake and down Cowan and Beaver rivers to Ile-à-la-Crosse lake. The route from Meadow Lake was the one, however, used by the party. A truck road leads from Meadow Lake to Green Lake settlement and from there a poorer road can be followed to Doré on Beaver river below the Grand rapids of the Beaver. At Doré the party was met by the Provincial Department's motorboat, which operates on Ile-à-la-Crosse lake, and taken to Wapache Wunak, at the north end of the lake, where there is a Hudson's Bay Company post. This post was used as a base for supplies and gasoline.

From Wapache Wunak the party proceeded by canoe down Churchill river to Dipper lake, an expansion of that stream, and thence over a portage route north to Studer lake. From here portage routes were found throughout the region, and in September the party returned to Wapache Wunak by descending the Mudjatik from Porter lake.

PREVIOUS WORK

In 1892, J. B. Tyrrell of the Geological Survey ascended Mudjatik river in his exploration journey from Prince Albert to lake Athabaska. His route was by way of Green lake, Beaver river, Ile-à-la-Crosse lake, Mudjatik and Gwillim rivers, Cree lake, Cree river, and Black lake. His report on the country between lake Athabaska and Churchill river, Geological Survey publication No. 601, gives a description of the country passed through and the rock outcrops observed along the way.

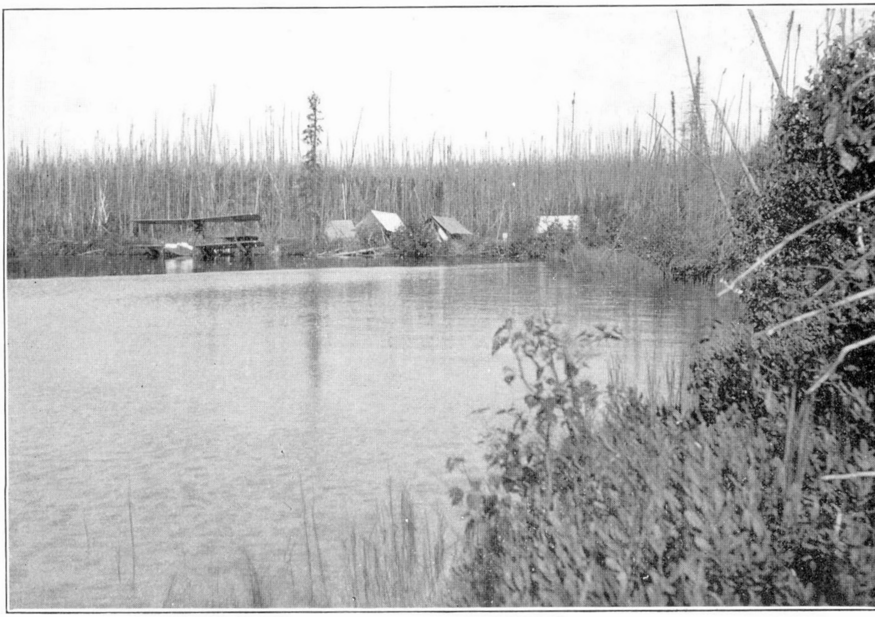
In 1931, Professor J. B. Mawdsley of the University of Saskatchewan was employed by the Provincial Government to investigate the mineral possibilities of the northern part of the province. One of his traverses was along Haultain river, a description of which is given in his mimeographed report to the Government.

POPULATION AND INDUSTRIES

The only industry of the region is trapping. A few white trappers cover the country around Porter lake. The Indians who have travelled the area are Chipewyans, who trade and come to religious service and for treaty to Wapache Wunak. They spend the summer partly at or near this post and partly along Churchill river in Dipper Lake region. In the autumn they leave in groups for their winter trapping fields. At present most of them go to Cree lake.

TIMBER

The timber resources of the area are poor. Only locally are there patches of sufficient size even for good cabin purposes. Much of the region has been swept by a succession of fires. Parts of the burnt stretches are marked by standing dead trees and tangled blow downs and others by



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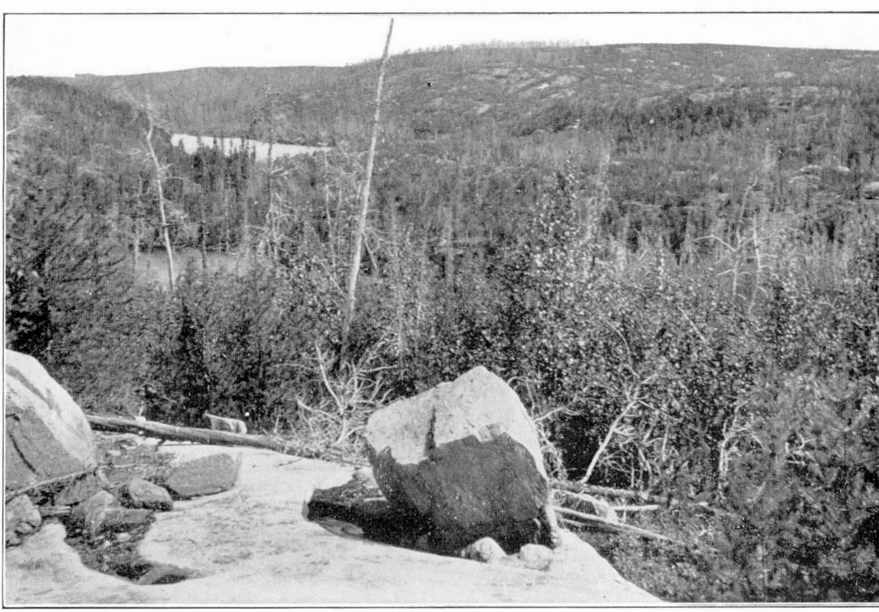
A. Burnt country, Segment lake.



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B. Granite-gneiss ridges east of Dot lake. Typical topography of the region.

second growth in various stages of development. The most abundant tree of the wooded areas is black spruce; few were noted with a diameter at the butt of over a foot. Local patches of white spruce with diameters of 1½ feet occur, as for example on the east bay of Porter lake. The sand-plains support a growth of Banksian pine, some of which reach a diameter of 1½ feet. In the swampy areas a few tamarack are found. Poplar and white birch are abundant among the younger growths, but few of either species have a diameter of over 10 inches. The jackpine-covered sand-plains and the birch groves form the most pleasing varieties of scenery and the best camping grounds in the region.

TOPOGRAPHY

The region lies within the Canadian Shield near its southwest border, the boundary between the Precambrian rocks and the overlapping younger formations to the south being on Ile-à-la-Crosse lake. The topography is typical of that found nearly everywhere throughout the Shield, the two main features being the comparatively low relief and the disorganized character of the drainage. The elevations vary from about 1,300 feet above sea-level, the height of Churchill river at Dipper lake, to about 1,800 feet, the approximate height of the highest ridge summits in the divide country between the Haultain and Mudjatik waters in the central part of the map-area. The local differences of relief are for the most part less than 100 feet, but in places, particularly in the central part of the area, hills and ridges rise to heights of over 200 feet above the level of the immediately adjacent lakes.

In detail the country is made up of hummocky ridges, none of which is continuous, however, for any considerable distance. Between the ridges are depressions, commonly occupied by lakes or muskegs. In places the flanks of the ridges are steep and even precipitous. Typical examples of rock ridges rising abruptly from the lake surfaces are to be seen on Blackstone, Complex, Segment, and numerous other lakes. Along the borders of the map-area, extensive deposits of sand have to a considerable extent smoothed out the irregularities of the topography.

The region is covered with innumerable lakes of all shapes and sizes. Many have very irregular outlines with numerous bays and many islands. In the central part of the map-area rocky shores predominate. The streams are marked by rapid current and are broken by rapids and waterfalls. Some lakes drain by spilling over cliffs.

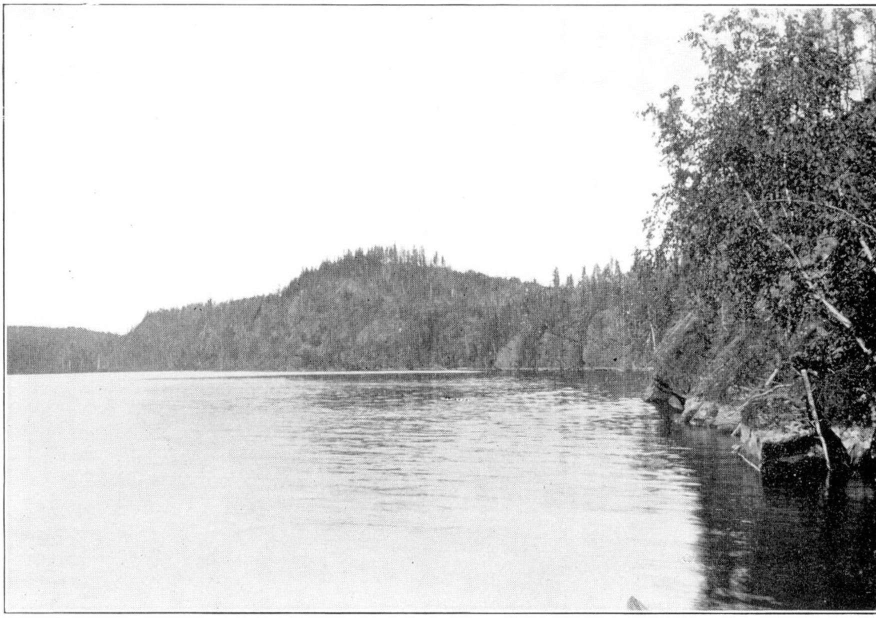
The factors responsible for the peculiarities of topography are: (1) geology and structure; and (2) glaciation. Many of the depressions are along the strike of belts of schistose rocks which are softer and more easily eroded than the granite-gneiss, the most widely exposed rock type of the region. In places the schists are mere fringes along the valley sides and there is commonly an abrupt rise where the granite-gneiss begins. As will be shown later these schistose bands are mere remnants of synclinal masses that escaped erosion when, in pre-Ordovician times, the country was deeply dissected. Evidently the drainage during this dissection became adjusted to rock structure. That this erosion was accomplished very early geologically and was not a result of Pleistocene glaciation is known from the fact that where the surface upon which Ordovician sediments were deposited is exposed, as it is for long distances farther east in northern Manitoba, it shows the same low relief and the same rock types as the present surface. In other words the Ordovician sediments were laid down on a surface of low relief very similar to the present one.

The region shows, however, abundant evidence of having been overridden by huge ice-sheets. The changes produced by this glaciation are partly the result of erosion and partly that of deposition. The hills were rounded and smoothed and rock surfaces were striated, furrowed, and polished. Much of the polished surface has disappeared in Recent times owing to a spalling off of thin layers as a result of temperature changes, but enough has remained to furnish numerous records of the direction of glacial advance. The striation bearings vary from south 30 to south 50 degrees west, with the majority averaging around south 35 degrees west. Erosion by the ice produced a characteristic profile for the hills and ridges, which can be seen to best advantage in small rock islands so numerous in some of the lakes. To the northeast the rock surfaces are smooth and have gentle slopes, evidently the result of heavy scouring, whereas those facing southwest are abrupt and irregular, the result of the tearing off along joint planes of blocks of rock by the ice as it advanced. Ice erosion also deepened certain valleys. In places where the direction of ice movement coincided with that of valleys excavated along structural lines the valleys have developed a fiord-like appearance. Good examples of these are to be seen on Complex lake and the side bays of the northwestward-trending lake immediately to the east of it.

The ice in its retreat left behind much unconsolidated material. Loose boulders or erratics of all shapes and sizes are scattered over the region and some consist of rock types not represented by bedrock exposed within the area. Large boulders of a white conglomeratic quartzite, in particular, are widespread and locally abundant and nowhere does this rock occur in place in the area. Ground morainic material, consisting of boulders, gravel, and boulder clay is scattered in varying amounts over the region. The sand-covered portions along the margins of the sheet represent largely terminal morainic material. These areas consist of sand-plains, locally flat, in other places rolling and marked by depressions probably kettle-holes, and in still other localities by sand ridges extending in a northwest direction. These ridges probably represent halts or even slight readvances of the ice during its general retreat.

The irregular deposition of this material is responsible for the disorganized character of the drainage. Valleys were dammed and lakes produced and these had to seek new outlets. A striking example of a lake produced in this manner is one lying 2 miles northeast of Cup lake, where a northwestward-trending valley is dammed by a sand-plain.

Locally morainal material is piled up in a striking manner along the shores of some of the lakes. The best example observed is on the north shore of the eastern part of the lake lying immediately north of Vedette lake. Here a wall of boulders rises abruptly in places to a height of 4 feet above the water. The cause appears to be ice shoves produced by the



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A. Steep, rocky shores, Blackstone lake.

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B. A typical view on Porter lake.

fracturing and refreezing of the surface ice in Recent times. The wall referred to must have been formed many years ago, for one tree which has grown out in front of it has an age of certainly over fifty years.

TRAVEL ROUTES

The chief canoe route of the region is the Mudjatik, or as it is known locally Deer, river, which forms the main part of the route from Wapache Wunak to Cree lake. It has a steady, swift current which makes it difficult to paddle up, but for canoes provided with outboard motors it is a good stream to travel. For much of its distance it is bordered by sand-plain country through which its course is marked by many meanders. Locally ridges of granite-gneiss approach the channel. A number of rapids and stretches of swift water are formed by the accumulation of boulders. Porter creek, forming the route from the Mudjatik to Porter lake, is a similar good canoe route marked by one rapid where the stream cascades over a low granite-gneiss ridge, and a smaller rapid at the outlet of the lake.

The lower part of Haultain river from opposite Cup lake to the Churchill meanders through a sand-plain country into which the stream has entrenched itself. This section is marked by many cut-offs and oxbow lakes. Higher up the stream is broken by rapids and falls, the rocks exposed, according to Professor Mawdsley, being biotite-granite-gneiss.

The third largest stream in the area is Blackstone river, which flows into the north end of Porter lake. It is a meandering stream flowing through sandy country and like the Mudjatik is easy to descend, but, owing to its swift current, difficult to ascend. Where it enters Porter lake the latter is bordered by a sand beach for a distance of over a mile, back of which lies a large muskeg area.

As already mentioned a canoe route from Dipper lake can be followed up into the area. There are still other routes into the region from the Churchill. One enters by way of Upson lake, a second by way of Airway lake, and still a third by the stream that drains Keller lake.

METHOD OF WORK

The region, as already mentioned, lies within the Mudjatik 4-mile topographic sheet. Copies of the compilation on a scale of 1 mile to an inch were obtained through the courtesy of the Topographical Surveys Branch of the Department of the Interior, and these were used as field maps and for the assembling of the geological information. As a result no surveying was necessary.

In addition to the flying boat the party was equipped with two 18-foot freight canoes, two 16-footers of the pleasure model type, and a collapsible canvas canoe that could be carried in the plane. The help of two Indians from Wapache Wunak was obtained to take the four larger canoes into the area. One of the freight canoes was left on Studer lake and the others taken to Soaring lake over a route marked by several long portages. Geological work was begun here and the Indians were flown back to Wapache Wunak. When the work around Upson, Airway, Keller, and Holt lakes had been completed the party returned to Studer lake, leaving the freight canoe on Soaring lake, from where it was taken out by Indians flown in for that purpose. From Studer lake the party proceeded northward, taking the freight canoe that had been left there, through Segment and Fuller lakes, thence westward to Porter lake, and finally down Porter creek and the Mudjatik to the Churchill.

The method of work was to examine in detail the outcrops along the shores of all the lakes upon which a canoe could be put and to make inland traverses at critical places. With the small canoes it was possible to get to many lakes where there were no regular portage routes. Much of the country was thus covered by side trips of three or four days' duration away from the main camps, made by members of the party working in pairs. Certain lakes that could not be reached by canoe routes but were large enough for the flying boat to land upon were examined by means of the collapsible canoe.

Having a plane with the party all summer greatly facilitated the work in many ways. By means of a small portable radio set which it carried and which was capable of both sending and receiving messages the party was in daily communication with Ile-à-la-Crosse station and more provisions and gasoline could be ordered when necessary. Having a plane at the disposal of the party also permitted the latter to travel with much smaller amounts of supplies than would otherwise have been the case, a very important consideration when so much portaging was necessary. In moving camp the plane was also of great assistance. A preliminary flight was usually made to choose the next campsite and to pick out routes of travel for the canoes. Then, as a rule, three trips of the flying boat transported most of the outfit, allowing the canoes to travel so light that only one or two trips on the portages were necessary. Still another and a most important use was in the mapping of the rock formations. After having examined the outcrops along the lakes of a section of the area the divide country was observed from the air. In many places where outcrops of granite-gneiss lined the shores and burnt hills of similar rocks filled the country between, large areas were quickly covered. In places where geological contacts of the granite-gneisses with older rocks were located from shore work, it was found possible to project these contacts inland by observations from the air. Local bands of dark rock could be seen to pinch out between masses of reddish, granitic rocks. The air observations were, therefore, a great aid in extending and supplementing ground observations.

GENERAL GEOLOGY

The rocks of the area belong to three groups. The oldest of these is a complex of sediments consisting of paragneisses and schists, quartzites, argillites, and local bands of limestone. Intrusive into these is a second group consisting of basic igneous rocks, now altered to a considerable extent into hornblende-bearing types. Locally the sediments are so intimately injected with this intrusive material that the mapping of the two groups has to be done on a percentage basis. The third group consists of granites and granite-gneisses with their associated syenitic, aplitic, and pegmatitic phases, which are intrusive into both of the first two groups.

This last group covers considerably over 90 per cent of the region. Included with the intrusive material are gneisses which may have resulted from the granitization of sediments which, had they been less altered, would have been mapped with group one.

SEDIMENTARY COMPLEX

The sedimentary rocks resemble those that farther east in Manitoba have been described under the term Wekusko series, but whether they are equivalent in age to that series is not known. In Mudjatik area these strata form narrow bands commonly occurring as fringes along the depressions. In places along some of the lakes these patches have widths of only a few feet and, as has been mentioned, there is often an abrupt rise from their surface to higher country underlain by the granite-gneisses.

The most abundant rock types of this group are dark biotite schists and gneisses, commonly garnetiferous. These are interbanded with, and grade into, quartzitic and argillitic varieties in which original bedding planes can readily be distinguished. Locally, zones of limestone, partly altered to secondary silicates, also occur. One such zone outcrops on four small islands in the south part of Keller lake to the east of the large island. This band has a width of about 100 feet and strikes about north and south. The bedding is well brought out by differential weathering, some layers standing out as much as 1 inch from the adjoining bands. The bands consist of layers of nearly pure limestone, in thickness from one-quarter to one-half inch, alternating with others composed of tremolite and pale green diopside. Some layers consist almost entirely of the latter mineral, a considerable number of crystals having a length of 2 inches and a diameter of 1 inch. A larger belt of similar rock is exposed in the northern part of Flinthead lake, forming part of the peninsula between the east and west bays and a portion of the adjacent northwest shoreline. The rock here is also well banded and the layers are locally highly contorted and drag-folded. Differences in texture and composition are responsible for the banded effect, some layers consisting of nearly pure, coarse-grained calcite, whereas others are marked by the presence of secondary silicate crystals, scapolite, tremolite and diopside, and flakes of biotite and graphite. Where the limestone belt comes in contact with the granite-gneiss, it is cut by many small pegmatite dykes and quartz veins. There, also, quartz replaces the limestone and the secondary silicate crystals become larger. In places, especially along the edge of the lake, differential weathering has caused some of the more resistant bands to stand out as much as 4 inches above their neighbours. Locally the rock is completely recrystallized into secondary silicate material. Farther east on Flinthead lake thin bands of limestone are interbedded with metamorphosed clastic sediments and on the west shore of the lake lying immediately east of Keller lake a similar rock association exists.

Of the numerous patches of quartzose sediments scattered throughout the map-area the widest is that lying along Flinthead lake. The dominant variety of rock is a biotite gneiss grading into argillite and quartzite, and, as already mentioned, with a few bands of carbonate-silicate rock. Certain bands are highly garnetiferous individual garnet crystals having a diameter up to $1\frac{1}{2}$ inches. The beds are locally highly contorted and drag-folded, the general strike being, however, northeast, and the dips nearly vertical. The strata are injected by a considerable amount of granitic material, consisting of quartz, pink feldspar, and biotite. In places the igneous part injected parallel to the bedding planes amounts to 50 per cent of the rock. In addition pegmatitic material cuts across the bedding planes. In the northern part of this area the sediments are intruded by a broad band of basic rock which later was folded with them at the time the granites were intruded.

The most persistent belt of sediments is one that extends southwest from Vedette lake to Holt lake, and from there swings northward along a series of lakes lying to the west of Complex lake. Its greatest width is on Holt lake, where at one point it is a mile wide. Between Vedette and Holt lakes the belt is represented by low ridges projecting up through muskeg country and is bordered on either side by higher granitic ridges. The rocks are dominantly biotite gneisses containing garnets, the latter commonly arranged in parallel lines marking original bedding planes. Towards the middle of Holt lake the belt contains white limestone and nearly pure white quartzite bands. On either side this sedimentary belt is bordered by a zone consisting of sediments injected by granitic material in the proportion of about 1 to 1. The part of the belt that swings northwest consists of similar hybrid rock. The sedimentary part locally contains flake graphite, and in places the intrusive material does also.

Locally the dominant rock type of the sedimentary series is a white quartzite containing considerable magnetite. A typical locality is on the north shore of Porter lake half a mile north of where the stream draining Centipede lake enters Porter. The area is underlain dominantly by basic intrusive rocks and is mapped as such, but associated with them are bands of grey quartzose sediments, commonly weathering white. Bedding planes are well marked and locally are contorted into a complicated series of small folds. Parallel to the bedding planes are rows of magnetite crystals, in places forming bands with widths up to half an inch. Local magnetite crystals appear within the quartzite layers and as zones cutting across the bedding. The fact that the magnetite occurs where the sediments are intimately intruded by the basic rocks and, as will be shown later, the latter contain grains and masses of magnetite, suggests that these rocks were the source of the magnetite. A similar association of magnetite-bearing quartzite and basic intrusives is well shown on the east side of Dot lake and at other places throughout the region.

As has already been mentioned in connexion with the rocks northwest of Holt lake, locally mapped in the same colour as the sediments are zones consisting of paragneisses injected by granitic and pegmatitic material in varying degrees of proportion. In most places the injection is of the "lit-par-lit" character and locally a well-banded effect is produced by the alternation of granitic bands with quartzose layers containing abundant biotite and also commonly garnets. In many places this hybrid zone fades out into solid sedimentary material on one side and into granite-gneiss on the other. In other places blocks and masses of this injected material occur in the granite. In addition to the localities already mentioned such rocks are typically shown on the east side of Centipede lake, the north end of Cup lake, and at many other places throughout the region.

BASIC INTRUSIVES

The basic intrusives are commonly associated with the sediments of group one. In places, however, masses and bands occur as inclusions and roof pendants in the granite-gneisses without accompanying sediments. These are apparently remnants of larger masses. The relationship of these rocks to those of groups one and three is everywhere clear and distinct. Where associated with the sediments, they are always intrusive, commonly occurring as narrow injections along the bedding planes, but locally they also cut across the strata and even contain inclusions of the sediments. Where in association with granite or granite-gneiss, the latter are everywhere seen to be of later origin. The acid rocks contain abundant inclusions of all shapes and sizes of the basic types and send granite and pegmatite dykes and quartz veins across them. Some of the inclusions have a darker border than the rest of the mass, due to the development of a greater proportion of hornblende near the contact with the granite. Good examples of this are to be seen along the portage route between Segment and Fuller lakes.

A brief description of a few typical localities will serve to illustrate the character and relationships of these basic rocks. One of the best exposures is that already referred to near the inlet of Porter lake. Here several small islands consist of pyroxenite (*See* Plate II B); other adjacent islands are composed of grey garnetiferous paragneisses intruded by similar dark basic rocks, and both these varieties are in turn cut by granite and pegmatite, the dominant rocks of the mainland. The rocks on these islands furnish the freshest basic material observed in the region. They are dark grey to black on the freshly broken surface, but weather to a bronzy appearance. In places they show a distinctly banded effect due to certain zones being more coarsely crystallized than their neighbours. In addition to forming bands, the coarser phases occur as rounded masses and as irregular segregations in the finer grained material. Magnetite grains and masses can, in places, be distinguished with the naked eye and locally, also, a little pyrrhotite. In thin section the dominant mineral present is the monoclinic pyroxene, diallage. In some sections it makes up most of the rock. A second characteristic feature is the abundance of considerable quantities of the green spinel, pleonaste. Olivine in small amounts in some sections, serpentine, pale secondary hornblende, magnetite, chlorite, and a little plagioclase as inclusions in the diallage are also present. To the north of these islands is a small area, already mentioned, underlain by a complex of quartzites, basic intrusives, and granite and pegmatite. The quartzite is injected by the basic rock and is cut by irregular masses of it. In places the pyroxenite grades over into hornblende schist which is cut by pegmatite and quartz veins.

A second locality where the relationships are well shown is on the east side of Dot lake. The sediments and basic rocks are here in about equal proportions. The former consist of grey and rusty, banded paragneisses and quartzites. These grade in places into banded amphibolitic rocks, apparently recrystallized material that was originally sedimentary injected by basic rock. Other zones consist entirely of the basic igneous material. The common variety of this type is a black, massive rock which in thin section is seen to consist of diallage, hornblende, and labradorite feldspar, the three in about equal proportions. Reddish granite dykes cut both the sediments and amphibolitic rocks and where the older complex is in contact with the regional granite the latter contains numerous stoped blocks of both the sediments and the basic intrusives. Farther north the basic rocks of this belt are locally altered into dark green, serpentinized masses.

Serpentinized rock is also shown near the end of the long southwest bay of Blackstone lake. Here a zone of the pre-granite complex varying in width up to 200 feet borders the western shore. In the face of a cliff 30 feet high a section across the strike of a group of banded rocks is exposed. The rocks consist of sediments intruded by dark pyroxenite and both varieties are in turn cut by granite dykes. The basic intrusive for the most part is injected lit-par-lit into the beds, but in some places cuts across the bands. Several of the pyroxenite bands have altered to serpentine in which a few veins of coarse, brittle chrysotile fibre one-sixteenth to one-quarter inch in thickness occur in zones up to 3 feet in length. The serpentine masses are from 1 to 6 inches wide and the wider ones contain as many as six parallel fibre serpentine veinlets. In some places a gradation can be observed between the serpentine and the pyroxenite and original crystal outlines may be seen in the serpentinized material.

One of the largest masses of this basic intrusive is the one already mentioned in connexion with the sediments at the northern end of Cup lake. The rock forms a prominent ridge to the east of the mouth of the stream which enters from Holt lake. The main mass of rock is dark and massive, consisting largely of pyroxene with minor amounts of serpentine and scattered grains of magnetite. An interesting feature is that the border of the intrusion is a well-banded rock consisting of green hornblende and labradorite feldspar. The banded structure is due to the concentration in alternate zones of the two minerals, some consisting almost entirely of hornblende and other bands being composed largely of the feldspar. In places on the weathered surface as many as a dozen well-defined bands can be counted to an inch of width. On the freshly broken surface the colour contrast is less distinct.

GRANITE, GRANITE-GNEISS, PEGMATITE

Granite and granite-gneiss cover much the greater part of the region. They show considerable variation from fairly massive types, through gneissoid varieties, to well-banded granitoid gneisses. In texture they vary from fine grained to coarse and in colour from reddish to grey. In thin section the chief minerals present are seen to be quartz and orthoclase, with usually some albite or oligoclase, and in many sections microcline. Micrographic intergrowths of quartz and feldspar are also present in small amounts in certain sections. Of the ferromagnesian minerals biotite is the most common, but it is commonly accompanied by some green hornblende. Apatite and magnetite are present as accessory minerals.

In a thin section of a reddish biotite granite from Keller lake, typical of the rock of that region, small irregular-shaped masses consisting of intergrowths of epidote and clinozoisite were found. Their presence may be due to the assimilation by the granite of calcareous sediments, remnants of which occur in the district. Evidence that assimilation of basic eruptive material has also been effected by the granite can be found on the portage route between Segment and Fuller lakes. On the west side of the first small lake proceeding in a north direction along this route, a well-banded gneiss is seen to contain numerous inclusions of amphibolite. The gneiss is darker in colour than most of the granite-gneiss of the region. In thin section it is observed to consist of andesine feldspar of a composition 40 per cent anorthite, diallage, brown biotite, and quartz with accessory magnetite and apatite. The rock has the composition of a quartz diorite, but it is clearly related to the granitic intrusives. Similar relationships are to be seen on the west shore of the southern part of Porter lake where the regional granite intrudes a narrow band of basic eruptive rock. The granite holds inclusions of the basic rock, some of which are partly absorbed, and in such places the surrounding post rock is more basic than the regional granite.

Pegmatites in the form of dykes and small lenses are common differentiates of the granite, all gradations existing from pegmatitic granite to coarse-textured forms. In places the coarse-grained material fades out into normal granite. The dykes are most abundant along contact zones where the sedimentary gneisses are intruded by granite. Some of the dykes have widths up to 60 feet. They consist of orthoclase, either white or pink, microcline, quartz, and locally minor amounts of biotite. In places they show a banded structure due to the parallel arrangement of the biotite crystals. Locally they contain inclusions of the sedimentary and amphibolitic rocks. In no place was the material seen to be sufficiently free from quartz and biotite to be used as a source of feldspar.

As has already been mentioned in connexion with the sedimentary gneisses, many of the contact zones between the sediments and the granites consist of an intimate complex of sediments injected by the intrusive material. In places it was necessary to map these on a percentage basis, where dominantly sedimentary the complex being mapped as sedimentary and where dominantly igneous as granite-gneiss. It is possible that some of the material mapped with the granites may really be granitized sediments. Certain localities where the strike of the foliation is very uniform suggest this and in places also granitic rocks were found to contain numerous, small, red, garnet crystals. That most of even the well-banded granite-gneisses are of intrusive origin, however, is shown by the presence of numerous inclusions of the amphibolitic and paragneissic rocks, some of which occur in extremely well-banded granite-gneisses.

STRUCTURE

To the east of Mudjatik area, in the region covered by the Foster Lake and Lac-La-Ronge sheets, the dominant structure is along northeast lines. This is well brought out by the drainage pattern, most of the lakes and islands showing a remarkable parallel arrangement in that direction. In Mudjatik area northeast structures are also locally pronounced, as for example along Complex and Blackstone lakes, but, as has already been mentioned, the most striking feature is that the structural lines locally take broad curves. The southern part of Holt lake, the northern part of Airway, the southern part of Blackstone, the lake connecting Studer and Segment lakes, lie in curving valleys that are controlled by structure. In each case patches of sediments border the lake and the gneissoid banding of the adjacent granite-gneisses parallels the structural planes of the altered sediments. There seeems but little doubt that these sedimentary zones are remnants of synclinal belts caught between rising masses of granite, and that their narrow widths are due to the deep dissection to which the country was subjected in late pre-Ordovician times. Evidently in this region the floors of the synclinal troughs were rolling and as a result deep erosion to the base of the synclines has brought out curving patterns.

An interesting feature in the region is the presence of linear depressions in the areas underlain by granite-gneiss. Some of these are revealed on the map by the drainage pattern; others were observed from the air or encountered on land traverses. Many have narrow bottoms occupied by muskeg and are bordered by abrupt rock walls. The prevailing trend is northwest. They are believed to represent tension fractures or large scale joints and some have developed into valleys owing to streams having adjusted their courses to them. The most persistent valley of this type runs northwest and southeast from near the north end of Holt lake.

SUMMARY OF GEOLOGICAL HISTORY

The geological history of the region is represented in the diagrams (Figure 1). The earliest event of which there is record is the accumulation of a series of sediments consisting of sandstone, shales, and limestone (A). The floor upon which these were deposited is not known. Wherever they are found in contact with other rocks the latter are always intrusive and, therefore, of younger age. The second event (B) is the intrusion of a series of basic rocks which arose from unknown depths and were injected chiefly along the bedding planes of the sedimentary series. They brought with them a certain amount of magnetite and pyrrohotite, but on the whole deformed the sediments but little and produced only a slight amount of mineralization. The third event and the most important one in the region's history was the intrusion of huge masses or batholiths of granite. This period of intrusion accompanied folding or mountain-building in which the surface rocks were compressed by forces acting along northwest-southeast lines. As the strata were thrown into folds the granite arose in the anticlines. It in part injected and replaced

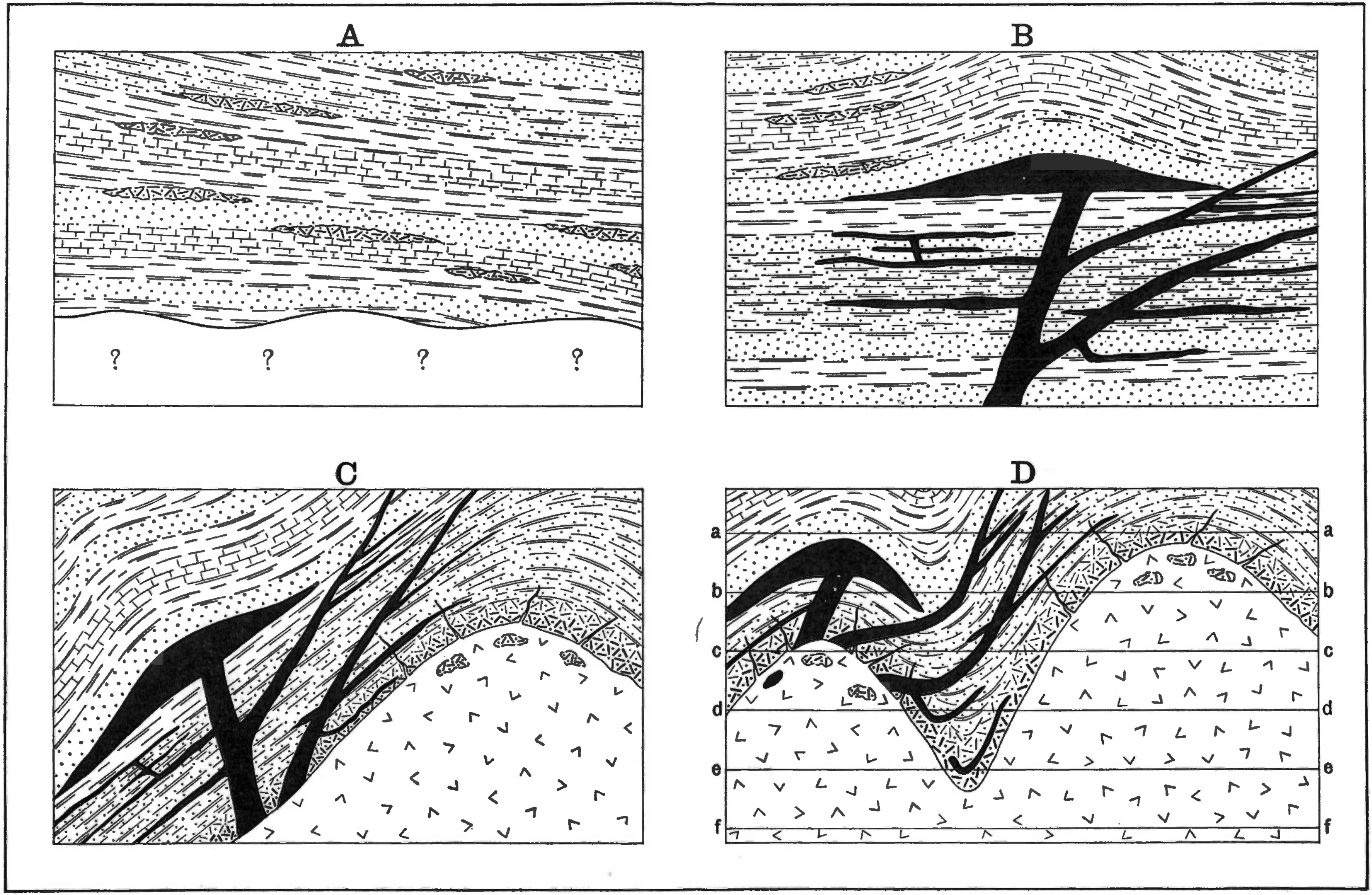

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Figure 1. Diagrams illustrating the geological history of the region.

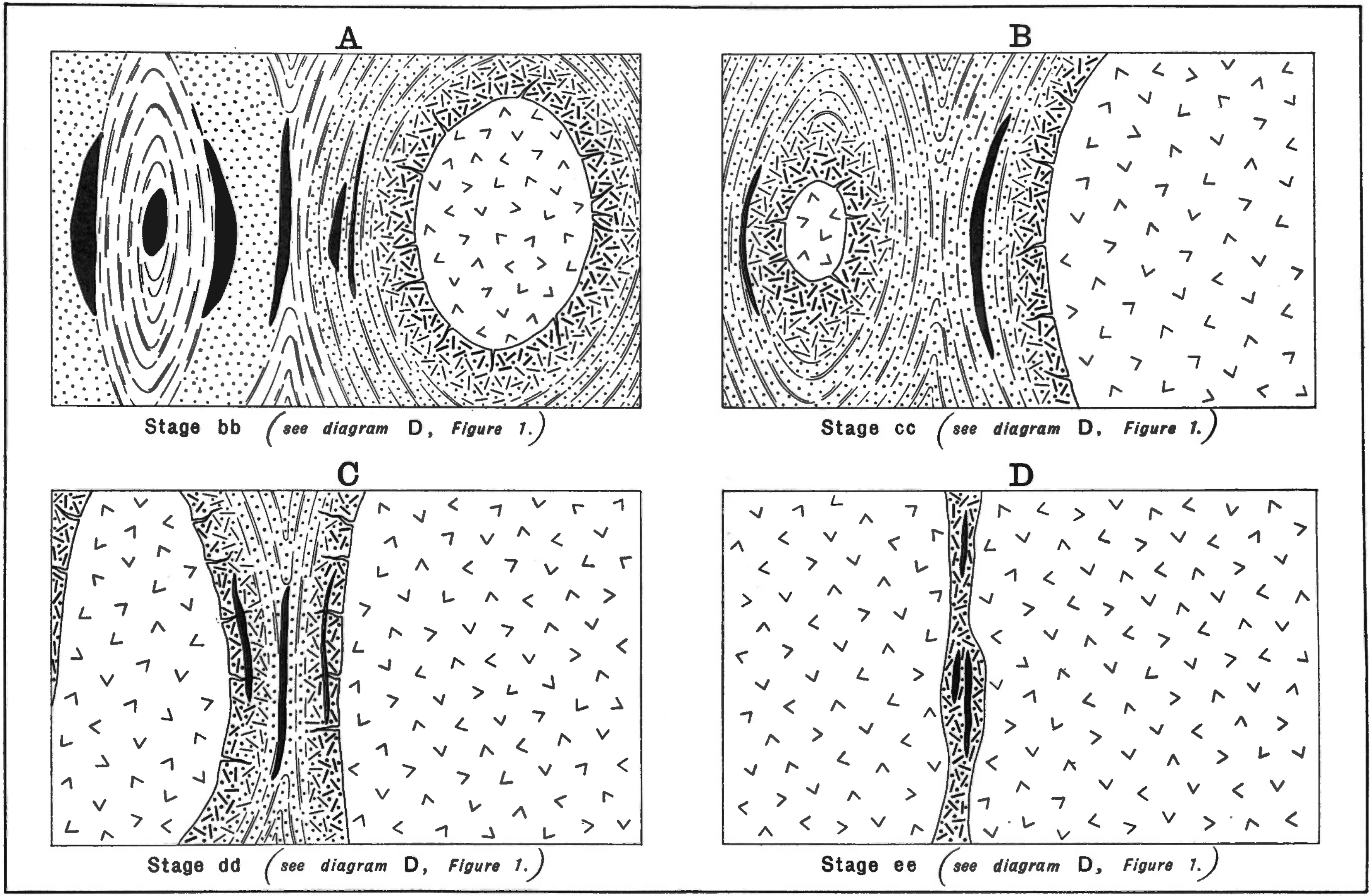

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Figure 2. Diagrams illustrating the geological history of the region.

the sediments at its contacts and in part progressed upward by stoping its way through the overlying rocks. These, owing to the pressure and heat, became altered or metamorphosed, with the development of a new set of minerals. As the granite cooled and solidified the gases or mineralizers it contained became more and more concentrated in the remaining molten part and as crystallization progressed these mineralizing solutions escaped through fractures producing mineral deposits in the surrounding region. Areas around cupolas or chambers at the top of the mass where the mineralizers on rising had become trapped are the places where mineralization would be expected to have been greatest. Diagram (D) shows two such cupolas with ore deposits around them formed by the escaped mineralizers.

The next event was the erosion of the region which continued for millions of years until the mountainous topography was reduced to one of low relief. As denudation continued and the country became progressively lower it passed through stages represented, respectively, by aa, bb, cc, dd, ee, and ff, on diagram D. The diagrams (Figure 2) are geological maps of the region at four of these stages. At stage aa, a geological map of the region would show nothing but sediments and basic intrusive rocks. Stage ff would show nothing but granite. The intermediate stages, bb to ee, show increasing amounts of granite appearing at the surface. The stage at which Mudjatik region is at present corresponds to that of ee, where only narrow remnants of the pre-granite complex lie between broad belts of granite.

It can readily be seen from the diagram, also, which type of country offers the most likely chances of furnishing ore deposits. As already mentioned, mineral zones tend to accumulate around the cupolas. As erosion progresses into the granite mass these upper deposits are removed and carried away with the country rock. Stage bb may be considered ideal prospecting country; stage cc, good; stage dd, only fair; and stage ee, poor. The last cannot be condemned entirely, for there are numerous examples of ore occurrences known in small masses of rock entirely surrounded by intrusive granite, but the prospects in general are much less encouraging than in those areas where the intrusive masses are but slightly incised.

As has already been mentioned this dissection was largely completed in pre-Ordovician times. It is probable that the Ordovician seas swept over the region and that sediments of that age were deposited on the Precambrian rocks. It is probable, too, that younger series of sediments accumulated during later Palæozoic and also during Mesozoic inundations. These strata, however, were eroded away during the Tertiary when once again the land was above the sea suffering denudation. The last important event was the Pleistocene glaciation, to whose effects on smoothing down the topography and disorganizing the drainage reference has already been made.

ECONOMIC GEOLOGY

Mineralization in the region is of two types, quartz veins and sulphide-bearing zones; the former variety is believed to have had its origin in the granitic intrusives; of the sulphides some are related to the basic intrusives and others to the granite. Small quartz veins and stringers are found cutting all the rocks, including the granites. None, however, was seen to carry any valuable minerals. At several places large quartz deposits were observed. One of these situated on the west shore of Studer lake near the south end was staked by Mr. A. Studer in 1933. It forms a low hill, bare except for a few small trees of banksian pine, and shows up as a prominent topographic feature. It lies in a contact zone of quartzose sediments altered by granite-gneiss. Its surface is smoothly glaciated, showing good lee and stoss slopes. The exposure has a length in a north and south direction of 240 feet and a width of 150 feet. The material consists of nearly pure quartz, mostly white and vitreous, but locally showing a pink shade. It contains scattered crystals of feldspar and near the south end of the exposure the border phase passes into a quartzose-pegmatitic granite. No sulphides were observed and an assay of a grab sample yielded no trace of either gold or silver.

A second quartz showing of similar type is found on the shore of a bay on the northwest side of the eastward-extending portion of the south end of Blackstone lake. Like the vein mentioned above it lies in a zone of sediments intruded and altered by granite. The main showing has a length of 200 feet and a width up to 80 feet. Fifteen chains to the north-east on the same strike is a second exposure 50 feet long and 30 feet wide. The material is white, vitreous quartz containing small feldspar crystals anl locally grading at the border into reddish pegmatite. A grab sample yielded negative results for both gold and silver.

Still a third vein of this type occurs at the narrows of the eastward extending lake, situated 4 miles south of Dot lake. It has a length of 230 feet and a width of 50 feet. Across a small bay an exposure of what appears to be a continuation of the vein has a length of 100 feet and a width of 30 feet. Both parts lie in gneiss consisting of sedimentary strata injected with granitic material in about equal proportions. Like the other veins a grab sample yielded on assay no values for either gold or silver.

On the large island in the central part of Fuller lake and on adjacent parts of the mainland two groups of claims have been staked. The claims were evidently laid out to include as much as possible of a band of a basic intrusive that is surrounded by granite. The rock is dark and well banded and is cut by red pegmatite and grey pegmatite. In thin section it is seen to consist of augite, brownish hornblende, bytownite, and magnetite, and hence may be termed a hornblende gabbro. The granite surrounding the belt is coarse and massive and contains inclusions of the gabbro. The latter locally shows rusty patches and these contain pyrrhotite. On the west shore of the island, a rusty zone about 12 feet wide consists of rusty quartz mineralized with pyrrhotite and pyrite. A grab sample of material from this zone was assayed for gold and silver with negative results. A small amount of diamond drilling was done on this showing. It consisted of three holes about 200 feet in total length. They were put in at lake level and apparently at steep angles. The fragments of core left at the locality consist of two types of rock, a black hornblende gabbro consisting of diallage, brown hornblende, basic feldspar and magnetite with a little secondary chlorite, and a fine-grained, even textured, aplitic rock consisting of quartz, orthoclase, albite, and biotite, clearly derived from the adjacent granite. On the other claims on this lake no signs of mineralization were noted.

Another group of claims is situated on the east side of Mudjatik river, 9 miles south of Old Woman rapids by river, or in a straight line $5\frac{3}{4}$ miles, and extends eastward to a small lake $1\frac{1}{2}$ miles from the river. The group consists of seven claims staked by Mr. J. E. Dennis in September and October, 1931. Two old claim posts bearing the letters D.M. and E.M. suggest that the locality had been previously staked years ago.

The rocks in the immediate vicinity of the claims belong to the three groups seen everywhere throughout the region, sediments, basic intrusives, and granite-gneiss. The sediments are represented by loose blocks locally so abundant, however, that it is probable that the underlying bedrock consists of the same material. The chief variety is a fine-grained, thinly bedded quartzite, of a dark grey to almost black colour. Locally where it has been intruded by granite it becomes garnetiferous and where it is injected by basic materials it becomes a dark variety, all gradations existing between the true quartzite and the basic intrusives. Basic rock outcrops immediately south of No. 3 post of the Silver Star claim. The rock shows banding in a southeast direction. The rock consists of diallage and hornblende and contains magnetite as a primary constituent disseminated as small grains within certain bands of the rock. Locally the rock is partly serpentinized. The third rock type is medium to coarse-grained granite-gneiss cut by pegmatite containing large crystals of pink feldspar, hornblende, biotite, and quartz. Small dykes of aplite containing well-developed garnet crystals, evidently differentiates of the granite, intrude the quartzite and the basic rock. Most of these are parallel to the banding, but locally they show crosscutting relationships.

The main outcrop forms part of the crest and northwest side of a long, low hill striking in a northeast direction across the Crow Foot, Silver Lodge, and Blue Bird claims. The rock consists of quartzite injected along its bedding planes by granitic material. The complex has been sheared and faulted along a zone 10 to 20 feet in width which can be followed for 1,000 feet in a northeast direction. The fault plane dips to the southeast at angles of from 80 to 85 degrees, and the direction of movement along it, as indicated by grooves and striations, dips 63 degrees northeast. Numerous tension joints dipping 10 to 25 degrees southeast run off from the main fault in the east side of the shear zone. These and some small drag-folds appear to indicate that the east side of the fault moved down relative to the west side. The amount is unknown. That the shearing is later than one phase of the granite intrusion is shown by the fact that a large pegmatite dyke has been cut off by the fault. The mineralization must, therefore, be related to the very late phases of the intrusion.

The zone has weathered to a rusty colour and in places the gossan due to the leaching out of silica has a depth of from 1 to 3 feet. The minerals in the fresh material are quartz, magnetite, pyrite, and pyrrhotite. The magnetite appears to be of two ages. In places it shows signs of being sheared and was probably introduced into the sediments by the basic intrusives. In other places it is associated with vein quartz and sulphides and appears to have had its origin in the granite. The pyrite and pyrrhotite occur as small veinlets cutting the sheared material, as small round masses with diameters up to 6 inches, and as disseminated crystals in quartz veins. Quartz stringers carrying some sulphides and magnetite occur on either side of the main shear for distances of from 20 to 30 feet. The largest vein occurs on the southeast side of the fault 550 feet south of the Crow Foot No. 1 post. It roughly parallels the fault and dips 20 to 30 degrees southeast, cutting the banding of the injected quartzite. The vein varies in width from 3 to 12 inches and can be traced for 20 feet. It consists of quartz with a slight pinkish tinge with extremely small amounts of sulphides and magnetite.

Numerous, small, shallow pits have been put down in the overburden in an endeavour to trace the main zone of sulphide mineralization. A grab sample of some of the best looking material was collected, an assay of which gave no values for either gold or silver.