A Petrographic Study of Granitization in the Norite at Dinty Lake, Northern Saskatchewan.

by

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A Thesis submitted in Partial Fulfilment of The Requirements for the Degree of

MASTER OF ARTS

in the Department

of

GEOLOGY

THE UNIVERSITY OF BRITISH COLUMBIA

APRIL 1940.

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Illustrations

(Both reproduced from the report of Dr. C.O. Swanson on the Dinty Lake Nickel Deposits).

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Introduction

(a) General Statement

The present work is intended to consider, and propose solutions for petrogenic problems arising from the examination of the Dinty Lake Nickel Deposits, Saskatchewan.

The fundamental problem involves the granitization of the nickeliferous norite body, and divides itself into three specific problems, namely to determine: (1) the degree to which the norite has been altered, (2) the processes controlling the granitization, and (3) the probable nature of the original ore body.

Although the sedimentary origin of much of the regional granitic gneiss was recognized by Alcock[1] before 1936, the known bodies of norite were considered to be intrusive into the granitized sediments. It was not until after the Dinty lake deposits were discovered in 1936 that their structural and mineralogical variations were ascribed to regional metamorphism. The property was examined in considerable detail in June, 1938 by Dr. C.O. Swanson.

[1] Alcock, F.J., The Geology of the Lake Athabaska Region: Can. Geol. Survey, Mem. 196, p.10, 1936.

Trenching, and diamond-drilling were the sampling methods, and magnetic observations were taken to determine the extent of the ore body. His report[1] on the depositsss gives conclusive evidenceof granitization.

The group of claims containing the main deposit belongs to the Borealis Mining Syndicate, and adjacent claims are held by the Consilidated Mining and Smelting company.

(b) Location and Topography

Dinty Lake is situated at the western edge of the Fond-du-Lac map-area of northern Saskatchewan. It is about 25 miles to the northeast of Goldfields and about 15 miles from Lake Athabaska into which it drains by way of the Beaver River. Dinty Lake measures about 2½ miles long and ½ mile wide.

The area to which the present problem is confined is about a quarter mile north of the lake. It is the largest norite exposure in the vicinity of the lake, having a width of about 300 feet and extending about 1000 feet along its north-south elongation. The exposure caps a broad ridge at an elevation of about 110 feet above Dinty Lake. Other similar, but smaller, norite bodies lie along the same zone, the largest being more than a half mile to the north.

[1] Swanson, C.O., "Report on Dinty Lake Nickel Deposits, Sask.", July 6, 1938.

The relief of the area is typical of the Laurentian Plateau region, the edge of which is marked by Lake Athabaska. Nowhere is the relief greater than 400 feet. Flat-topped hills, though modified by glaciation, suggest a former peneplane. Drainage is disorganized, and countless lakes and swamps occupy the depressions.

Dinty Lake partly crosses and partly follows the strike of the bedrock. Since the physiography is largely controlled by glaciation, local modifications are not necessarily guides to the geological structure.

(c) Petrographic Study and Acknowledgments.

During the winter months of 1939-40 the writer devoted considerable time to the examination of diamond-drill core samples from the property. A set of thin sections made from the cores were studied in detail by means of the petrographic microscope.

The writer wishes to express his indebtedness to Dr. C.O. Swanson for the use of the materials and equipment, and for the many helpful suggestions and frequent words of advice which were invaluable in the undertaking of this work.

General Geology.

(a) Principal Rock Units.

The underlying bedrock of the area is the regional granite gneiss. It consists of highly metamorphosed sediments varying in texture from banded quartzitic paragneiss to a rather basic and gneissic granite or orthogneiss. The paragneiss is uniformly banded suggesting an original sedimentary bedding, but there are no horizon markers. The more massive orthogneiss has the characteristics of an intrusive rock in certain parts but other specimens show a gradation into streaked and foliated gneiss with basic clots and inclusions.

The largest and most notable inclusions are the masses of pyrrhotite-bearing norite. They range in composition from biotite-rich norite to pyroxenite dense with pyrrhotite and through gneissic portions to highly felspathic types called "anorthosites" for convenience. These varieties include many altered and hybrid types believed due to processes of granitization. To the confusing mixtures of granite gneiss and norite types the term "migmatites" is applied.

A great many irregular pegmatite dikes cut the gneiss and norite. Intruded into all three are a few lamprophyre dikes of fresh massive material with dark mica phenocrysts.

The economic value of the property is based on the nickel content of the pyrrhotite. Assays show that even the rich parts of the deposit contain only .2 to .5 percent nickel, and therefore connot be commercial ore.

(b) Structure

The regional structure is shown by the conformable banding of the paragneiss. No such extensive interpretation of the intricately folded sedimentary gneiss has yet been worked out, however, for mapping, made difficult by widespread glacial deposits and sand plains, is still very disjointed.

In the vicinity of Dinty Lake the structure is fairly uniform. The banded gneiss assumes a north-south strike with a variable dip to the west, and generally conforms to the elongation of the norite zone. The western part of this area has a steep dip and is generally well banded. Near the ore bodies and to the east, however, the more massive gneiss is interpreted as forming structural terraces to which the norite also conforms. This structure involves flat dips to the west.

The conformable nature of the main norite body was determined by diamond drilling as shown in Plates I and II. This leads to the conclusion that it was originally a concordant intrusive, probably a sill.

Numerous cross-faults with small offsets cut the gneiss and norite. Most of them are practically vertical and strike west to northwest. Some of these are occupied by the pegmatite dikes which are only a few feet wide, while coarsely brecciated material defines the others.

Another set of faults strikes 40 to 70 degrees east and dips steeply to the northwest. They are poorly defined and no displacement is apparent. The lamprophyre dikes follow these fractures which cut all other bedrock. Only by the slightly magnetic property of the dikes can these injections be traced on the surface.

The structure of the area in question is seen, from this outline, to be quite simple, with very few features which might complicate the reconstruction of the original ore body.

In mapping the area Dr. Swanson[1] found no trace of structural features such as "sedimentation" structure within the norite itself.

[1] Personal communication.

Diamond-drill Cores and Thin Sections.

The specimens referred to in this study were selected as representative samples of the rock types in the area. They are taken from three of the twelve diamond-drill holes sunk in and near the main Borealis deposit. All three holes (D.D.H.1,2,3; Plate II) lie in the same vertical east-west plane, and are arranged as shown by their numbers. From the structural relations of the norite it can readily be seen that with this arrangement the specimens represent different stratigraphic horizons in their respective drill-holes and follow no known structural or constricting features.

From the 59 specimens at hand 18 thin sections were cut. They were selected to represent the more typical rocks, and their distribution is indicated in Plate II. The following table gives the index number, location, and essential nature of each thin section.

The microscopic examination of these thin sections constituted the sole means of textural and quantitative determination. The remaining specimens proved helpful megascopically, and grains of several were examined under the microscope in refraction oils as a check on their mineral composition.

No.	D.D.H.		Rock Type.
D.L. 1*	1	356'	Biotite granite, "normal" granite gneiss.
3	3	33	Gneissic granite, with gar. and qtz..
6*	1	500	Granitic gneiss, sedimentary.
7	3	117½	Andesine rock, with chlor. and qtz..
9*	1	609	Granitic gneiss, cataclastic.
10	2	40	Garnet gneiss, typical.
14*	1	308½	Garnet gneiss, near pyr. inclusion in gr..
18	1	62½	Contact pyr.-pyroxenite and gar. gn..
21	1	166	Garnet gneiss, with pyr.-pyx. inclusion.
24	3	85	Altered norite, with pyrrhotite and mica.
30	1	215	Altered norite, with scattered pyrrhotite, etc.
35	1	231	Altered norite, with amphibole and chlorite.
37	2	55	Typical norite.
40	2	172	Altered pyroxenite, with pyr. and amph..
46	3	160	Contact pyr.-pyroxenite and gar. gn..
57	2	121	Mica lamprophyre, near upper contact.
58	2	125	Mica lamprophyre, center.

* Situated well beyond the limit of the norite.

Aside from the petrographic difficulties, the fact that the thin sections constitute an infinitesimal part of the rocks which they represent, indicates that they cannot be accurate quantitative guides to the rock composition. This is especially true in the present case where the rocks known to be heterogeneous and irregularly altered. Moreover, the thin sections show wide variations even in the same type of rock. This feature, however, is the essential characteristic upon which this study is based, for the fundamental problem is the interpretation of these variations.

Petrographic Description of the Rock Types.

(a) Regional Granite Gneiss

As described in general on a preceding page the granite gneiss varies widely in texture and composition in different parts. The variations are believed to be due partly to original differences in the composition of the sedimentary rocks but mainly to differences in the degree of granitization. As a basis for comparisons, the "normal" granite gneiss may be described as the most highly recrystallized rock showing the mineral characteristics of an altered rock.

Of the four representative thin sections of the regional gneiss, section No.9 appears to be most highly recrystallized, but quartz, the characteristic mineral of the sediments, is not present. Section No.1, then, is taken as the "normal" granite gneiss. Its composition compares fairly closely to that of No.6 in which a sedimentary bedding is preserved. These rocks are composed essentially of quartz (30%) and orthoclase (40-60%) with biotite (5-20%) and garnet 2-8%) as the common accessories. Small amounts of magnetite and pyrrhotite are usually present among the dark minerals. A few grains of medium plagioclase and some sericite flakes occur with the orthoclase. The garnet is a pinkish variety, probably almandite, and commonly contains inclusions of quartz, biotite, and magnetite. The larger garnet crystals are invariably fractured, and in both sections the fractures have a common orientation, indicating stress conditions. The texture of the light minerals is allotriomorphic microcrystalline but the accessories usually form large streaks or clots. The other specimens of granite gneiss differ from the "normal" in mineral proportions and texture. One section shows an abundance of quartz and another very little. Cataclastic textures are common.

(b) Norite and Related Types.

(1) Norite

The least altered norite is a hypidiomorphic fine grained to microgranular rock. Hypersthene and a few grains of enstatite make up 65 percent of it, and labradorite ($Ab_{45}An_{55}$) about 15 percent. Reddish-brown biotite is present in amounts up to 12 percent, and associated with it are a few grains of titanite with magnetite (?) rims. These minerals are all primary, for the first indication of alteration is a streak at one edge of the specimen where sericite has reduced the plagioclase to a few barely recognizable remnants.

An altered norite specimen, though difficult to distinguish from the unaltered rock in the hand specimen, shows only a textural similarity under the microscope. No trace of pyroxene remains, but it is replaced isomorphously by fibrous uralite rimmed by chlorite. The plagioclase is a sodic andesine and is interstitial between the dark minerals. It is slightly sericitized. Biotite shows a tendency to be concentrated in schistose streaks. Each of these minerals compares closely in abundance with the corresponding minerals in the unaltered norite.

(2.) Pyroxenite

The norite grades into pyroxenite by a decrease in the amount of felspar. In most specimens labradorite is completely substituted by pyrrhotite. A small proportion of augite is also developed. In the fresh pyroxenite biotite is the only accessory mineral.

Alteration products commonly present are garnet, amphibole, magnetite, and secondary biotite. A specimen of highly magnetic pyroxenite consists of fibrous uralite enclosing scattered pyrrhotite and minor amounts of biotite and chlorite.

(3) Hybrid Types

The highly altered types of rock within the norite body are represented by the majority of the specimens. It cannot be assumed from this that there is necessarily a preponderance of hybrid material in the body, yet from the field relations such types are found to persist over large portions of the norite area. No estimate of the proportion of unaltered norite and pyroxenite has been made, but the bulk of this frayed sill is probably affected by granitization.

Of the many hybrid types at hand, the most common is a migmatite closely related to the norite. There is no truly representative thin section of this, but powdered specimens under the microscope were examined. They are rich in both sodic and medium plagioclase with considerable biotite and garnet. The mineral relations are shown by a thin section of a more granitic type. The sodic felspar (oligoclase) contains andesine-labradorite as poikilitic inclusions. Both reddish and black garnet are present as small rounded grains. Magnetite and biotite are associated with them forming gneissic clots. A few pyroxene grains also occur with the garnet Another thin section is about 80 percent andesine with small amounts of quartz and albite. Chlorite is present as veinlets crossing the whole specimen.

When describing the fragmental material of the norite exposure, Cooke[1] probably referred to a migmatite type close to the norite composition. He observes that "the rock --- is rather fine-grained, equigranular, and dirty gray, about the texture and grain size of loaf sugar. In hand specimen it is readily mistaken for a fine-grained, rather basic granite, or gneiss. --- The feldspar is andesine, $Ab_{60}An_{40}$ to $Ab_{55}An_{45}$, and on the whole is fairly fresh ---. Its proportion varies, in different fragments, from about 30 percent of the thin section to nearly 100 percent". These felspathic varieties have been called anorthosites.

Garnet gneiss is another variety of hybrid commonly found in the norite body. It consists mainly of plagioclase and garnet, with the usual accessory minerals of the regional gneiss. Quartz is abundant in certain specimens and forms a mosaic pattern. Alkali felspar may also be present as isolated patches.

There is no gradation from the norite or pyroxenite into the garnet gneiss. The contact zones are very narrow, alteration products such as garnet and sericite are confined to a quarter inch width at the edge of the pyroxenite masses.

In contrast to the fresh appearance of the minerals in the typical norite, the biotite in hybrid types is usually bleached, or partly altered to chlorite. Sericite

[1] Cooke, H.C., Goldfields Area, Sask., Geol. Survey. Can., Prelim. Report, Paper 37-3, (1937) p. 19.

is almost invariably present among the felspars, and amphibole is not rare as an alteration product of pyroxene.

(c) Pegmatites

The veins or dikes which follow east-west cross faults of the area consist of quartz and soda-rich felspar (oligoclase) with minor amounts of garnet, chlorite, and magnetite. Except for the slight chloritization these pegmatites appear to be unaltered.

(d) Lamprophyres

Thin sections of the lamprophyre dike material show no effects of granitizing solutions. This is in agreement with their crosscutting relationship to all other rocks in the area.

The texture and composition of the lamprophyre is shown by two thin sections from a dike within the norite body. The central part has phenocrysts of phlogopite, potash felspar, and magnetite. Some euhedral felspar crystals are intermediate in size. Near the contact there is only a slight decrease in the size of the phenocrysts, and the matrix is somewhat richer in hornblende and magnetite.

Phenomena of Granitization.

The following section will be devoted to a summary of the petrographic evidence upon which the conclusions of this study are based. The evidence is not all microscopic, however, in fact the main arguments have been observed in the field. "That the granite gneiss has intruded the norite is shown by the shape of the norite, by the development of hybrid rocks due to reaction between the norite and the granite, and by the presence of isolated slabs or fragments of pyrrhotite-bearing norite at some distance from the main contacts".[1]

There is also abundant petrographic evidence of granitization throughout the area. That the regional granite gneiss was developed by the granitization of sediments needs no support from the present study, for the structural relations and mineral composition, along with the widespread and erratic occurence, preclude any possibility of an igneous origin. In confirmation of the granitization process, however, thin sections of the granite gneiss, representing rocks more than 100 feet outside the main contacts, show microscopic evidence. A typical specimen of the regional gneiss as described in the preceding section has very nearly the same mineral composition as another specimen which still retains the banded appearance of a thin-bedded sediment.

[1] Swanson, C.O., Report on Dinty Lake Nickel Deposits, Sask., July, 1938, p.8.

Petrographic features of the norite complex, which support the idea of granitization and help to explain the structural phenomena, include variations in texture and mineral relations. At the contacts between the garnet gneiss and pyrrhotite-bearing pyroxenite certain alteration products develop which are no doubt due to a reaction. The contacts are are quite sharp in two thin sections. One of these (No. 18) shows garnet and pyroxene grains grouped in gneissic fashion in the gneiss, and garnet rims developing around hypersthene grains of the pyroxenite. Biotite and magnetite are extensively developed along the contact zone and among the gneissic clots.

Section No. 46 shows a sharp contact between pyroxenite and a coarse band of andesine. Narrow streaks of hypersthene, garnet, and biotite run parallel to and near the contact. The hypersthene is a highly ferruginous variety, some crystals containing tabular inclusions. The pyrrhotite is granular and interstitial, and has inclusions and rims of magnetite which appear to be related to the biotite flakes. There is considerable sericite developed in the felspar area, but the process is nowhere near completion. The felspar is basic andesine and contains no accessory minerals.

An inclusion of pyrrhotite-bearing pyroxenite in a similar felspathic type is represented by section No. 21. No garnet is present, but the evidence of alteration consists of rims of fibrous amphibole between the grains of hypersthene and pyrrhotite. The border of the inclusion is quite irregular and remnant grains of pyroxene are scattered through the gneiss. Biotite is abundant between the dark minerals, and several flakes of it in the thin section are bleached to a pale green with streaks of iron oxide deposited parallel to the cleavage.

Through all specimens of typical garnet gneiss which are located within the norite, tiny rounded grains of pyroxene occur with larger garnet crystals and biotite flakes. The biotite is more closely associated with pyroxene than with garnet.

The general character of the migmatites as described in a preceding section is evidence of an advanced stage in the granitization process. The development of untwinned sodic plagioclase indicates the high degree of regional metamorphism.

Process of Granitization

An interpretation of the petrographic details described above leads to an acceptable explanation of the processes controlling the granitization. The conclusion is not arrived at, however, without investigating more than one possibility as to the original nature of the norite inclusion. Omitting any discussion of the granitization of the regional sediments -- assuming from the fragmentary evidence that the process was a normal one - the discussion will be confined to the norite changes.

(a) The Anorthosite Problem.

From the irregular distribution of the pyrrhotite, the large tongues of gneissic granite, and masses of hybrid rocks within the ore body, the possibility of original differences in composition is suggested. The arbitrary boundaries between some of the main rock types as shown in Plate II suggest an original banded structure. The existence of primary anorthositic layers might be taken as a possible explanation of the plagioclase-rich rocks.

In describing the norite in other parts of the region, Alcock noted that "an interesting feature in connection with these rocks is the occurrence of complementary varieties, some dikes consisting of labradorite with only minor amounts of pyroxene and iron oxide and others being made up almost completely of orthorhombic pyroxenes".[1] It is not clear, however, whether both varieties occur in the same "dike". The possibility of such a situation is worthy of serious consideration in the present case, for a composite sill of complementary varieties is remotely concievable.

The main structural argument in favor of the anorthosite bands is the rough correspondence of the gneissic horizons in three drill holes, and the injection of tongues of gneiss parallel, in general to the floor of the sill. The

[1] Alcock, F.J., Geology of Lake Athabaska Region, Sask., Can. Geol. Survey, Mem. 196, (1936) p. 19.

evidence for this, however, is fragmentary, and the correspondence may easily be coincidental. There are confusing occurrences of gneiss and norite in places where the specimens are more closely spaced, showing that interpolation for large distances is not possible.

The more convincing of the possible petrographic arguments are (1) that the sharp contact between pyroxenite and andesine rock types is the result of an injected plagioclase layer into a still hot norite body, and (2) that the existence together of calcic and sodic plagioclase in migmatite is the result of granitization of the anorthosite.

The refutation of the first of these arguments is that it is not reasonable to assume a series of such injections of anorthosite into a sill. The second is faulty in that the basic plagioclase is not labradorite and in any case it could be developed from norite, the pyroxene going to form garnet, chlorite, and mica.

(b) Granitization of Norite

There is now no reasonable argument, from the study of the thin sections, to oppose the idea of an original norite body which had no anorthositic variations. The possibility of crystal sorting, to cause labradorite-rich layers,has no supporting evidence. There are no labradorite rocks represented, and there is no gradation between such a type and the norite. Besides, there is more than one felspathic band to account for.

Further evidence supporting the homogeneous nature of the original sill includes the nature of the plagioclase and the distribution of the femic minerals. The most calcic plagioclase is observed in the unaltered norite, and has a composition of $Ab_{40}An_{60}$. As granitization effects increase, felspars of a more sodic composition are formed as shown by the hybrid types in which the felspars range from labradorite, $Ab_{45}An_{55}$, to Andesine, $Ab_{65}An_{35}$, with a steady gradation. Gneissic hybrids represent all stages in transition, but those more closely in contact with pyroxenite have the more basic felspars.

That the gneiss has intruded the norite is also indicated by the development of gneissic clots of monoclinic pyroxene, biotite, and garnet by reaction of the granitizing solutions on the norite. The alteration is definitely shown by the phenomenon of rimming at the gneissic contacts as previously mentioned.

The granitization of the norite complex involved considerable addition of material. Assuming section No. 37 to be typical of the original norite, it can be seen that to produce the migmatite type such as No. 30 its composition must have been changed appreciably.

To account for the formation of garnet of the almandite variety, brown biotite, and monoclinic pyroxene from the original combination of hypersthene and labradorite, very little gain or loss of material is necessary. The abundance of chlorite and amphibole, however, suggest the addition of silica and water. Since orthoclase is rare in the granitized body, potash is assumed to have been confined to the sedimentary gneiss. The presence of soda plagioclase in considerable quantities may be ascribed to residual alkali liquid after the reaction between the norite constituents.

It is reasonable to assume, therefore, that the injection of acid solutions from the underlying granite was the only important addition of material in the granitization process.

(c) Accompanying Effects

The same factors of temperature and pressure which accompanied the regional granitization, caused a rearrangement of the pyrrhotite. Originally the sulphide probably occurred as a primary mineral, being disseminated through parts of the norite with a fair degree of regularity. The effect of the granite injection was, no doubt, to concentrate the pyrrhotite from granitized parts, injecting them into the complex in the form of thin seams.

The folding which is so evident throughout the area was undoubtedly a major factor in the granitization process. By way of fissures and fracture zones the rearrangement of the sulphides which it caused, was facilitated. The abundance of pegmatites which follow a definite set of fractures is conclusive evidence that the movement was contemporaneous with the granitization process. The coarsely crystalline quartz-felspar pegmatites which are cut by seams of sulphides can only be ascribed to fracturing and magmatic injections as a late stage in the granitization process.

Geologic History.

From the preceding discussion the sequence of events in the development of the norite complex at Dinty Lake can be briefly summarized: The origin of the ore body dates back to a pre-Cambrian, a time when thick sediments covered the area. The least metamorphosed remnants of these, and the general composition of the resulting gneiss, indicate that they were largely composed of coarsely fragmental and highly aluminous material, probably in the form of argillaceous quartzites.

The norite complex was then injested into the sediments as one member in a series of such intrusions in the region. The nickel-bearing pyrrhotite accompanied the original magma and was deposited among the minerals of the norite.

Regional folding followed this development after the lapse of an undetermined period of time, and granitic injections into the sediments and the igneous bodies of the entire region. This transformed the sediments largely into a granitic gneiss, but much of the original bedding is still preserved by coarse banding.

The norite complex was transformed by the granitizing solutions into the frayed lenses which remain in evidence along a definite stratigraphic horizon of the surrounding gneiss. The remnants of norite which remain show that although the sill was not entirely assimilated, a considerable part of it was metamorphosed, with the development of migmatites and other gneissic hybrids. The least altered norite shows signs of hydrothermal alteration. Tongues of garnet gneiss penetrated the sill to great distances. The regular distribution of the sulphides was disturbed, resulting in the production of dense pyrrhotite-bearing pyronenite and seams of sulphide along brecciated zones. Pegmatite dikes were formed as a late phase of the igneous activity, and occupied a set of cross faults in the region.

Further movements at a later time caused another series of fractures which was accompanied by the injection of lamprophyre dikes. A small amount of pyrrhotite was again rearranged, and was deposited in seams which cut the slightly sheared lamprophyres.

Since the time of these developments, the only changes have been erosion, weathering, and extensive glaciation.

Conclusion

The nickel-bearing norite body at Dinty Lake has undergone a radical transformation. Part of it has been assimilated by granitic intrusion, while the remaining part has suffered various degrees of alteration. The granite gneiss which has developed within the borders of the norite can be distinguished in its petrographic features from the regional gneiss. The essential processes controlling the granitization were the regional folding and the introduction of acid emanations from the underlying granite. The original nature of the deposit was a pyrrhotite-bearing norite sill which, except for the distribution of pyrrhotite, was essentially homogeneous throughout.

Bibliography.

Alcock, F.J., The Geology of the Lake Athabaska Region: Can. Geol. Survey, Mem. 196, (1936).

Cooke, H.C., Goldfields Area, Sask., Geol. Survey. Can., Prelim. Report, Paper 37-3, (1937).

Swanson, C.O., Report on Dinty Lake Nickel Deposits, Sask., July, (1938).

Plate I

MAP OF MAIN BOREALIS DEPOSIT

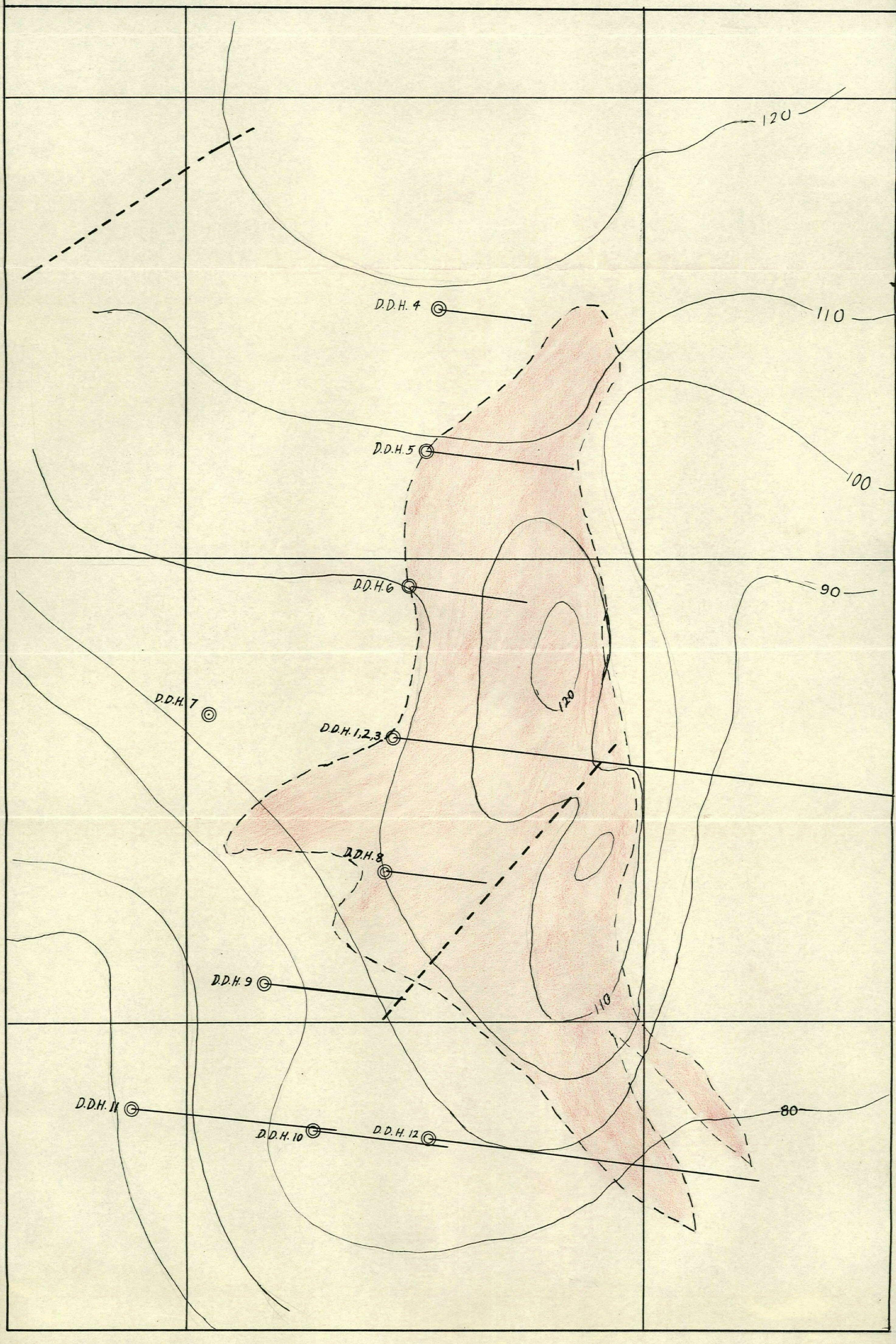
Norite complex and Hybrid Rocks

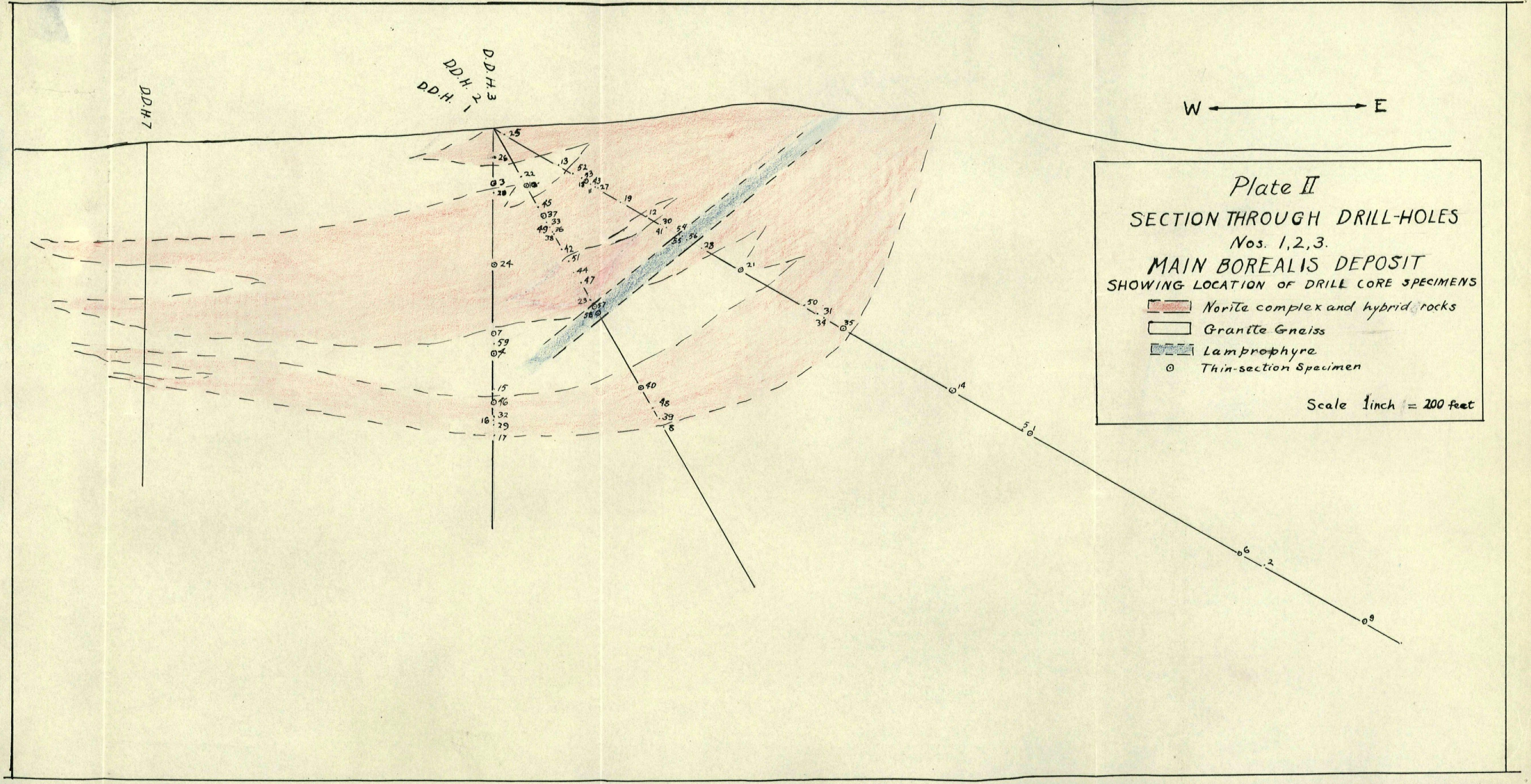
Granite Gneiss

Lamprophyre

Contours show elevations above Dinty Lake

Scale 1 inch = 100 feet




D.D.H.7
D.D.H.3
D.D.H. 2
D.D.H. 1
W
E
Plate II
SECTION THROUGH DRILL-HOLES
Nos. 1,2,3.
MAIN BOREALIS DEPOSIT
SHOWING LOCATION OF DRILL CORE SPECIMENS
Norite complex and hybrid rocks
Granite Gneiss
Lamprophyre
Thin-section Specimen
Scale 1inch = 200 feet