THE
INVESTIGATION OF THE PRE-CAMBRIAN
VOLCANIC CENTERS OF THE
FLIN FLON AREA

BY

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CONTENTS

THE INVESTIGATION OF THE PRE-CAMBRIAN VOLCANIC CENTERS IN THE FLIN FLON AREA

INTRODUCTION

The area under discussion in this report comprises a small section in the heart of the Flin Flon Mining District, nearby the town of Flin Flon and the Hudson Bay Mining and Smelting Company. These are located approximately on the Manitoba-Saskatchewan boundary at latitude 54° 45'. Communication is by a branch line of the Canadian National Railway from The Pas, Manitoba, where a Recording Office is located. The Sherritt-Gordon Copper Mine is reached by a spur from this Flin Flon line.

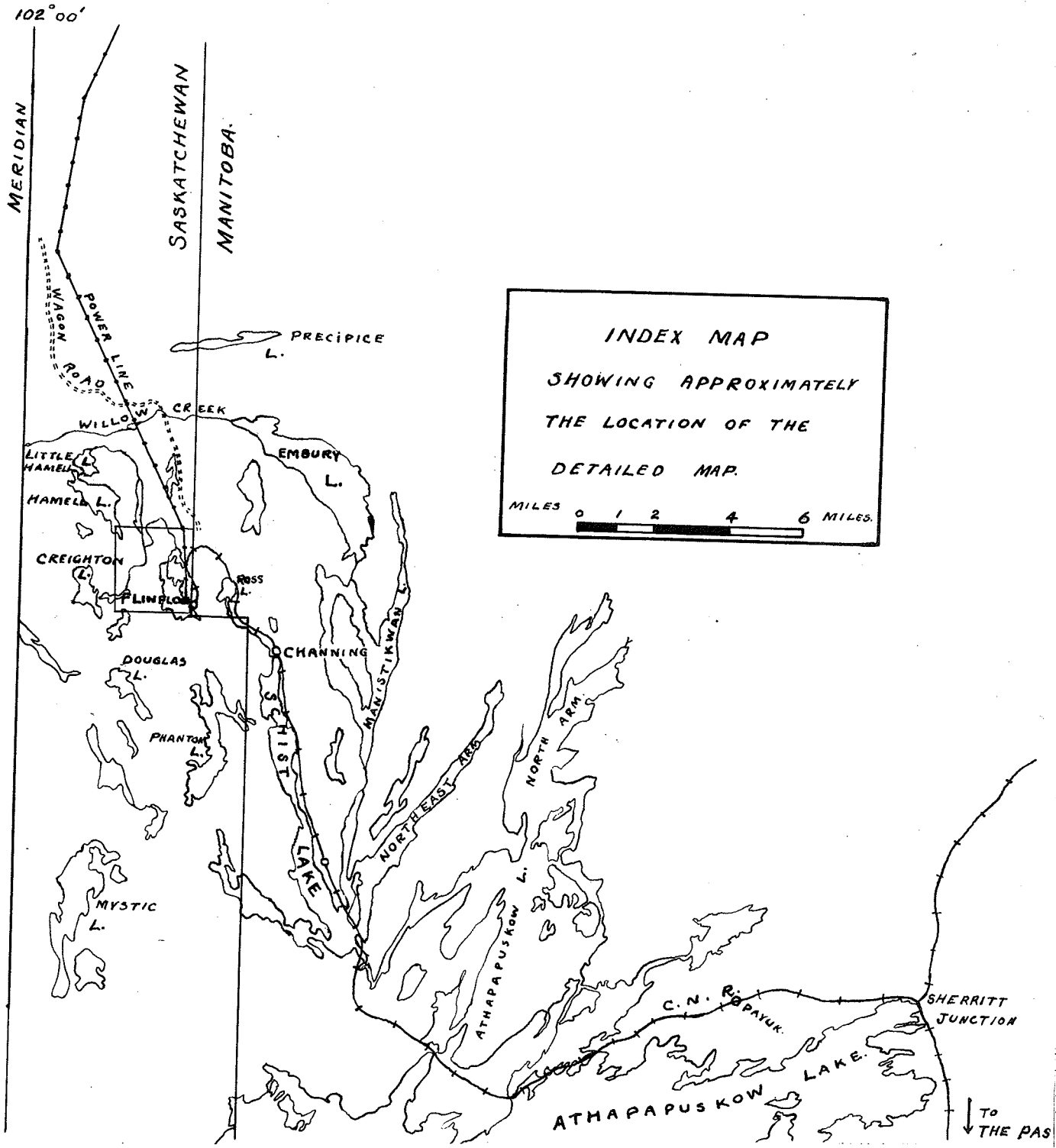
The area of the volcanic centers occurs on the north-west side of Flin Flon Lake and is therefore on the Saskatchewan side of the boundary. This territory has been extensively burnt, thus making detailed geological work possible. From the lake the larger of the volcanic centers, termed the Road Volcanic Center, is clearly visible, standing out above the neighboring formations. This center is reached within a few minutes from Flin Flon Lake, by a portage trail running to a lake further west. Approaching the center this way, it rises up quite abruptly from a low grassy area. Its borders are equally distinct on the west and north, but on the south it interfingers with many types of explosive breccias, tuffs and flows.

The Club Lake Volcanic center lies due north of the Road Volcanic center, and south of Club Lake. Its western border rises up very abruptly but elsewhere it interfingers with explosive materials and flows.

The area of these volcanic centers affords about the most facinating geology that one could conceive. A remarkable amount of data which dovetail to an amazing degree tend to prove that a major granitic in-

trusion reached to within a few hundred feet of the surface and then broke through a series of lavas and sediments to form two or more centers of volcanic activity. About these is a series of explosive breccias, tuffs and flows which in their field relationships and in their lithology are clearly related not only to the necks of the volcanic centers but also to the granitic intrusive.

Younger more basic intrusives lie within the Road Volcanic Center and a second, younger series of explosive breccias, tuffs and flows are similarly related.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CREIGHTON L.
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ROSS L.
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PRE-MISSI COMPLEX

East of the Missi and definitely underlying it is a complex of volcanics and intrusives which have very little bearing on the area described herein and will therefor not be discussed further.

MISSI SERIES

The Missi series in this section occurs in the bottom of a large valley which to the north is occupied by Creighton Creek. The most southerly outcrops on the west side lies just north of where the Creighton granite reaches the valley, and on the east side just opposite this point.

The Missi series here is made up of a basal conglomerate generally badly sheared, a middle division largely quartz-mica schists and quartzite, and an upper division largely conglomerate. The middle division is relatively very soft while the upper and lower divisions are moderately soft. As a consequence these rocks are readily eroded and their presence is responsible for the valley here. The upper conglomerate division forms a ridge along the east side.

South of the last outcrop the valley continues to the Road Volcanic Center in such a manner as to suggest the continuity of the series but no rock readily recognizable as such is to be found. However, along the northern edge and at a few places within, one of which is indicated, are other small masses of a peculiar highly sheared light-grey to white rock which is different from any other in the volcanic center. Much of this is clearly well bedded and made up of grains of quartz. All of it shows irregular rounded quartz grains and some has distinct boulders in it. Furthermore it very closely ressembles definite Missi about a mile to the north which has been altered by a small granitic intrusion, the Club Lake Volcanic Center.

Microscopically the Missi is seen to consist of large rounded to subangular quartz grains in a medium to five grained, siliceous groundmass usually with considerable biotile. Shearing and silicification are evident.

In places the groundmass appears as a dense granular mass suggestive of mylonitization, but which has been definitely traced as due to silicification with only limited accompanying shearing. The feldspars in the groundmass have been the most readily susceptible to this alteration. The larger quartz grains have also been altered or injected with the later quartz so that they sometimes no longer ressemble original units; but show no evidence of mylonitization. Shearing has given rise to considerable sericite probably derived from feldspars and white micas. Biotite partly altered to chlorite is common.

The sediments from immediatly west of the Club Lake Volcanic Center take on a somewhat different appearance as they have been indurated and granitized. Quartz and pyrite have been introduced, epidote and zoisite formed hydrothermally, while biotite and hornblende result from recrystallization of the mafic materials.

Sediments of this type afford evidence as to the original nature of the peculiar inclusions on the Road Volcanic Center. The most important of these inclusions is fine to medium-grained consisting dominantly of quartz, feldspar, sericite, biotite and chlorite. Well formed elongated crystals of zoisite are common and calcite has been extensively introduced. There are a few large rounded units of quartz more or less localized to one band. This same coarse band has been more permeable to the penetration of epidote. The whole structure of this rock is suggestive of a sediment and ressembles the above mentioned granitized and indurated Missi.

Another such remnant occurs in the volcanic center on the north side, where the Missi would occur if projected on down the valley. This rock is medium-fine grained and has abundant large biotite remnants which more or less show a general alignment. There seems to be a band of fine materials between two coarse bands which is suggestive also of a sediment. The rock has been considerably altered by granitic stringers, and these are responsible for some large feldspars being present. Other examples of doubtful rock studied

are most likely of igneous origin.

The evidence points rather conclusively to certain remnants being Missi especially as they are cut by dikes which would account for their alteration and induration. The induration is a common characteristic of the Missi almost in all localities where it is traversed by intrusives. The preservation of the Missi here and not in the stretch immediately to the north resulted from this induration. The absence there is readily explained as being due to glaciation. It is clear that the ice moved down this valley to the south. The constrictions at the south end therefore would account for the relatively greater erosion in this section.

THE FLIN FLON SERIES

The Flin Flon series is distinctly divisible into three parts, a lower and upper one of dark green and gray volcanics, and a middle one of intermixed light gray and dark green volcanics.

The Flin Flon series lies on top of the Missi. The contact for one and a half miles was carefully studied. In this stretch besides curving around in a semi-circle, it shows many minor crenulations. Around the whole length of this including these minor changes in direction, the strike and dip of strata both above and below correspond roughly or exactly with that of the contact. At most crenulations there are minor structures in the volcanics which plunge south. The contact can be seen clearly near the Flux-line railway and along Creighton Creek. In the first locality it curves around in an arc; the beds of both series follow the arc and in the volcanics there is plainly visible a minor syncline plunging south. There is no evidence of a fault here and it is difficult to conceive how a fault could be between the two series. On Creighton Creek the contact is as low as 10° to the east and is irregular. To the south along the trend of the contact, volcanic rocks are well exposed and there is no break in their continuity such as would be necessary if a fault followed the eastern boundary of the Missi.

Further definite confirmation of this is presented in connection with the description of the Road-Volcanic Center and related extrusives. The Flin FLON volcanics in places lie on the upper division of the Missi found in the area under discussion, and farther north rest on a still higher division. In places the volcanics can clearly be seen to truncate the beds in the Missi. In one place the strike of the beds in the two formations are at an angle of 20°. It is concluded that the volcanics in part at least overlie the Missi unconformably.

THE LOWER FLIN FLON DIVISION

To the south of the Road Volcanic Center there are limited areas of a volcanic series which in no way is comparable to the pre-Missi Complex. It is fresher and less gneissic and structurally indicates a close stratigraphical relationship with the overlying rocks. It is not in direct contact with the Missi anywhere but one mile to the north similar volcanics lie on the Missi. Between these areas small patches of similar rock above the Missi, and also in the Road Volcanic Center may be related. These rocks are classified as the Lower division of the Flin Flon series.

Structurally this southern area of volcanics conforms to the Middle division, and if the Missi originally conformed to the sturctures of these two, which is likely since it does to the north, it would necessarily have lain below the Lower division.

The Lower Flin Flon division is made up mainly of massive dark green and gray volcanics which are probably largely lavas. Rarely they are amygdaloidal and show pillow structure. In many places they show rounded phenocrysts of quartz, and some parts are hard and cherty. Frequently phenocrysts of feldspar or knots of this mineral occur. These types except for color are somewhat similar to the rhyolites and quartz porphyries of higher beds.

In the series there are also well bedded tuffs, and some of the massive rock probably represents tuff. Breccias made up of similar green fragments in a green matrix are rare compared to their abundance in higher series.

Only one section from the southern area was studied microscopically. This represented a green lava consisting dominantly of idiomorphous hornblende with some quartz and feldspar, a considerable part of the quartz occurring as veinlets. The rock is a porphyry, the feldspar phenocrysts being partially or completely altered to a fine granular mass of epodite and zoisite. Amygdules, of epidote with a radiating structure, also occur.

Magnetite as an accessory, and calcite in the quartz veinlets, occur sparingly. The composition in per cent is approximately as follows: Quartz and Feldspar--30, Hornblende--60, Epidote and Zoisite less than 10, calcite and magnetite.

Of the sections studied from the northern area, only one was of the greenish type described above. Large feldspar phenocrysts or knots ~~of it~~, which have altered slightly to epidote and are showing breakdown into a granular mass due to silicification, form about fifty-five per cent of the rock. The green masses surrounding the feldspars consist of medium grained closely compacted idiomorphous hornblende, sometimes present to the extent of excluding all other minerals. Interstitially a little quartz and feldspar occur. Within the hornblende areas and entirely apart from the large comparatively unaltered feldspars, are fairly large masses of epidote which most probably represent amygdules. The phenocrysts are oligoclose. The rock closely ressembles that from the southern section, and is added evidence for correlating the two areas, since this type of lava does not occur elsewhere.

An example of a gray lava from this area was also studied. This was porphyritic, the feldspar phenocrysts showing a high degree of saussuritization and only being recognizable by their outline. The groundmass is fine-grained consisting of quartz, chlorite and small patches of altered feldspar. Hornblende phenocrysts form about five per cent of the rock and are of late development forming at the expense of the other mafic minerals and cutting across the earlier flow structure. Calcite has been introduced at a later period. The composition in per cent is approximately: Quartz--40, Saussuritized Feldspar--35, Hornblende-5, Chlorite--15, Calcite, Magnetite and a trace of introduced epidote.

South of the Club Lake Volcanic Center there is an area lying at the base of the Middle division which was believed from field evidence to be a remnant of the Lower Flin Flon.

Under the microscope it is seen to be a rock which is dominantly hornblende and cut by quartz stringers which have brought in considerable calcite. The hornblende occurs as elongated needles and rods, and as idiomorphous crystals. In places it is present to the exclusion of all other minerals. A siliceous groundmass occurs amongst the hornblende but much of it may also be of an introduced nature. Magnetite is an accessory. The character of this rock therefore is the same as the other green lavas of the Lower Flin Flon, although no phenocrysts or amygdules were seen.

CREIGHTON GRANITE

The Creighton Granite as shown on the accompanying map is part of a large area which extends to the north-west, west and south-west for many miles. The part shown here is the most easterly. The granite has not been found in contact with the Missi though if both are continuous to the south, in the area south of where Creighton Creek first flows over the Missi, it is apparent that they must lie in contact for a short stretch. The granite however definitely cuts the Lower Flin Flon volcanics south of the Road Volcanic Center. Since the Missi and Lower Flin Flon are the youngest rocks the granite is in contact with, and since these are not greatly deformed here, it seems logical to conclude that the granite nearby was that part nearest to the surface at the time of intrusion.

The relationship between the granite and the Road Volcanic Center are obscured by a draw which is due to the presence of a relatively young feldspar porphyry dyke of a type which is more readily eroded than most other rocks. Similar material and possibly part of the same dyke follows the base of the Missi to the north for miles. Near the volcanic center it apparently followed the base as far as possible and then continued along the same trend into the adjacent rock.

The Creighton granite throughout the many square mile to the northwest is coarse grained. In many places there are small dykes and it was noted that the texture in these, as along the contact with the country rock, was coarse even in stringers of a few inches at distances several feet from the main mass.

In the south-eastern part the granite takes on quite a different aspect. From a short distance north of Creighton Creek to four thousand feet to the south, in many places along the contact the granite grades to rhyolitic or quartz porphyritic material of a fine to dense texture. Throughout much of the area of the little knob between Creighton Creek, the Missi, and the feldspar porphyry dyke, the granite varies greatly in texture and is maily fine grained. In many places it is a quartz porphyry, elsewhere a feldspar porphyry, and in still other places it shows no phenocrysts. Dykes given off to the south in the Lower Flin Flon volcanics grade sharply from granitic material to rhyolitic or quartz porphyritic material. In the area of the volcanic center and southward for one thousand feet where the granite contact is obscured there are no granitic dykes but there are some of rhyolitic and quartz porphyritic texture. These are most reasonably considered to be related to the Creighton granite.

The foregoing evidence further indicates that this part of the granite must have been closest to the surface, and more strongly suggests that it must have been very close to the surface.

Under the microscope the typical granite is seen to be coarse-grained and very salic, with quartz and feldspar in approximately equal amounts. In all the slides studied orthoclase was the dominant feldspar being about twice as abundant as the other acid feldspars, namely, acid oligoclase, and rarely albite and microcline. The mafic content is largely biotite, considerably altered to chlorite, together forming less than ten per cent.

All the sections showed clear evidence of silicification, and frequently were cut by quartz stringers. Epidote is present in some representing a hydrothermal alteration of the feldspars. This epidote is sometimes well developed occurring as fairly large masses. In the finer grained phases of the granite, representing the chilled contact, the epidote is quite disseminated occurring with the ferromangnesians as well as the feldspars. In the coarse granite the large feldspars apparently formed ready paths for the hydrothermal solutions so that the epidote occurs entirely within these minerals. There is also abundant evidence of sericitization of the feldspars which are as a result often clouded with sericite. This process no doubt occurred along with the epidotization. Sometimes also calcite is common in the feldspars, as well as disseminated or as stringers throughout the rock.

Pleochroic halos are common in the biotite and seem to owe their origin to titanite, which in a few cases was noticed elsewhere in the granite sections, sometimes undergoing a breakdown into an amorphous mass. Apatite is a common accessory but is not the cause of the halos in the biotite. Magnetite and pyrite are usually present. The epidote is usually colorless or almost so, but in a few cases where it has developed in the neighborhood of mafic materials it is greenish and pleochroic.

The typical Creighton granite may therefore be summed up as an aphanitic rock, containing abundant well developed feldspars, dominantly orthoclase and acid oligoclase, which has been moderately silicified, the latter action tending to produce a granular mass of the feldspars. Hydrothermal action has clouded the feldspars with sericite, epidote and some calcite. The composition was found to be quite uniform and may be expressed in per cent as follows: Quartz--40, Feldspars--45, Biotite and Chlorite--5--10, Epidote--0--5, Calcite--2, Magnetite, Pyrite, Apatite and traces of Titanite.

Some phases of the granite have as low as twenty per cent quartz with

resultant increase of the feldspars. Two sections of a quartz-dioritic phase were also studied, and were found to be very uniform although coming from widely separated places. Hornblende forms a little over ten per cent with biotite slightly less common. Feldspars form about fifty per cent and quartz thirty per cent. The feldspars are here more highly epidotized than elsewhere. Apatite is quite abundant as an accessory.

THE ROAD VOLCANIC CENTER

What is herein described as the Road Volcanic Center is a relatively high area which abruptly cuts across the south end of the large valley occupied by the Missi. It is therefore a pronounced topographical feature which does not readily fit in with the linear ridging to the north, south and east. Likewise the geology is quite different from that in any of these localities. There are a great variety of materials including innumerable small isolated blocks or areas of many different types. There are some relatively large areas which are clearly intrusive bodies and also numerous dykes. Some masses are clearly lavas, others are bedded tuffs and some are explosive breccias. There are other peculiar breccias some of which appear to be intrusive.

In many places the rock varies greatly in texture which in part is clearly due to original variations and in part appears to be due to alteration. For instance hornblende, or garnets and chlorite, or epidote in places with quartz, are abundant along certain lines or cracks, or in certain irregular centers, and decrease in number or size of crystals away from these; thus suggesting alteration around holes or cracks, which in part may have been fumaroles or breaks along which vapors and gases escaped to the surface. Near these and elsewhere there is much rock with a bleached appearance and as a consequence there are gradations into various other types of materials. There are so many types of materials and so many intermixtures that it is quite impossible to describe all. The boundaries are to a large extent extremely irregular. Some extrusives have many irregular offshoots and some rocks present an appearance suggesting that they had been stirred together when in a plastic state. Closely associated blocks of bedded material often show widely different orientations.

In a number of places many small faults are observable but do not form any recognizable system. They represent in the main block faults

They represent in the main block faults and there is no evidence of major faulting. These occurred at several different times, effecting even the youngest intrusives.

From this maze of materials certain features stand out clearly. Along the north-western edge opposite the Creighton granite are hard light gray rhyolitic materials which have the appearance of chert or porcelain and are similar to rocks found along the contact of the granite and in dykes related to it. These same rhyolites occur elsewhere in the volcanic center and are even denser and more like porcelain. They are especially common in peripheral regions but also occur as altered remnants within. This type of rhyolite in the field was termed "porcelain rhyolite."

The most prominent rock of this area is another rhyolite which was termed "hornblende rhyolite" due to the presence of hornblende which in many places is very abundant. This rhyolite more or less forms the central core of the volcanic center and where it occurs in intrusive contact with the porcelain rhyolite can be seen to be later. Sometimes there is a gradation between the two types to a dirty light gray rock differing from the porcelain rhyolite only in the presence of hornblende. Microscopically this gradational phase was found to represent the earlier rhyolite which had been indurated with the later hornblende materials.

In many places these materials in their massive form grade to breccia which has indefinte to definite fragments. These in part appear to be intrusive, the fragments representing materials that have cooled more rapidly and therefore are harder and finer grained. Definite explosive breccias are common, many of which have been picked up by later magmatic materials, the fragments as a result undergoing varying stages of alteration, and representing both types of rhyolites. The typical porcelain rhyolite breccia consists of large angular fragments of this white weathering rhyolite in a green groundmass.

Others show fragments variously rounded and assimilated. The hornblende rhyolite breccia shows similar occurrences.

Together the rhyolites occupy most of the northwestern and western part of the area, and occur throughout the southeastern part in relatively smaller masses. The field evidence suggests that they represent plugs or necks, dykes and remnants of these, and that they were developed near the surface.

They are altered in places in the manner generally found in this locality, garnets sometimes being very common. This material is cut by stringers of epidote and, epidote and quartz. In some irregularly oval areas it was noted that from country rock of hornblende rhyolite, there was a gradation towards the center to bluish rhyolite showing no hornblende, to light buff material, and finally to a core of epidote. Many other peculiar features were noted.

Microscopically a gradual transition has been traced from the chilled granite contacts, through a finer-grained phase (rhyolite) from the edge of the volcanic center opposite the granite, to the typical dense porcelain rhyolite. A section of the rhyolite from the edge of the volcanic center is very similar to the chilled granite, which occurs opposite it across the small intervening draw, and the latter seems to definitely represent a deeper seated phase of the former. The minerals present and the alterations in each are indentical and they look alike texturally. The mafic content is higher in the rhyolite possibly in part at least due to contamination as the rhyolite was intruded in the country rock. In other places the rhyolite is exceedingly fine-grained and its composition is identical with the granite. Apatite was observed as an accessory in some of the rhyolite also.

The hornblende rhyolite is medium fine-grained and contains as a rule less than twenty per cent hornblende as large moth-eaten phenocrysts. Minute needles of chlorite occur sparingly in the groundmass.

Magnetite and pyrite are quite common, and apatite is an accessory. Garnets were present in two of the slides studied from the central part of the intrusion of this rhyolite.

These rocks cut and intensely alter the rocks logically assigned to the Missi series which occur within the volcanic center. They also cut and include blocks of green volcanics which are believed to be remnants of the Lower Flin Flon series. These occur mainly in the south and south-eastern sections. Green dykes may also be cut by the rhyolites. These rocks clearly represent more than one period of intrusion.

Besides these light gray intrusives there are materials of various shades between these and dark green and gray. These in part are due to alteration of some of the other types but some may also represent separate intrusives bodies in a sequence from the light gray to the dark green intrusives.

In the eastern and south-eastern one-third of the area there are numerous intrusive bodies of green rock, some up to one thousand feet long by one hundred feet wide. They are of very irregular shape mainly tending toward lenticularity but with many irregular offshoots. The larger bodies are suggestive of necks or plugs. There are smaller bands or dykes which likewise are irregular and rarely show any continuity. These rocks definitely cut the rhyolites already described; though rhyolites and quartz porphyries of similar appearance of still later age are known and which also cut the Middle Flin Flon series which will be described later. Some show chilled edges. There is a sequence of these green rocks, at least three distinctly differing ages and types being readily recognizable and there seem to be more.

The rocks of this later series are in places indistinguishable from the Upper Flin Flon rocks and possibly earlier intrusives related to these. One of the oldest of the later green intrusives is a peculiar spotted material.

It has light greenish gray spots or phenocrysts of feldspar mainly about one-quarter inch in diameter and in most places making up by far the greater part of the rock. The matrix is green and the whole has a faded or bleached appearance and is fairly uniform in texture. The long extension to the south is entirely of this material except for some later dykes.

There are a few other areas of fair size, all of which appear to be small stocks or necks. This type of material is the most extensive of the green intrusives. Other somewhat similar materials mainly of later age also occur and this general type of porphyry was intruded at several periods. Dykes of this type were noted beyond the volcanic center, in the Lower, Middle and Upper Flin Flon series, to the north, east and south. To distinguish it from other porphyritic green intrusives, this pale bleached porphyry was termed "pale-face" diorite.

Microscopically the "pale-face" is seen to consist of forty-five to fifty per cent large altered feldspar phenocrysts, in a groundmass of quartz, chlorite and some altered feldspar. The feldspars have all been highly saussuritized and in one case seemed to represent andesine, old twinning bands being faintly discernable. The saussurite is dominantly zoisite, with epidote, quartz and calcite. The phenocrysts have no regular shape due to alteration processes. Calcite is common as stringers cutting everything else. Typically this rock does not contain any hornblende, possibly only due to complete alteration to chlorite, but phases closely allied to it, or less altered parts, have from five to twenty per cent with the resulting decrease in chlorite content. Chlorite is common altering also from biotite. The composition in per cent is approximately; Quartz--30, Saussuritized Feldspar--50, Chlorite--10--15, Hornblende--0--20, Epidote, Titanite, Biotite and considerable Calcite. This rock therefore may best termed a quartz diocite.

The other late green intrusives show great variety in texture and color which in part is due to differences in the size of the bodies and position relative to the contact, for in the larger masses there can be seen a gradation from coarse or porphyritic texture in the center, to fine or dense texture at the contact which is usually of a different shade. The masses are usually relatively small, that is less than fifteen feet wide and fifty feet long, and of irregular shape. They were noted beyond the volcanic center as well as within it, being quite abundant to the east. Because of similarity to extrusives in the upper division they are not readily distinguishable. None were noted that were considered to be a likely source of any large quanitiy of extrusive material but they are probably related to nearby necks which must lie to the east or south-east.

Some of these green intrusives are definitely known to cut the "pale-face" and some of these show the same alteration of the feldspars to saussurite. One such rock has smaller phenocrysts with clear cut outlines. Interlocking with these are coarsely crystalline masses of hornblende. Titanite is very common but altering to an amorphous mass due to hydrothermal effects. Another similar porphyry has the phenocrysts forming less than twenty-five per cent of the rock, in a groundmass of equal proportions of quartz and hornblende with some feldspar and other minerals of minor importance.

Another type cutting the "pale-face" is not porphyritic but shows a high degree of hydrothermal alteration with the development of abundant epidote which probably replaced the feldspars of the groundmass. This is the only intrusive which has abundant biotite. Hornblende occurs as a late development. The composition in per cent is as follows: Quartz--30, Epidote--35, Biotite--25, Hornblende--10, and some magnetite.

Other green intrusives show no extensive hydrothermal alteration and in part are definitely known to be later than some of the intrusives cutting the "pale-face" and may all be later. One consists of sixty-five or seventy per cent hornblende the remainder being quartz and possibly feldspar, with a little epidote and traces of titanite. Other similar intrusives contain about forty per cent hornblende and ten per cent chlorite, with quartz and feldspar together, about forty per cent. Basic oligoclase was definitely identified in one of these. Such rocks as these probably represent the last volcanic activity of this center.

THE

CLUB LAKE VOLCANIC CENTER

The Club Lake Volcanic Center occurs southwest of Club Lake at the northwestern limit of an extensive outcrop area. It is marked by a hill with a steep to vertical northwestern slope bordering a swamp which in the main marks the contact between the Missi and the Flin Flon series. The base of the cliff here may also approximately mark the contact but if this is so a minor anticline lies to the west for on a small outcrop in the valley only the western half is Missi, the eastern half being made up of rocks related to those of the cliff which are post-Missi.

The Club Lake Volcanic Center is a complex which shows rocks of many different textures and colors badly intermixed. Contacts are both sharp and gradational. The area outlined on the map is largely coarse textured gray to pink granitic material. This rock besides occurring in a central rounded mass has a long wedge-shaped protrusion extending southwestward along the bedding. The outcrop in the valley shows some granitic material, some induration and granitization of the Missi; and probably closely underlay or was at the outer limit of the granitic intrusive body. The absence of outcrops between this area and the cliff however, suggests that the connecting link was thin and probably like the southward protrusion. From these data the mass would appear to lie in the Flin Flon series just above the Missi and to have a mushroom or laccolithic shape so far as the southern and western extensions are or were concerned since the latter is now largely removed by erosion. The abrupt cliff suggests however that the core area as now exposed may be the top of a neck extending down into the Missi. Some granitic or rhyolitic dykes west of the Missi on the opposite side of Creighton Creek, may be related to the Club Lake mass.

In a few places the granitic material shows sharp contacts but mainly the contacts are gradational. The protrusion southward grades

from coarse to fine granitic material, to dense green rock not distinguishable from enclosing volcanic rocks which in part are bedded and in part explosive breccias so are clearly extrusive. In places around the core area the granitic material grades to and becomes irregularly mixed with indefinite inclusions of dense rhyolitic material. Outward the rhyolitic material increases in abundance and the granitic material eventually disappears,--usually within something like ten feet. Beyond are indefinite dyke-like bands of rhyolitic material of a light greenish-gray color and a peculiar brecciated appearance. The fragments are very poorly defined and the appearance suggest that as the magma moved those parts which touched the walls cooled rapidly to a very dense material which however was carried along and intermixed with the liquid material until eventually the whole mass congealed.

These features indicate that the magma was injected under conditions permitting of extremely rapid cooling around the contact of the core and beyond. Presumably it was very close to the surface.

Within the central core the granitic material shows a wide range. In places it is a fresh pink to gray coarse textured granite such as might be found in any plutonic mass. This material grades through various stages to dark gray materials of a micaceous schist or coarse-textured igneous rock appearance and to the cherty rhyolite already described. The dark gray material especially the micaceous schist appears to grade to dark gray and green volcanic rock such as occurs around the mass in places. Over much of the area the dark rocks and the light granitic rocks are intimately intermixed. In places the dark materials occur in definite inclusions and these appear to be of volcanic rock in various stages of alteration. Elsewhere the two types, largely including the igneous textured phase of the dark material, are intermixed in such a way as to suggest that they were stirred together in a plastic state.

Immediately to the south of the Club Lake Volcanic Center and directly on the Missi is a very considerable thickness of very coarse explosive breccia. Similar material may be represented in the small outcrop in the valley to the west. The character of this material clearly indicates that it was very close to a vent and as the abundance and size of blocks decrease very rapidly toward the south it is clear the vent must have been to the north. The breccia contains materials ranging from granitic to rhyolitic textured material similar to those of the center to the north; it contains materials similar to the indurated and altered Missi, and green volcanic rock. All of these features are exactly what might be expected from an explosive eruption in the vent to the north. Overlying this basal breccia is a series largely of rhyolite flows and explosive breccias containing rhyolitic fragments. In general lithology and in many detailed respects such as the abundance of small pyrite crystals or pseudomorphs of iron oxide after pyrite these extrusives resemble the intrusivesof the volcanic center. Further it is clear that the thickness of these rocks greatly decreased in both directions away from the vent. There is therefore no doubt that the Club Lake granite occupies a vent which was the source of these extrusives. The material within it now of course represents the last intrusion which may never have reached the surface and which naturally might be expected to differ from the earlier extrusives of the series surrounding it.

Surrounding the volcanic center there are many dykes related to it. These are largely small, irregular and indefinite and not readily distinguishable from the rocks they cut.

Within the volcanic center and near by there is much evidence of alteration some of which has already been presented. It seems clear that blocks from the intruded rocks were enveloped by the magma, altered and assimilated in a manner similar to that observed in modern volcanoes. Besides there is evidence of alteration nearby suggestive of being the

result of escaping vapors. Along cracks and in zones the rocks are distinctly reddened. Hornblende needles show up fairly abundantly and are probably the result of alteration.

The relationships clearly show that the intrusion and volcanic activity was post-Missi and of Middle Flin Flon age.

Microscopically the Club Lake granitic body is clearly related to the Creighton granite. Its composition in per cent may be expressed as follows: Quartz--35--40, Feldspar--50, Epidote--1--10, Biotite (Chlorite)--8, Magnetite and Pyrite up to--3, Calcite, Apatite and rarely Titanite. The feldspars present are orthoclase, albite and acid oligoclase.

The feldspars show slight degrees of sericitization and epidotization, and sometimes contain introduced calcite. Silicification is more prominent in this series than anywhere else and all stages of this alteration are present. When this alteration is very slight the feldspars become very faintly granular, whereas when extreme a complex granular body of quartz and feldspar is produced.

The dark phase in this granite is similar but contains about forty-five per cent hornblende, altering slightly to green biotile. No epidote or calcite occur in this rock. Very similar to this phase are certain dark green dykes which cut the surrounding country rock. Hornblende forms about twenty-five per cent and biotite ten per cent. Silicifications is evident. Quartz porphyry dykes also occur which are related to this volcanic center. The groundmass is very fine and sericite is quite common. The quartz phenocrysts are uncommon but large and have been fractured and injected with later quartz.

The green volcanics contain abundant introduced epidote and considerable magnetite. They consist of fifty per cent quartz and feldspar, twenty per cent hornblende and twenty-five per cent epidote. The

schist which grades to the volcanics contains about thirty per cent biotite and chlorite and slightly less calcite. Introduced pyrite is present in place of magnetite. This schist may in part be tuffaceous.

THE

MIDDLE FLIN FLON DIVISION

The Middle Flin Flon series of volcanics is continuous from the southern limit shown on the accompanying map, northward for more than six thousand feet. South of the Road Volcanic Center, the Middle Division rests on the Lower Division. The top of the Lower Division in most places where exposed is found to be very rusty. The rustiness extends for a depth of two feet in places and much more, locally, along cracks. The rusty zone in places is highly sheared and very soft. No rustiness occurs in the basal part of the Middle division so this zone is considered to be a weathered surface.

Northward from the Road Volcanic Center the Middle division except for possible isolated patches of the Lower division, rests with angular unconformity on the Missi. The angle in one place was measured at 20°. Far to the north beyond the Club Lake Volcanic Center, the Middle Flin Flon again rests on the Lower division. It is notable that in the section where the Middle division rests on the Missi, the trend of this formation, of its basal contact, and of the contacts between other formations stratigraphically below this, show a well defined swing toward the east as if they had been bulged out in this direction. Further, in this section for a distance of about one mile north of the Road Volcanic Center, the basal Missi is more highly sheared than to the north suggesting it had been subjected to some extra folding. The bulge comes in the area where the granite also bulges to the east. These features suggest that the surface of the Missi where it is overlain by the Middle division was higher than elsewhere and that it was bulged up in an anticline. This may have been formed by the intrusion of the granite.

The Lower division of the Flin Flon Series may have been continuous

at one time. In fact this seems most reasonable since in part it is tuffs and breccias that would have been laid down everywhere. Therefore part was probably eroded away and deformation may have occurred prior to the deposition of the Middle division. At any rate the evidence indicates that the Middle division is in angular unconformity with the Lower division. Along the contact in one place the beds of the Middle division appear to overlap to the north as if laid down on a slope.

In the area of the Road Volcanic Center, the Middle series is badly broken up through faulting and later intrusion. The lower part occurs mainly as isolated masses within the eastern third of the volcanic center area. Patches occur also along the southern side and up the west side in a narrow band possibly to the gully separating this area from the Creighton granite, as in this section there are some amygdaloidal rhyolites, some breccia and some evidence of bedding suggesting that these rocks here are extrusive. Immediately to the south of this volcanic center there is a considerable mixture of materials which probably includes isolated patches of the Lower division volcanics and intrusives.

The Middle Flin Flon rocks are largely rhyolitic extrusives. The basal member which is not continuous is an explosive breccia. This contains sharply angular blocks of materials ranging from coarse textured granite to dense rhyolite. Complete gradations between the two types can be found in the various blocks. There are also blocks of green volcanic material and of other materials which in appearance, texture and composition so closely resemble indurated and altered Missi as to be considered as derived from this formation. A variety

of other materials also occur. The matrix is a fine green tuffaceous material and in places the blocks are absent, only the green tuffs occurring at the base. The sharp knife-edge angularity of many blocks, intermixture of a variety of types of these, and many other features indicate clearly that the breccia is the result of an explosive eruption. In places there are bombs: irregularly ovaloid masses up to two and a half feet long, of rhyolitic materials which show a dense cherty chilled edge of equal thickness all around which grades to a much coarser material in the center. Locally the basal member appears to be conglomerate and contains rounded masses of chert, quartzite and fine conglomerate.

The physical appearance of many of the beds is exactly similar to much of the intrusive material in the volcanic centers and to the Creighton granite.

A fine grained phase of the basal breccia was studied microscopically. Fragments of a very dense rhyolite occur in a tuffaceous groundmass which is fine grained in part and made up of materials similar to the fragments. This material alternates with coarse bands rich in biotite. The fragments have a cloudy groundmass due to minute grains and specks of magnetite and flecks of biotite. Epidote is also common and there are a few phenocrysts of orthoclase so that the material closely ressembles the earlier intrusive rhyolites of the Road Volcanic Center.

One granitic fragment from the basal member probably represents a feldspar porphyry. A few large phenocrysts of orthoclase and oligaclase occur in a fine grained groundmass of quartz and feldspar. Silicification is extensive. Except for quartz being more abundant than feldspar, the rock ressembles the Creighton granite.

Another granitic fragment was taken from immediately south of the Road Volcanic Center. It closely ressembles phases of the Creighton granite that are low in quartz. The feldspar is dominantly orthoclase. Sericite and calcite are common within the feldspars. Graphic intergrowths are present.

In the series there are other similar breccias which however show blocks almost exclusively of rhyolitic materials in a green tuffaceous groundmass. There are light gray well bedded rhyolite tuffs which generally show considerable hornblende. Rhyolite flows which are amygdaloidal and vesicular in many places also occur. Rarely they show rounded quartz phenocrysts. Some breccias contain distinct to indistinct light gray rhyolitic fragments with considerable hornblende in both fragments and matrix, and passing from one to the other. Locally garnets were noted in both materials also.

Interbedded with the light gray rocks are green materials which in the main seem to be tuffs but some are flows. Pyrite or pseudomorphs of iron oxide after pyrite occur in rocks of this series in fair abundance.

The slide studied of the amygdaloidal rhyolite did not show any amygdules but a primary flow structure was evident. Silicification is extensive and epidote stringers common. Biotite and a little magnetite form about twenty per cent of the rocks. The section studied of the green materials appears to be a very silicified flow. Hornblende forms about forty per cent, as well formed elongated crystals of late development. Much calcite has been introduced, and there is slight epidotization of some of the feldspars. The uppermost beds of green tuffs consist of about twenty-five per cent hornblende which has developed at the expense of the abundant chlorite and possibly also some

epidote. Feldspars are evident and usually have epidote masses or crystals within.

Hornblende as a late development is displayed also in the breccias, here cutting across both groundmass and fragments but being less common in the latter as they are more dense. The fragments are very similar to the rhyolites of the Road Volcanic Center. Apatite occurs in both materials. Epidote and garnets are also present.

The series and the materials of the series show a wide difference on either side of the Road Volcanic Center and change materially away from it. The breccias are much coarser and thicker near the volcanic center, and coarse textured granitic blocks, up to one and a half feet, were noted here only. Going north the size and the number of blocks greatly decreases until only tuffs were noted beyond fifteen hundred feet. Similarly the other members of the series become thinner or change in character so that for five hundred feet beyond the fifteen hundred foot point there are only green materials, largely clearly tuffs, and the series is thin. It is notable that this change corresponds to the bulge in the Missi and reaches its maximum at the point about equidistant from the two areas of the Lower division, this again supporting the idea of an upwarp of this area in post-Lower division time and suggesting the presence of a hill here during deposition of the Upper division.

South of the Road Volcanic Center the Middle division is considerably thicker and contains much more of the light gray materials and is mainly rhyolite flows and explosive breccias. The breccias occur both near the base and the top of the series. They are definitely

finer towards the south but studies have not continued far enough to state conclusively that this is a consistent trend.

Interesting and peculiar features were noted at the northern end of the isolated southeastern area of this series. At the edge of the outcrop there is what appears to be a dyke breccia. It is made up of indefinite and definite fragments varying from dense cherty rhyolite to coarser quartz porphyry which occur in a similar matrix. To the north are some isolated patches of similar materials which appear to lie on top of the Lower Flin Flon series. Going southward on the main occurrence the dyke-like appearance becomes less clearly defined, and beyond an area of drift similar breccia occurs in the series which is clearly extrusive. The materials are similar to the Creighton granite. It therefore appears that granitic magma escaping along a fracture near the surface was so rapidly chilled that those parts which came in contact with the walls were almost immediatley solidified but by the force of intrusion were carried on and eventually the material flowed out on the surface.

The relationships and the microscopic determinations indicate that the rocks of the Middle Flin Flon series near the Road Volcanic Center were derived from this source.

From the gap fifteen hundred to two thousand feet north of the Road Volcanic Center, breccias and flows again come in, increasing remarkably in abundance toward the Club Lake Volcanic Center. The basal breccia in particular is well exposed and in the short distance of six hundred feet becomes very thick and very coarse. Blocks up to four feet in diameter were noted. There is an abundance of coarse granitic textured rocks. By far the greatest development of this type of breccia occurs just south of the Club Lake Center, as it did south of the Road Volcanic Center suggesting that the prevailing wind during both eruptions was

southward.

The Middle Flin Flon series in the vicinity of the Club Lake Center is very similar to that near the Road Center but owing to less study, more difficult structure and poorer outcrops, a less complete picture of the formation has been obtained. To the east the series appears to thin out, to contain less of the light gray rhyolitic materials and finer pyroclastics. The rhyolites in the Club Lake section seem to have a larger quantity of pyrite or of pseudomorphs of iron oxide after pyrite. The same peculiar breccias with indefinite and definite fragments of various texture in a similar matrix as found to the south, occur here. The hornblende bearing rocks were not noted to anything like the same extent here as to the south. In general it seems to be clear that the extrusives in the north came from the Club Lake Volcanic Center.

The two volcanic centers although differing from each other are both clearly related to the Creighton granite and are both of approximately the same age. Evidence points to the Road Volcanic Center being somewhat earlier than the Club Lake Center, and therefore might well be more basic. Furthermore the former was probably formed before the final intrusion of the Creighton granite into its present position and is probably closely allied with certain earlier phases. This accounts for their close proximity but slightly varying nature. The Club Lake Center on the other hand probably formed when the main mass of the Creighton came into its present position and thus is almost identical with it.

UPPER FLIN FLON DIVISION

The Upper Flin Flon division occurs along the west shore of Flin Flon Lake. It rests in all localities on the Middle division though to the north near Little Flin Flon Lake the Middle division appears to be thin and not readily recognizable, and may even pinch out. The relationships between the Upper and Middle divisions were carefully studied throughout most of the length of the contact. Northward and southward from the Road Volcanic Center they appear to be conformable, but to the east the relationship appears to be different. In one place the Upper division strata appeared to successively overlap those of the Middle division and the attitudes of strata in the two divisions appeared to be quite different. The relationships strongly suggested that there had been a hill in this location at the beginning of Upper Flin Flon time and that some erosion and possibly some local deformation had taken place here. The presence of faults of different age cutting the green intrusives further supports the suggestion of deformation.

What has been included as the top of the Middle division in some places, a breccia made up of rhyolitic fragments in a green matrix may more properly belong to the late period of volcanic activity represented by the rocks of the Upper division. Above this there is a thick series of green volcanic rocks which are in the main tuffs, in many places very well bedded. There are some breccias with green fragments in a green matrix, and some flows which in places are amygdaloidal and show pillow structure. In the section above this basal part there are similar materials with a variety of interbedded breccias and flows. The breccias are in the main readily distinguishable from thoseof the Middle division though some have light gray fragments in a green matrix--

like those in the lower series. In the Upper division the light gray fragments are only in part rhyolite like that in the Middle division. Many of them especially higher in the series are distinctly quartz porphyry and some contain so many small rounded quartz phenocrysts, possibly in places amygdules, as to have the appearance of sago pudding. In addition there are generally many green fragments, some which are exactly similar to the coarse porphyry found in the Road Volcanic Center. Others are lightly to thickly spotted with round spots of quartz, quartz and epidote, or epidote. These are in the main very irregular in shape and probably were originally jagged pieces of highly vesicular lava or pumice.

Generally these breccias are cemented by soft green tuffaceous material and were clearly the products of explosive eruptions. About the middle of the series west of the lake there is a considerable zone of breccia carrying quartz porphyry. Next to or within this zone there are irregular thin bands of quartz porphyry which in part are probably flows. In the series there are other flows which have a texture in part exactly similar to the coarse green porphyry of the Road Volcanic Center. They show definite pillow structure with the pillows in places entirely of porphyry and in other places with only the center showing many phenocrysts. In places they weather decidedly vesicular. Other green flows some showing pillow structure also occur. In places the flows passing to a breccia suggestive of flow breccia. There are some well bedded tuffs which also have a texture much like the coarse porphyry.

The flow studied microscopically from the basal part of the series appears to have been a porphyry but has been subjected to a high degree

of chloritization effecting both the mafic materials and the feldspars so that chlorite now forms over fifty per cent of the whole. The feldspars are most probably oligoclase. Introduced calcite is abundant and there is a little hornblende of late development.

Higher in the series other flows are common. One of these contains large phenocrysts of feldspar and hornblende in a medium-grained groundmass of quartz feldspar and chlorite. Oligoclase is the dominant feldspar but orthoclase is also fairly abundant. Calcite has been introduced. The composition in per cent may be expressed as follows: Quartz--20, Feldspar--45, Chlorite--20, Hornblende--10, Calcite--5, Biotite, Magnetite and Epidote.

Another section of similar material possibly represents a pillow as two phases of the same material are present. One phase is fine-grained and composed dominantly of minute needles of hornblende, and contains numerous calcite amygdules. The other phase is coarser and contains less hornblende. Feldspar phenocrysts occur commonly in this material, while only one occurred amongst the fine-grained phase. The feldspars of the groundmass were identified as oligoclase but are very indistinct due to considerable epidotization. In the field these flows texturally ressemble some of the green intrusives of the Road Volcanic Center and microscopically they are somewhat similar. Correlation however is made impossible by the high degree of alteration suffered by these intrusives, but it is not unlikely that they are related.

One section studied seemed to represent a flow breccia, fragments of a hornblende rich material with feldspar phenocrysts occurring in a siliceous groundmass with abundant coarse brown biotite. The hornblende occurs as a multitude of fine needles surrounding the slightly epidotized feldspars. Other areas in this rock consist mainly of coarse hornblende altering to biotite and may represent foreign material which has given rise to much of the biotite of the groundmass.

Well up in the series, the breccia fragments are rather peculiar, having been so highly epidotized as to make their identification impossible. One section of these showed a very coarse aggregate of quartz and epidote with traces of biotite, chlorite and calcite. Another could definitely be spotted as a lava as it had abundant amygdules of epidote and quartz together. The groundmass was also of quartz and epidote but fine-grained. Traces of chlorite and some hornblende needles were also present.

Along the shore of Flin Flon Lake, about fifteen hundred feet north of the large island, in what is probably the highest part of the series, rocks of a different type are exposed. Here grains of quartz and feldspar occur in a green groundmass. The quartz grains up to one-third inch in diameter are rough and irregular, or rounded, or show distinct crystal outlines. They range from very abundant to rare and absent megascopically. Many of the grains are distinctly blue and some are as vividly blue as found anywhere. In places the rock shows well defined pillow structure; elsewhere it has distinct textural differences suggestive of tuffs. The material certainly appears to be extrusive. Associated with this are darker green and gray rocks with white, red and green amygdule-like masses.

Two of the sections studied were rhyolite porphyries. The groundmass is fine-grained and contains large phenocrysts of feldspars, quartz and knots of quartz. Inclusions are common in the feldspars; mostly biotite, epidote and apatite. Silicification is evident being aided by fracturing. Garnets were present in one of the porphyries. Chlorite, biotite, hornblende and epidote are quite limited in abundance. Another of these late rocks was slightly more basic, coarse brown biotite forming twenty per cent with chlorite, hornblende and

epidote in equal proportions about fifteen per cent. The hornblende and epidote are of late development and well crystallized, but are prior to the silicification which introduced some calcite. The structure and composition of this rock is quite suggestive of one of the greenish intrusives of the Road Volcanic Center although of course much less altered.

Throughout a large area lying mainly west of the northern two thousand feet of Flin Flon Lake the volcanics of the Upper division including the highest just described, show hornblende needles, in places very abundant. Northward and southward they were not noted or were less abundant. These crystals are of secondary origin possibly due to alteration by nearby intrusion or volcanic activity. If this is true it affords a clue as to the center from which some of these later volcanics originated. Further it was noted that explosive breccia was much more abundant in the series east and south of the Road Volcanic Center than to the north. In view of the various features described it is believed that the Upper division of the Flin Flon series is closely related to the green intrusives of the Road Volcanic Center, and that part came from the necks there exposed and the remainder from other vents somewhat to the east down the dip obscurred below the surface by extrusives.

RHYOLITE AND QUARTZ PORPHYRY DYKES OF POST-CREIGHTON GRANITE AGE

Within the Creighton granite and in the Upper division of the Flin Flon series there occur rhyolite and quartz porphyry dykes which are similar to those related to the Creighton granite. They differ however in that though some show no phenocrysts of quartz most are distinctly porphyritic, whereas the earlier rocks though rarely showing phenocrysts usually show none. Also the later rocks were not noted to show the abundance of small crystals of pyrite or pseudomorphs of iron oxide after pyrite found in the earlier ones. They are commonly light gray and cherty in appearance. Most of those within the Upper Flin Flon series are very irregular in shape and relatively small in size. They are commonly lenticular, rarely tabular in the surface exposures, and therefore many be tongue-like in underground extent. The material of which they are composed is not readily distinguishable from that of blocks in the explosive breccia in the middle part of the Upper Flin Flon division, or from that of bands nearby which are believed to be flows. Some follow the bedding and are not readily distinguishable from flows whereas others cut directly across the strata. These features suggest that these dykes and sills are closely related to the rhyolite and quartz porphyry extrusives.

In some of the dykes in the Flin Flon series, the quartz phenocrysts are distinctly blue. If this characteristic is original it suggests the possibility of relationship to the upper part of the Upper division. Some dykes carry fine grains of feldspar. In some there is a banded texture as if the dyke is due to repeated injections. Quartz occurs abundantly in some, as stringers and irregular masses. These dykes are altered and carry hornblende needles in places as do

most of the surrounding rocks. They are sheared to about the same extent as the volcanics in which they occur. These features further support the belief that the dykes are of about the same age as the enclosing extrusives.

In the area of the Creighton granite about forty-five hundred feet north of the east end of Creighton Lake there are some quartz porphyry dykes which cut feldspar porphyry dykes. The quartz prophyries, some of which show feldspar phenocrysts also, are fresh and young in appearance. They are similar to those described above and may be related.

Microscopically in all these dykes, feldspar phenocrysts are common while quartz phenocrysts are rare or absent entirely. The hornblende is early in all cases, occurring as moth-eaten phenocrysts, and sometime in aggregate masses. The groundmass materials are fine to medium grained. There is slight epiditization and sericitization of the feldspars.

STRUCTURE

The general structure of the Flin Flon series northeast and east of the Road Volcanic Center is synclinal with a trend of about 35° east of south, and a plunge south of roughly 30° to 40°. Within this area there are many minor folds with similar trends and plunge. In places these are relatively open but elsewhere they are slightly overturned toward the west. In the section under discussion along the lake north of the Road Volcanic Center no minor folds other than small ones were noted so that in the section from the base of the Missi to the lake shore there is practically no repetition of strata. The dips range mainly from 30° to 50° to the east. The maximum thickness of the Flin Flon series exposed west of the lake is probably about eight hundred feet. The Missi at the first outcrops north of those next to the Road Volcanic Center is probably not over two hundred and fifty feet, whereas twenty-five hundred feet to the north it is probably over three hundred and fifty feet.

Immediately south-east of the Road Volcanic Center there are exposed two small anticlines, the one on the east open, the one on the west much narrower but not overturned. They plunge south-easterly at about 40°. Westward there is a syncline plunging 40° south, and then an anticline represented by the narrower band of the Lower Flin Flon division, succeeded by another syncline.

Within these last two folds, in the south there are minor folds which are overturned so that dips are mainly from 30° to 70° to the east. Toward the north the folds appear to be more open.

From the foregoing it is clear that the Road Volcanic Center is in the axial part of a major anticlinal area. The structures plunge south which accounts for the extension far to the west of the Flin

Flon series. The Missi, if it had not been cut out by the Creighton granite, would have swung abruptly to the west in the area of the Road Volcanic Center. Indeed there is enough of the Missi left in this area to show quite distinctly the beginning of this swing; and the swing in the feldspar porphyry dyke here, which so closely follows the base of the Missi is further emphatic evidence of the change in attitude.

Exactly on the axial trend of the Road Volcanic Center to the north, in the Pre-Missi Complex, there is indicated a great anticlinorium which for over two miles shows the same southward plunge. Thus the evidence is such that the structure as postulated for the volcanic center area is undoubtably correct. Referring back for a moment to the sections on the Flin Flon series it becomes much more apparent why the areas of green volcanics southwest of the Road Volcanic Center are considered to be of the Lower Flin Flon division and to overlie the Missi.

It is interesting to note that the structures immediately southeast of the Road Volcanic Center are much more open than is commonly the case. It seems probable that the Volcanic Center acted as a hard knot and resisted deformation. Such an hypothesis would explain the irregularity in the trend here of the contact between the Lower and Middle divisions of the Flin Flon series.

THE ROAD VOLCANIC CENTER.

COMPLEX

LARGELY INTRUSIVE BRECCIA

DRIFT

COMPLEX

MIDDLE FLIN FLON EXTRUSIVES

COMPLEX

HORNBLENDE RHYOLITE
PORCELAIN RHYOLITE
HORNBLENDE RHYOLITE BRECCIA
PORCELAIN RHYOLITE BRECCIA
TUFF
COMPLEX OF ALTERED ROCKS
INCLUDED VOLCANICS
AMYGDALOIDAL LAVA
PALE-FACE DIORITE
YOUNGER ALTERED DIORITES
YOUNG FRESH DIORITE
UNCLASSIFIED DIORITES
COMPLEX OF MIDDLE FLIN FLON MATERIALS
ALTERED MISSI

ACTUAL CONTACT
APPROXIMATE CONTACT
ASSUMED CONTACT

SCALE IN FEET
50 100 150

THE ROAD VOLCANIC CENTER.

N

COMPLEX

COMPLEX

LARGELY INTRUSIVE BRECCIA

DRIFT

COMPLEX

MIDDLE FLIN FLON EXTRUSIVES

COMPLEX

- HORNBLENDE RHYOLITE
- PORCELAIN RHYOLITE
- HORNBLENDE RHYOLITE BRE
- PORCELAIN RHYOLITE BRECC
- TUFF
- COMPLEX OF ALTERED ROCK
- INCLUDED VOLCANICS
- AMYGDALOIDAL LAVA
- PALE-FACE DIORITE
- YOUNGER ALTERED DIORITES
- YOUNG FRESH DIORITE
- UNCLASSIFIED DIORITES
- COMPLEX OF MIDDLE FLIN
- ALTERED MISSI
- ACTUAL CONTACT
- APPROXIMATE CONTACT
- ASSUMED CONTACT

MANITOBA
SASKATCHEWAN

N

FLIN FLON CREEK

FLIN FLON RWY.

FLIN FLON LINE

CREIGHTON CREEK

LITTLE FLIN FLON LAKE

FLIN FLON LAKE

CLUB LAKE

CLUB LAKE VOLCANIC CENTER

ROAD VOLCANIC CENTER

CREIGHTON CREEK

BEAVERDAM LAKE

YOUNGER VOLCANICS

OLDER VOLCANICS

YOUNGER VOLCANICS

CREIGHTON CREEK

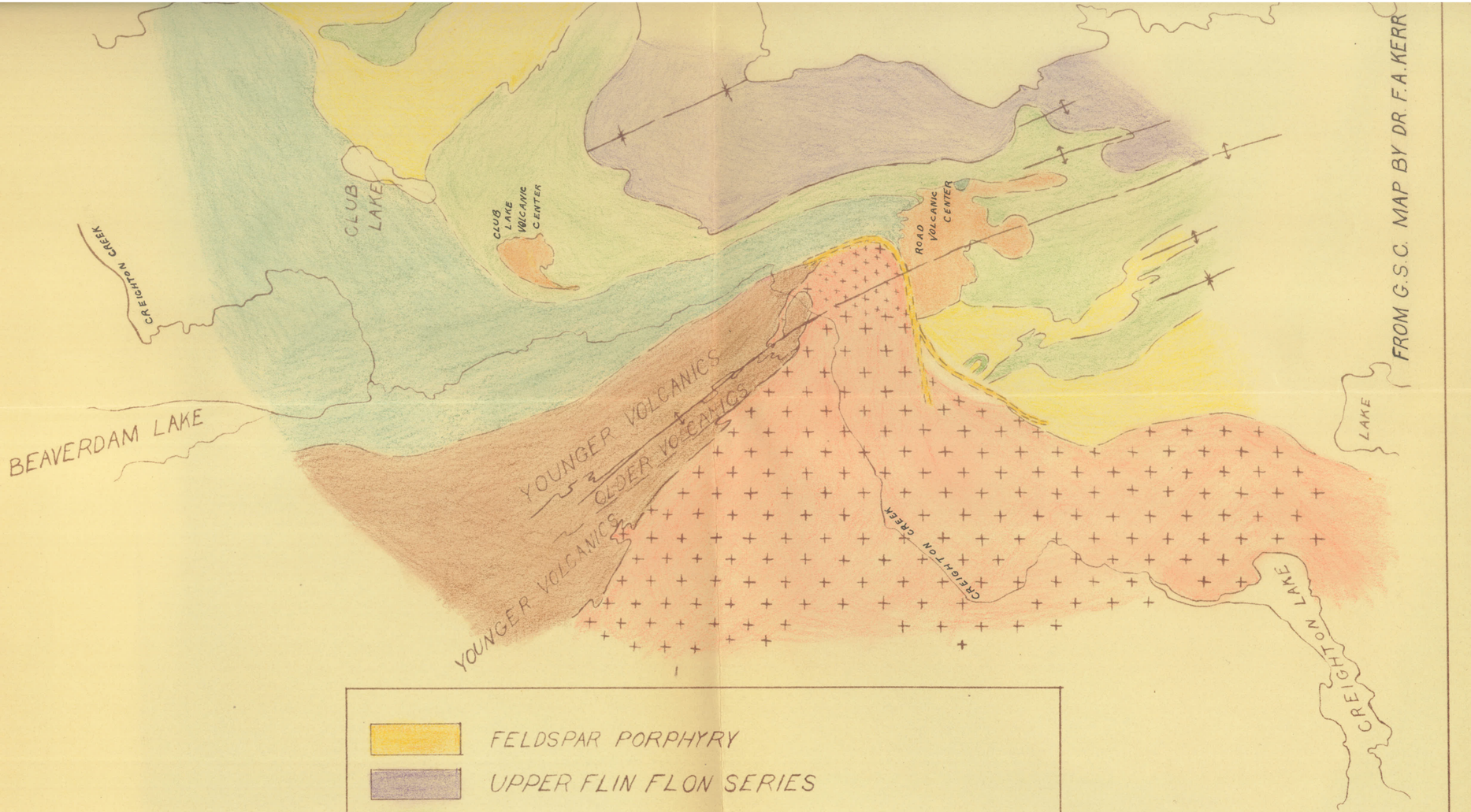
CREIGHTON LAKE

LAKE

FELDSPAR PORPHYRY

UPPER FLIN FLON SERIES

FROM G.S.C. MAP BY DR. F.A. KERR


CLUB LAKE
CLUB LAKE VOLCANIC CENTER
ROAD VOLCANIC CENTER
CREIGHTON CREEK
BEAVERDAM LAKE
YOUNGER VOLCANICS
OLDER VOLCANICS
YOUNGER VOLCANICS
CREIGHTON CREEK
LAKE
CREIGHTON LAKE
FROM G.S.C. MAP BY DR. F.A. KERR
FELDSPAR PORPHYRY
UPPER FLIN FLON SERIES
MIDDLE FLIN FLON SERIES
VOLCANIC CENTERS
FINE GRAINED CREIGHTON GRANITE
COARSE GRAINED CREIGHTON GRANITE
LOWER FLIN FLON SERIES
MISSI SERIES
PRE-MISSI COMPLEX
ANTICLINES AND SYNCLINES
SCALE IN FEET
550'
1100'
2200'