UNIVERSITY OF MANITOBA

Thesis

THE GEOLOGY OF THE KENORA AIRPORT AREA

Submitted by

John Morris Hodgkinson

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ABSTRACT

A geologic map of approximately 90 square miles of the Kenora Airport Area is presented, with a scale of one inch to one mile.

One area of greenstones and amphibolites, the Keewatin Metavolcanics, and two areas of granitic rocks, intrusives of the Dryberry Dome and the Melick Gneiss Group, are major rock type divisions.

A fault is proposed between the Melick Gneiss Group and the Keewatin Volcanics.

The petrography of these rocks is described, and the chemical composition of the Keewatin greenstones is discussed on a basis of nine rock analyses.

A study of the crystallographic structure of the potassium feldspars in the Dogtooth Leucoadamellite found little variation in obliquities ($\Delta = 0.85$ to 1.00 ± 0.025). The area is not suitable for a statistical study of the relationship between obliquity and rock composition.

A geological history of the area is suggested, with one phase of regional metamorphism north and another south of the fault. It is not known if these two phases were contemporary.

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CHAPTER I

INTRODUCTION TO THE KENORA AIRPORT AREA

The mapping and study of the petrology of the rocks in the area north and east of Kenora, Ontario, was undertaken in 1960 and 1961, to correlate with a gravity survey which was made by Colin Riley, of the Department of Geology, University of Manitoba.

Colin Riley's work, which is now completed (Riley,1965), was concerned with the area of the contact between the Keewatin Volcanics and the "Laurentian Granites". The most up-to-date map of this area prior to the completion of the one presented with this thesis was that of A. C. Lawson (1885) with minor alterations by A. L. Parsons (1913). Davies and Pryslak (1967) have published a map which includes this area, since the thesis mapping was completed. The chief purpose of this thesis is to provide an improved map of the area to aid the geophysical interpretation.

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My gratitude is due to Dr. A. Turnock for both his help and encouragement.

Mr. Ken Ramlal, Department Analyst, provided the chemical analyses of nine samples of Keewatin Volcanics, also the Na_2O, K_2O and CaO composition of six granitic rock specimens which were necessary for the study of the structure of potassium feldspars of the Dogtooth Leucoadamellite.

Dr. J. C. Davies, Resident Geologist at Kenora, also provided generous help, and Prof. R. B. Ferguson advised with the X-ray Crystallographic work.

LOCATION AND ACCESS

The area comprises about ninety square miles north and east of Kenora, Ontario, close to the north shore of the Lake of the Woods.

The paved highways in the area are: the Trans-Canada Highway, the Fort Frances Road, and the Reddit Road. In addition to the paved roads there are several gravelled and dirt roads, and the well graded Jones' road, which is a private road. The Trans-Canada Highway has been in places re-routed subsequent to the field work.

In most parts of the area the roads were sufficiently close together to provide adequate traverses for the scale of mapping needed.

PREVIOUS WORK

Robert Bell (1883) published a reconnaisance map and a brief report of the Lake of the Woods area. A. C. Lawson spent two summers and part of a third working in the Lake of the Woods area from 1883 to 1885, and he published a detailed report and map in 1885. Both Bell and Lawson had to survey topography, as well as geology, as no base maps were available. Lawson's topographic map was more accurate than Bell's.

Lawson gave the name Keewatin to the greenstones (altered volcanic and sedimentary rocks) in the Lake of the Woods region. He introduced this new term because he thought they were older than the typical "Huronian" as described in Geology of Canada, written by Sir William Logan in 1863 (Lawson, 1885, p.10). This term has since been applied to the oldest metavolcanic rock in the regions throughout the Superior Province of the Canadian Shield. It has thus become a semi-lithological term rather than a stratigraphic term. If the term has any validity as a stratigraphic term, it is in the Lake of the Woods region, which is the type locality, although a type section has never been described. In 1905 a report from a Special International Geological Committee confirmed Lawson's main findings (Van Hise (1905)).

A. L. Parsons made additions to Lawson's map of the Lake of the Woods area following field work in the summer of 1912. (Parsons, 1913).

The map presented with this thesis (Figure 1, p.80) is the first new geological map of the Kenora Airport Area to be published since 1913.

From 1913 until 1931, the additions to the literature of the area were brief descriptions of mining properties: Hopkins (1921) and Bruce (1925).

In 1931 G. G. Suffel described the geology of the Bigstone Bay Area, which is south of the area described in this thesis. Suffel divided the Precambrian rocks into three systems: Keewatin, Laurentian, and Keweenawan. Suffel (p.68) described east-west folds in the greenstone at Bigstone Bay which are consistent with more extensive emplacement of the Laurentian granites along the anticlines than along the synclines.

J. E. Thomson (1937) described the geology of the north central part of the Lake of the Woods, an area south-west of the thesis area. It is west of, and adjoins the Bigstone Bay Area, mapped by Suffel. This area is important to the present study because the Keewatin rocks described therein appear to be along the strike from the Keewatin of the map area.

Thomson divided the Precambrian of the area into four systems: Keewatin, Timiskaming, Algoman, and Keweenawan. The Keewatin is by far the most widespread. The Timiskaming is restricted to a small outcrop area seven miles long in the centre of his map area, which is about eight miles from the thesis area. The Algoman rocks occur "(1) as the border phases of the large granite batholiths lying north and south of the greenstone belt on the Lake of the Woods, and (2) as small intrusive stocks within the boundaries of the older lava-sedimentary complex". (Thomson, 1956, pp.18-19).

Thomson notes considerable variation in the texture, composition, and colour of these Algoman rocks, but no evidence was found of more than one period of plutonic invasion. Much more recently, J. C. Davies (1965) has described the geology of the Ewart and Forgie Townships, which are thirty miles west of Kenora. He reports acid plutonic rocks of two distinct periods of emplacement.

Thomson (1937, pp.20-21) describes a quartz diabase which forms northwest-southeast trending dykes up to 300 feet wide. These dykes are "...presumably part of the Keweenawan basic intrusives so commonly found in the Lake Superior region." (Thomson, 1937, p.20).

Goodwin (1965) has compiled a map of the Lake of the Woods area, and has divided the Keewatin into two complete volcanic sequences. His map did not extend north of the Trans-Canada Highway, into the thesis area, but the compilation of Davies (O.D.M. Map 2115, 1967) does.

CHAPTER II

GENERAL GEOLOGY

INTRODUCTION

Figure 1 (p.80) is a geological map of the Kenora Airport Area, on a scale of one inch to one mile. The base map were compiled from air photographs. The geologic data was obtained by: traverses along the roads; shore-line mapping; and traverses through the bush at key locations. Most of the fieldwork was done in the autumn of 1960. Figure 2 (p.81) shows all sample locations by numbers on the map. Where two or more samples are taken from one outcrop they are identified by a small-case letter.

The area is roughly rectangular, six miles by eighteen, and its long dimension trends north-west. Precambrian and Pleistocene rocks are exposed. About 18 square miles (15%) of the bedrock area is occupied by greenstone, the remainder (85%) by granite rocks. The unconsolidated Pleistocene and Recent rocks have not been mapped. They are noted, only where their thickness precludes the study of the Precambrian.

The Keewatin Volcanics strike north 40° east across the map area, thereby separating the granitic rocks into two distinct areas.

Northwest of the Keewatin Volcanics, in and around Melick Township, the granites are further divided into two types. Adjacent to the volcanics the rocks are strongly banded. Farther north there is no banding.

Southeast of the Keewatin Volcanics six intrusive plutonic rock types are distinguished in the "Dryberry Dome" granitic complex. Four are gneissic and two are massive. All have acid composition. Pegmatitie, granite, and aplite dykes and quartz veins cut all the earlier rocks.

No Keweenawan dykes were encountered, although quartz diorite dykes have been mapped in the adjoining areas to the south (Suffel, 1931, p.67) and to the south-west (Thomson, 1937, pp.20-21) of the Kenora Airport Area. Davies and Pryslak (1967) have since reported diabase in the western part of Dogtooth Lake.

A list of the formations in the Kenora Airport Area is given in Table 1. Petrographic descriptions of the rock types are contained in Appendix A.

THE KEEWATIN VOLCANICS

The Keewatin Volcanics occupy the central part of the Kenora Airport Area, between the Melick Gneiss, to the northwest and the plutonic intrusives of the Dryberry Dome, to the east. These Keewatin Volcanics are part of a "belt of schistose rocks" which A. C. Lawson (1885, p.10) named the Keewatin rocks, after the town of Keewatin which is 3 miles west of Kenora. Lawson rejected the name "Huronian" which had previously been used by Bell (1873, p.102) for this belt of schistose rock because he did not consider

TABLE I

TABLE OF FORMATIONS

CENOZOIC	
Pleistocene and Recent	Sand, Gravel and Boulder Clay
PRE-CAMBRIAN	
Melick Gneiss Group	Minor Intrusions:Pegmatite, granite, and aplite
	Melick Granodiorite
	Melick Gneiss
Granite Intrusives of the Dryberry Dome	Porphyrytic Adamellite
	Dogtooth Leucoadamellite
	Dogtooth Granodiorite
	Hilly Lake Biotite Granodiorite
	Longbow Granodiorite Gneiss
Keewatin Volcanics	Amphibolite-Medium Grained
	Acid Schist and Basic Schist
	Amphibolites-Fine Grained including pillow structures, Agglomerates, and sediment.

them equivalent to the "typical Huronian of Sir William Logan, as described in the Geology of Canada (1863)" (Lawson, 1885, p.10). Since Lawson used the term Keewatin, it has been applied to the oldest basic volcanic rocks exposed in localities throughout the Superior Province of the Canadian Shield. This has led to a loss of precision that the term might have had when applied solely to the rocks in the type locality. Horwood, in the Geology and Mineral Deposits of the Red Lake Area (1945, p.17), says "No attempt has been made to prove the ages of the various formations and the names Keewatin, Timiskaming, and Algomian have been used simply to show that these formations are similar to formations that bear the same name in other sections of the Pre-cambrian Shield." MacDonald describes the Geology of Gorham Township and Vicinity in which the volcanics "...are classed as Keewatin because of their lithological similarity to the type Keewatin Rocks." (1941,p.4).

J. M. Harrison (1957, p.29) states that, presumably, the term "Keewatin" now means the oldest volcanic rocks of any area in the Pre-cambrian of Ontario and Quebec. In the Burchell Lake Area, which is 65 miles east of Port Arthur, Ontario, P. E. Giblin (1964, p.6) has used "Metavolcanics" to refer to rocks which had been termed "Keewatin" by T. L. Tanton (1938). He thereby has refused to perpetuate use of the term "Keewatin" as a lithological term.

Thomson (1937) has separated part of the sedimentary rocks from the Keewatin and named them Timiskaming. Goodwin (1965) has subdivided the Keewatin into Upper and Lower parts, each of which is represented by the sequence: basic volcanics, acid volcanics, and sediments. However, until definitive mapping can provide evidence on which the subdivision of the Keewatin rocks can be made, consistent with the rules of the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961) the term "Keewatin" should be used, as it was by Thomson, for the rocks of the schist belt of the Lake of the Woods Area, which includes both meta-volcanic and meta-sedimentary rocks.

The volcanic rocks in the Kenora Airport Area are part of what A. C. Lawson mapped as Keewatin rocks. They are herein named the Keewatin Volcanics.

The largest part of the outcrop area of the Keewatin Volcanics is occupied by basic volcanics. Within the area of the basic volcanics a roughly triangular area of acid and basic schists occurs. A zone of coarsely crystalline amphibolite cuts the other two parts of the Keewatin Volcanics. The rock types within the three zones of the Keewatin Volcanics are: (a) fine grained amphibolite, which is, in part, pillow lava and agglomerate, and sedimentary rocks; (b) basic schist, sericite schist, and "porphyrytic" sericite schist; and (c) coarse grained amphibolite. The petrography and chemical data for these rocks are contained in Appendices A and B.

FINE GRAINED AMPHIBOLITE

The fine grained amphibolite varies in texture from fairly massive with conchoidal fracture to well lineated and schistose.

The structures in the rock are difficult to see on fresh surfaces, but on well weathered surfaces pillow lavas and agglomerate are recognized.

Pillow lava (Specimen 22) is well exposed at the intersection of the C.P.R. tracks and the road which passes south of Lawrence Lake. It has been chemically analysed (Table 6).

One layer, 30 feet wide, of interbedded metasedimentary rock (quartz-biotite-schist) and amphibolite was encountered south of Black Sturgeon Lake (Specimen 8, see Figure 2). The sediment increases in proportion to the amphibolite towards the north-west side of the layer.

ACID AND BASIC SCHISTS

The acid schists are sheared volcanics. Agglomeratic structures are recognized on some weathered surfaces. Other rocks are less sheared than the majority and have preserved a cherty lustre which is typical of fresh silicious aphanitic lava. The shearing has developed sericite schist.

Quartz and feldspar porphyries are common among the less sheared rocks, and in some of the sericite schists relic phenocrysts of quartz can be seen.

The basic schists are well exposed in road cuts south of Lawrence Lake. They are very fine grained rocks which weather to a fairly light colour, in consequence of which it might easily be mapped as acid volcanics if the control of chemical analysis is not available. Two specimens of basic schist (Nos. 16 and 18) were analysed, and both contain less than 50 per cent SiO_2. Descriptions of these specimens are contained in Appendix B. Both basic schists are very fine grained and show rough bands which may reflect original layering. They are considered to be meta-tuff. Carbonate is abundant in them. The carbonate is probably secondary.

COARSE GRAINED AMPHIBOLITE

Medium to coarse grained amphibolites occur at places within the Keewatin Volcanics. The alignment of some of the outcrops indicate a continuous band across the outcrop area of the Keewatin Volcanics. Because they are found close to very fine grained amphibolite, the grain size is considered to reflect the original texture, rather than be result of the metamorphism which has affected all the Keewatin Volcanics. Such a texture strongly suggests that the coarse grained amphibolite is a metamorphosed sill or dyke, rather than a flow. However, thick flows can crystallize to form coarse grained primary igneous rocks.

The details of the mineralogy of the Keewatin Volcanics are given in Appendix A. Among the basic amphibolites there are two main mineral assemblages, which can be distinguished by the type of amphibole: (a) Hornblende-epidote-plagioclase; (b) Actinolite-plagioclase. These types are typical of the fine grained amphibolites and the coarse grained amphibolites respectively. Mineralogic variation occurs within both types. Secondary biotite, chlorite, and calcite are present in some specimens. Zoisite is present in one section of the coarse grained amphibolite.

The Keewatin Volcanics have suffered at least one period of regional metamorphism, which has produced parallel folding and probably isoclinal folding at a great depth, and which has altered almost all the rocks of basaltic composition to amphibolite. This makes structural description of them very difficult. A further complication in any structural interpretation of the Keewatin Volcanics is that although basic flows are normally of uniform thickness, the more viscous, acid flows may form most irregular shapes, therefore a simple layered structure, with layers of uniform thickness, cannot be assumed for the original form of the rocks.

The variation of the chemical composition, based on the analyses of 9 samples, is discussed in Appendix B. They show that the Keewatin Volcanics are part of a differentiated series. Wilson et al (1965) show that they belong to the basalt andesite rhyolite association, typical of continental orogenic belts or island arc systems. Carbon dioxide metasomatism is probably responsible for a reduction of the CaO content of some of the samples.

GRANITE INTRUSIVES OF THE DRYBERRY DOME

WESTERN EXTREMITY OF THE DRYBERRY DOME

The rocks of the western extremity of the Dryberry Dome (Goodwin, 1965) are acid plutonic intrusives. Granodiorite and diorite occupy the largest outcrop area. Other rocks which outcrop in this area include adamellite and amphibole-rich border phases of the granodiorite.

The oldest rocks in the western part of the Dryberry Dome are the Longbow Granodiorite Gneiss, the Hilly Lake Biotite Granodiorite, and a quartz diorite (see Figure 1). These rocks contain xenoliths of Keewatin material in their marginal parts, and are strongly gneissic.

A younger and less gneissic rock intrudes the Longbow Granodiorite Gneiss in the area between Longbow Lake and Dogtooth Lake. This is the Dogtooth Granodiorite. An even later massive pluton, the Dogtooth Leucoadamellite, intrudes the western margin of the Dogtooth Granodiorite.

Included with the descriptions of the rocks of the Dryberry Dome (Appendix A) is that of a porphyrytic adamellite stock which intrudes the Keewatin Volcanics within a quarter of a mile of the west end of the Dryberry Dome, just west of Hilly Lake.

Throughout the area of the Dryberry Dome, pegmatite, granite, and aplite dykes cut the members of the Dryberry Dome. These rocks probably represent the last stages of the acid plutonic activity.

LONGBOW GRANODIORITE GNEISS

The Longbow Granodiorite Gneiss occupies the area around Longbow Lake, after which it is named. Its western margin is in contact with the Keewatin group; and its eastern extent is limited by the complex of igneous rocks around Dogtooth Lake. The northern and southern boundaries were not mapped.

The west margin of the Longbow Granodiorite Gneiss crops out with Keewatin rocks in a high road-cut on the old Trans-Canada Highway. The relations between the two rock units have been obscured by the emplacement of pegmatite and of aplite dykes. No indication of the amount or direction of the displacement, which might have occured at this contact, was seen. Inclusions of basic fragments are common in the marginal portion of the granodiorite gneiss.

The colour of the Longbow Granodiorite Gneiss varies from pink to grey. The preferred orientation of the biotite grains imparts a gneissosity which is quite marked in the hand specimen.

Lenticular inclusions of amphibolite are locally abundant. They are oriented parallel to the foliation of the enclosing granodiorite, with which they share sharp contacts.

The texture is generally that of a plutonic igneous rock, except where local mylonization has effected recrystallization. The strong gneissosity, as mentioned above, is the result of the parallel arrangement of biotite. It is generally parallel to the contacts of the pluton and of the inclusions. The gneissosity probably developed as a result of magma flow.

HILLY LAKE BIOTITE GRANODIORITE

The Hilly Lake Granodiorite crops out beside the Trans-Canada Highway from Hilly Lake to about one mile eastwards. Suffel (1931) shows that the extent is not more than one mile south of the highway. North of the road its extent is at least two or three miles. Heavy cover of Pleistocene Sands obscures its northern boundary.

The Hilly Lake Biotite Granodiorite is younger than the Keewatin Volcanics. Sharp intrusive contacts can be observed in the road cuts along the Trans-Canada Highway. On the ridge north-west of Hilly Lake, an intrusive breccia has developed along the contact between the Hilly Lake Granodiorite and the Keewatin Volcanics. The breccia zone is one hundred feet wide at this location, measured between where the granodiorite makes up 5 per cent and 95 per cent of the total outcrop area.

The granodiorite between the lenses of Keewatin amphibolite is more mafic than at the south end of Hilly Lake. This suggests that assimilation of some of the amphibolite is responsible for a change in composition approaching diorite.

QUARTZ DIORITE

The quartz diorite is poorly exposed because of a heavy cover of sand. Three exposures were seen west of Island Lake. The rock is gneissic and it contains inclusions of basic material. The exposure nearest to the Keewatin Volcanics has many basic inclusions, and the grain size of the minerals in the quartz diorite is less than at the other outcrops.

DOGTOOTH GRANODIORITE

The rocks encountered in the north-south traverse across Dogtooth Lake, at the east end of the map area, include adamellite, granodiorite, and an amphibolite which is not shown in Figure 1. The adamellite and granodiorite grade into one another and form what is called the Dogtooth Granodiorite. The amphibolite which is intruded by dykes of the granodiorite, is probably a hybrid rock formed by an earlier granitic rock which intruded basic rocks. The variation of composition of the Dogtooth Lake Pluton is progressively more basic southwards towards the amphibolite. There is no evidence which suggests that this is caused by contamination from the amphibolite.

The contacts of the pluton with the surrounding rocks are sharp, and dykes and apophyses of the Dogtooth Granodiorite cut all the adjacent rocks except for the Dogtooth Leucoadamellite which is interpreted to have been a later intrusion.

THE DOGTOOTH LEUCOADAMELLITE

The Dogtooth Leucoadamellite intrudes the Longbow Granodiorite Gneiss and the Dogtooth Granodiorite south-east of Longbow Corner at the junction of the Trans-Canada Highway and the Fort Frances road. An apophysis of the Leucoadamellite crops out one half mile south of the road junction along the Fort Frances road, where a typical example of the rock may be seen.

Away from the highway, in the main outcrop area, exposures are extensive. High ridges with little vegetation are separated by steep sided valleys, the positions of which are probably controlled by jointing in the leucoadamellite.

The contacts of the Dogtooth Leucoadamellite with the Longbow Granodiorite Gneiss and the Dogtooth Granodiorite are sharp. The presence of rounded quartz aggregates up to 1 cm. diameter in the leucoadamellite is a diagnostic feature which makes identification in the field rapid despite the similarity of colour of the Dogtooth Granodiorite. Dykes containing the rounded quartz aggregates cut the adjacent Longbow Granodiorite Gneiss and the Dogtooth Granodiorite, indicating that the leucoadamellite is younger than both of them.

PORPHYRYTIC ADAMELLITE

A porphyrytic adamellite stock intrudes into the Keewatin rocks along the Trans-Canada Highway approximately one mile west of Hilly Lake. The outcrop is roughly oval; its major and minor axes are two miles long and one mile long respectively.

The contacts between the porphyrytic adamellite and the Keewatin rocks are sharp. Dykes and apophyses of the adamellite cut the Keewatin around the margin of the main outcrop of the formation. Also, a later pink granite cuts the Porphyrytic Adamellite.

OTHER INTRUSIVES OF THE DRYBERRY DOME

THE FORT FRANCES ROAD

Granitic rocks crop out along the Fort Frances road, south of Dogtooth Lake. They have not been studied in detail.

DYKES AND VEINS IN THE DRYBERRY DOME

Pink pegmatite, pink granite, and pink aplite veins occur throughout the intrusive rocks of the Dryberry Dome. Quartz veins are widespread, but less abundant.

MELICK GNEISS GROUP

The Melick Gneiss Group includes all of the rocks found north-west of the Keewatin rocks. The name is taken from Melick Township, which lies within the outcrop area of the gneiss.

The Melick Gneiss is adjacent to the Keewatin rocks, and the Melick Granodiorite is immediately north-west of the

Melick Gneiss. A grey gneiss intrudes part of the Melick Gneiss.

Dykes of pegmatite, granite, and aplite intrude the Melick Gneiss.

THE MELICK GNEISS

The Melick Gneiss forms a three mile wide band of mixed or interlayered amphibolites and quartzo-feldspathic rocks, which strike across the north-west part of the map area. The majority of these rocks are strongly foliated, with a strike at a slight angle to the contact with the Keewatin rocks. In the north central part of the outcrop area (Figure 2, Location 27) ptygmatic folds and intrusive contacts in the Melick Gneiss disturb the uniformity of the strike.

Outcrops of Melick Gneiss are plentiful, and at many places form cliffs as high as fifty feet. Elsewhere, flat glacial pavements expose to view the uniformity of the foliation. Road cuttings are numerous within the map area and most rock samples were collected from fresh surfaces in them.

The band of Melick Gneiss which cuts across the map area is bounded on the north-west by the Melick Granodiorite and on the south-east by the Keewatin Group. The boundary between the Melick Gneiss and the Melick Granodiorite is defined by the limit of the gneissic layering.

The southern boundary of the Melick Gneiss follows a depression, which is bounded by a discontinuous ridge. This depression is interpreted to be the surface expression of a fault. The foliation of the Melick Gneiss is inclined to the line of this assumed fault, and microscopic patches and zones of mylonite, which are found throughout the Melick Gneiss, are particularly prominent close to this southern contact. The location of both the northern and the southern boundaries of the Melick Gneiss have been recognized in aerial photographs.

The Melick Gneiss extends beyond the map area both westwards and northwards.

Masses of greenstone occur withinthe Melick Gneiss. The foliation of the gneiss is parallel to the schisosity of these greenstones. The widths of these greenstone masses vary from a few inches up to about 50 feet. They are not common, yet were seen both close to the Keewatin contact, to the south, and close to the granodiorite contact to the north.

The Melick Gneiss is cut by late granite and pegmatite dykes, as are all the major units in the map area.

The foliation in the Melick Gneiss is sub-parallel to its contact with the Keewatin Volcanics, as described above. The dips are not uniform despite the regularity of the strike. The predominant dip is steeply towards the contact with the Keewatin but dips of 40° both towards and away from the contact are recorded.

Aerial photographs show that topographic features parallel the banding of the Melick Gneiss. This suggests that softer portions of the Melick Gneiss may be less well exposed and may not have received the attention that was given to prominent quartz-rich rocks.

MELICK GRANODIORITE

A uniform, slightly gneissic granodiorite occupies about seven square miles of the outcrop area in the north-west corner of the Kenora Airport Area. This granodiorite extends at least several miles north beyond the map area. It has been named the Melick Granodiorite.

The Melick Gneiss contains bands which resemble the Melick Granodiorite, and so the boundary between the two rock types has been drawn on the textural features: that is, where the rock is strongly foliated it has been mapped as Melick Gneiss. Late pegmatite and granite dykes cut both the Melick Gneiss and the Melick Granodiorite.

OTHER INTRUSIVE ROCKS IN THE MELICK GNEISS GROUP

Near the east shore of the Western part of Black Sturgeon Lake, ptygmatic folds occur in the Melick Gneiss, and intrusive breccia is formed between a grey gneiss and angular blocks of Melick Gneiss. The Melick Gneiss was therefore rigid when the intrusion took place, and the ptygmatic folds must predate the intrusion because no similar displacement disturbance was seen in the grey gneiss.

DYKES IN THE MELICK GNEISS

Of eight dykes which were examined in the Melick Gneiss, five are pegmatite, two are pink granite, and one is aplite. One pegmatite (Location 28) is a graphic intergrowth of quartz and perthitic feldspar. A pink aplite vein cuts the Melick Gneiss and a pink pegmatite vein on the east shore of Black Sturgeon Lake, west.

CENOZOIC

PLEISTOCENE AND RECENT

Pleistocene sands and gravels are most extensive in the area around the airport and east of Jones' Road. In the rest of the area a mantle of sand and boulder clay overlies much of the Pre-cambrian but it is not very thick, and the Pre-cambrian rock protrudes through this drift cover in many places.

Glacial striae in the area strike south-west.

STRUCTURE

The geological workers from Lawson up to the present have found evidence to suggest strong folding within the Keewatin Volcanics immediately south of the Kenora Airport Area. The trends of these folds vary from due east to north-east. These directions parallel the schisosity of the metavolcanics.

Early workers paid scant attention to the granites, and very little of them were mapped beyond about one mile from the Keewatin Volcanics. The exceptions are along the shorelines of lakes and rivers and the C.P.R. tracks. This reflects the prime interest of these workers, which was to map the regions of Keewatin Volcanics.

Riley's gravitation survey found a sharp rise in the gravity profile across the outcrop of the Keewatin Volcanics; and, although, he could draw "no firm conclusions"(Riley, 1965,p.24), his data are generally consistent with: (1) either vertical dips or steep dips (less than 30° from the vertical) towards the granitic rocks; and (2) a depth of 20,000 feet to the base of the block of Keewatin Volcanics which crops out in the Kenora Airport Area.

The mapping, which was undertaken for this thesis, has shown that the gneisses which are south-east of the Keewatin rocks are foliated roughly parallel to the schistosity in the Keewatin rocks. Strike and dip determinations on this foliation (Figure 1) are not uniform, but many show dips which are steeply away from the Keewatin Volcanics. These gneisses are the western margin of the Dryberry Dome, which is a complex batholith, over fifty miles long. The apparent inward slope of the contact of the Dryberry Dome, against the Keewatin rocks is inconsistent with the definition of a batholith given by Billings - "...the walls are steep, smooth, and dip outwards, so that the body (batholith) enlarges downwards;" (1942, p.290) -, but this inconsistency is probably a local variation from the general shape of the Dryberry Dome.

The two massive adamellites in the south-east part of the Keewatin Airport Area are small stocks.

The north-west boundary of the Keewatin Volcanics is marked by a fault which separates it from the Melick Gneiss. This fault is identified by the angular discordance of the Melick Gneiss, topography, and lineaments in aerial photographs.

The Melick Gneiss, which is strongly banded, has irregular dips. The strike forms a smooth curve from east-west to north-south, concave to the north-west. The strike of the banding is sub-parallel to the contact with the Keewatin Volcanics.

The south-east and the north-west boundaries of the Melick Gneiss have been recognised on aerial photographs. The south-east boundary follows a depression with discontinuous ridges on either side. It is considered to be the surface expression of a fault. The north-west boundary is the limit of the banding in the Melick Gneiss, which can be seen in aerial photographs. The unbanded rock north-west of this limit is the Melick Granodiorite.

Thin sections of the Melick Gneiss show mylonization along fracture zones (Plate 9b). This is evidence of cataclastic deformation, which supports the interpretation that the contact between this gneiss and the Keewatin Volcanics is a fault.

METAMORPHISM

METAMORPHIC GRADE

The metamorphic grade has been determined using Turner and Verhoogen's classification (1960, pp.533-553).

Rocks of the greenschist facies contain epidote with albite. Those in higher metamorphic grades contain epidote with oligoclase or more calcic plagioclase.

The almandine-amphibolite facies, the next higher facies of regional metamorphism, is divided into four subfacies:

1. Staurolite-almandine,
2. Kyanite-almandine-muscovite,
3. Sillimamits-almandine-muscovite,
4. Sillimanite-almandine-orthoclase.

The staurolite-almandine subfacies and the kyanite-almandine-muscovite subfacies cannot be distinguished in basic or quartzo-feldspathic rocks. In the sillimanite-almandine-muscovite subfacies the plagioclase is "...andesine to labradorite in amphibolites, and anorthite in calc-granites. Epidote is absent or negligible." (op.cit.,p.549).

The compositions of the plagioclases from the Kenora Airport Area are shown in Table 3 (see Appendix A, p.39) Two

Keewatin basic schists contain albite, but twenty other Keewatin rock samples contain oligoclase or andesine, which indicates a grade of metamorphism in the almandine-amphibolite facies, within either the staurolite-almandine subfacies or the kyanite-almandine-muscovite subfacies. This variation in plagioclase composition suggests lack of equilibrium in the plagioclase-epidote assemblage. It is probable that carbonate metasomatism has affected the basic schists, which contain biotite, albite, quartz, and opaque minerals in addition to the calcite.

METAMORPHIC HISTORY

The regional metamorphism, both north-west and south-east of the fault separating the Melick Gneiss and the Keewatin Volcanics, reached the staurolite-almandine subfacies or the kyanite-almandine-muscovite subfacies of the almandine-amphibolite facies. The similarity of the grade shows that the two parts of the area could have been regionally metamorphosed at one time, but as there is no evidence of the amplitude of the displacement of the fault, the time relationship is uncertain.

METASOMATISM

Carbonate metasomatism locally affected the basic schist in the Keewatin Volcanics. Potassium metasomatism may have caused the widespread occurence of microcline in the Melick Gneiss and Melick Granodiorite. (see pp. 49 & 50).

CHAPTER III

CONCLUSIONS

The Keewatin rocks in the Kenora Airport Area are extremely sheared in places; and, although direct structural evidence from the area was not found, they are probably strongly folded.

The Keewatin basic volcanic rocks are part of a differentiated series, and the acid volcanics probably represent further differentiation of the same series. The coarse grained amphibolite is probably an intrusive igneous rock of the same series.

The granitic rocks of the Dryberry Dome are a sequence of intrusive rocks in which the oldest rocks are more gneissic and less alkaline than the younger ones.

The Melick Gneiss is distinguished by layering, abundant microcline, and seriate texture. Mylonization is found in places. It has a faulted contact with the rocks to the south east of it. Correlations have not been carried across this fault.

THE GEOLOGICAL HISTORY

The Keewatin greenstones of the Kenora Airport Area are a marginal part of a large volume of Archean volcanic rocks. The granitic rocks have intruded into them. The gneissic texture in the granitic rocks is considered to be primary and parallel to the metamorphic structures in the adjoining Keewatin rocks. The emplacement of the gneisses took place during regional metamorphism. Probably the undetermined cause of the metamorphism was responsible for the mobilization of the gneisses.

The regional metamorphism reached the almandine-amphibolite facies either the staurolite-almandine subfacies or the kyanite-almandine-muscovite subfacies.

The Dogtooth Granodiorite intruded the Longbow Granodiorite Gneisses after the gneiss had crystallized. The gneissosity of the Dogtooth Granodiorite is less distinct than that of the older gneiss, and is probably a flow texture. The Dogtooth Leucoadamellite and the porphyrytic adamellite are massive and were emplaced after the close of the regional metamorphism.

The formation of dykes of pegmatite, granite, and aplite; and veins of quartz (some with tourmaline) was the last acid igneous activity in the map area, but Davies and Pryslak (1967) have mapped Keeweenawan diabase dykes at Dogtooth Lake.

For the Melick Gneiss group, north of the Keewatin rocks, the history of the rocks cannot be clearly stated because of a lack of critical information. The chief unresolved problem is the genesis of the Melick Gneiss.

The area has suffered regional metamorphism to the almandine-amphibolite facies. This parallels the history of the Keewatin amphibolites. Potash metasomatism is the probable cause of the widespread presence of microcline throughout the area, but this has no parallel in the south-east.

The Melick Granodiorite is foliated, although not layered, parallel to the layering in the Melick Gneiss. It is therefore thought to be of similar age.

A grey gneiss which is intrusive into the Melick Gneiss north of the Black Sturgeon Lake narrows has sharp contacts and must, therefore, be younger than the Melick Gneiss. Ptygmatic folds in the Melick Gneiss in this region may be earlier than the emplacement of the grey gneiss.

The mylonization in the Melick Gneiss shows that dynamic metamorphism occured, probably at the same time as the fault which brought the Melick Gneiss adjacent to the Keewatin Volcanics.

The results of mapping are consistent with the structural interpretation of the gravity survey by Colin Riley (1965).

RECOMMENDATIONS FOR FUTURE WORK

Detailed mapping of the Keewatin Volcanics and chemical analysis of samples, might prove the relation of the Coarse Grained Amphibolite to the other Keewatin Volcanics.

A chemical study of the plutonic rocks of the Dryberry Dome is necessary to investigate the possibility that they form part of a differentiation series and that that series may be related to the Keewatin Volcanics differentiation series.

The Melick Gneiss is a distinctive rock type which extends beyond the limits of the Kenora Airport Area.

Field mapping of the complete belt of Melick Gneiss should be undertaken as a preliminary to the determination of the origin of the layering. (i.e. a relic structure or the result of metamorphic differentiation).

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APPENDIX A

PETROGRAPHY

KEEWATIN VOLCANICS

Examples of fine grained amphibolite and basic schist are described in Table 2, which includes each of the rock samples for which a chemical analysis has been made (p.54). The acid schist is essentially a sericite rock, some of which contains relic phenocrysts of quartz and plagioclase.

The coarse grained amphibolite contains a pale green amphibolite which is probably actinolite.

A pillow lava (Specimen 6b and Plate 2b) beside the Trans-Canada Highway just east of the porphyrytic adamellite shows monomineralic zoning. The spaces between the pillows are filled with white calcite and red-brown garnet, and the borders of the pillows have been replaced by epidote, so that there is a sequence from the pillow lava outwards, as follows:

(a) Hornblende-epidote-plagioclase-opaque,

(b) Epidote-plagioclase,

(c) Epidote,

(d) Red-brown garnet,

(e) White calcite.

TABLE 2

MINERAL DESCRIPTIONS OF THE NINE KEEWATIN VOLCANIC ROCKS FOR WHICH CHEMICAL ANALYSES ARE AVAILABLE

Specimen Number	Description
18	Basic Schist. Very fine grained. Essential minerals carbonate, quartz, feldspar and chlorite. Accessory minerals biotite and magnetite. Contains lenses of chlorite, biotite and magnetite.
16	Basic Schist. Very fine grained, with quartz filled tension cracks. (The sample used for the chemical analysis was chosen to avoid quartz veinlets which are visible in the hand specimen). Essential minerals carbonate, biotite, albite, quartz and opaque iron mineral. Accessory chlorite is associated with the biotite. The veinlets are quartz, muscovite and tourmaline. (Plate 3a).
17a	Fine Grained Amphibolite. Location: 135 feet west of granite. Patches of subhedral hornblende in a groundmass of plagioclase and epidote. Large grains of epidote form veinlets. Accessory mineral sphene. (Plate 2a).
17b	Fine Grained Amphibolite. Location: 7 feet west of granite. No thin section available.
17c	Fine Grained Amphibolite. Location: 20 inches from granite. Essential minerals hornblende, plagioclase and epidote. Accessory mineral very fine grains, opaque.
14	Fine Grained Amphibolite. Essential minerals hornblende, plagioclase, and epidote. Accessory minerals carbonate, and sphene associated with opaque mineral. The rock has eyed structure of coarse grained hornblende, epidote, and calcite, which is probably the result of local recrystallization. (Plate 1a).
19	Fine Grained Amphibolite. Essential minerals hornblende (pleochroic: X = pale yellow; Y = green; Z = blue-green $C \wedge Z \approx 20^{\circ}$), and plagioclase. Accessory minerals calcite and opaque grains.

continued

TABLE 2 CONTINUED

Specimen Number	Description
23	Fine Grained Amphibolite. Mafic rock colour indices 70.7. Essential minerals amphibole (optically -ve, 2V = 90^{o}, $Z \frown C \approx 15^{o}$, pleochroism: X = pale yellow, Y = pale green, Z = blue-green. Probably actinolite). Accessory minerals magnetite, epidote, and tourmaline.
22	Fine Grained Amphibolite. Taken from central part of a pillow. No thin section available.

SUMMARY OF THE MINERALOGY OF THE KEEWATIN VOLCANICS

Amphibole. -- Two types of amphibole are present. Common hornblende, which is characteristic of the fine grained amphibolites, is the more widespread. It is deeply pleochroic (X =yellow green, Y = green, and Z = blue green), optically negative, large 2V (estimated 2V = 80^{o}), and extinction angle $C \frown Z \approx 20^{o}$.

A pale green amphibole, approaching actinolite in composition, occurs in the coarse grained amphibolites. It is pleochroic (X = colourless, Y = pale green, Z = very pale green), optically negative, extinction angle $C \frown Z = 15^{o}$ to 20^{o}, birefringence ≈ 0.31, and 2V very large. In specimen number 11 (Plate 4a) the pale green amphibole has reaction rims of dark green.

Plagioclase. -- The plagioclase is quite fresh in most of the amphibolite, and falls within the oligoclase-andesine range of composition (see Table 3).

The plagioclase in the basic schist, which contains no amphibole, was identified as oligoclase (An_{15}) from the refractive index of one specimen, and albite in two others (Table 3).

Biotite. -- A brown variety of biotite occurs in the actinolite amphibolites, and in rocks free of amphiboles. Some of the latter rocks contain green biotite which is believed to be originally brown biotite in the stage of incomplete alteration to chlorite.

Epidote.-- Small anhedral grains of epidote occur with the plagioclase in the amphibolite which contains the common hornblende. Epidote coexists with actinolite in only one specimen of those examined.

Zoisite. -- The chemically simpler member of the epidote group, zoisite, occurs in one specimen of the amphibolite which contains actinolite. Neither epidote nor zoisite are found in the biotite bearing basic schists.

Carbonate.-- Carbonate is widespread in the Keewatin Volcanics. It is most abundant in the basic schists, with up to 15 per cent estimated to be in specimen No.8. Carbonate is also abundant in veins throughout the volcanics, for example in the pillow lava described above (p.35). An X-ray

TABLE 3

COMPOSITION OF PLAGIOCLASE IN THE ROCKS OF THE KENORA AIRPORT AREA

Rock Type	Number of Samples			
	Albite	Oligoclase	Andesine	Total
Melick Gneiss	-	2*	3*	5
Porphyrytic Adamell-ite	-	-	2	2
Dogtooth Leucoada-mellite	-	2	-	2
Dogtooth Granodiorite	-	2	1	3
Hilly Lake Biotite Granodiorite	-	3	3	6
Longbow Granodiorite Gneiss	-	-	2*	2
Keewatin Coarse Grained Amphibolite	-	1	-	1
Keewatin Basic Schist	2	1	-	3
Keewatin Fine Grained Amphibolite	-	-	1	1
Total	2	11	12	25

* One of this group determined by refractive index, ± 0.003. All others determined by extinction angle of albite twinning in sections normal to (010).

powder photograph showed that the carbonate in the pillow lava is calcite.

Chlorite.-- Chlorite is commonly associated with biotite in the fine grained tuffs, but it is less common in the hornblende amphibolite. It is generally associated with biotite but may also be an alteration product of the actinolite.

Sphene.--Sphene occurs in the fine grained hornblende amphibolites, but not in the actinolite amphibolites. It is not abundant in any rock and when present may occur as anhedral or subhedral grains.

Quartz.-- In some of the fine grained rocks quartz is very difficult to distinguish from the plagioclase. It is found in secondary veinlets in the rock, but is not abundant in any of the basic volcanics. Relic quartz phenocryst occur in some of the sericite schists.

Opaque Minerals.--The opaque minerals are not easily identified because of their small grain size. However, magnetite and pyrite were recognized in the fine grained schists and magnetite in the amphibolites.

Garnet.-- Garnets were seen at only three locations in the map area, and only one of these is within the Keewatin rocks. Their occurence, which has been described above (p.35), is in the interstices of a pillow lava, associated with calcite and epidote.

GRANITIC INTRUSIVES OF THE DRYBERRY DOME

THE LONGBOW GRANODIORITE GNEISS

The Longbow Granodiorite Gneiss contains essential quartz, plagioclase, microcline and biotite; and accessory epidote, apatite, pyrite, hematite, sphene, and zircon. Hornblende is present locally. Alteration minerals include laths of white mica and epidote, which are in the plagioclase.

The plagioclase is anhedral to subhedral, and strongly altered. Some relic zoning is discernible where the plagioclase is not completely decomposed. Such plagioclase is within the andesine range of composition.

The quartz and microcline are anhedral and interstitial to the plagioclase. These minerals are unaltered, in contrast to the plagioclase, except that the quartz shows strain shadows under crossed nicols. Three samples of the microcline were examined by X-ray powder photography and they were found to have high obliquities, between 0.85 and 0.95 (see Appendix C).

The pleochroism of the biotite is dark green to pale yellow green; it is probably an iron rich variety. Chlorite replaces much of the biotite. Some crystals are bent.

The amphibole, which is locally present, is pleochroic with X = pale greenish yellow, Y = dark green, and Z = blue-green: it is common hornblende.

Epidote is widespread but not abundant. It replaces, in part, the plagioclase and also occurs with aggregates of biotite and iron ore minerals. Some of the epidote has lamellar twinning and subhedral form; it may well be primary.

Quartz and plagioclase are the most abundant minerals in the Longbow Granodiorite Gneiss composing about 25 per cent and 50 per cent respectively. Microcline ranges from 0 to 20 per cent.

Evidence from five thin sections suggests a partial incompatibility of hornblende with microcline. Estimates of the relative proportion of hornblende and microcline in the five sections are given in Table 4.

TABLE 4

MODAL PERCENTAGE OF HORNBLENDE AND MICROCLINE
IN LONGBOW GRANODIORITE GNEISS
(Estimated from thin sections)

Specimen Number	Percentage Hornblende	Percentage Microcline
25	0	20
7	0	5
24	tr.	5
13	2	tr.
20	10	0

HILLY LAKE BIOTITE GRANODIORITE

The Hilly Lake Biotite Granodiorite is a medium to dark grey altered granodiorite in which biotite, quartz, and plagioclase are discernible in hand specimens. The rock is gneissose, but the gneissosity is less distinct than in the Longbow Granodiorite Gneiss. It is, also, finer grained than that rock. Thin sections reveal that the rock has suffered mylonization at some places; the igneous texture is preserved in patches around which very fine grained minerals have recrystallized.

Essential minerals are quartz, plagioclase, and biotite. A thin section (Specimen 21) shows about 10 per cent hornblende, but this may be above average. Accessory minerals include microcline perthite, apatite, sphene, zircon, carbonate, magnetite, hematite, leucoxene, and rutile needles which occur in the biotite. Alteration minerals are white mica and epidote, but some of the latter may be primary.

The plagioclase is mostly oligoclase, but andesine is present in some specimens. Its range of composition is $Ab_{75}An_{25}$ to $Ab_{62}An_{38}$. It is well altered and commonly zoned, and tends to be euhedral, except where mylonization has eroded the crystals. In contrast, all the quartz is anhedral.

Microcline is present in small amounts, and it, too, is anhedral and interstitial to the plagioclase. Most of it is perthitic.

The biotite is mostly a dark olive green variety but some is greenish brown. In places it is altered to chlorite.

The amphibole is a blue-green variety of hornblende.

QUARTZ DIORITE

The quartz diorite contains essential quartz, plagioclase, biotite, amphibole, and epidote; and accessory apatite and chlorite. The plagioclase is estimated to have a composition of $Ab_{60}An_{40}$.

DOGTOOTH GRANODIORITE

In the extreme north of the Dogtooth Granodiorite over 95 per cent of the rock is quartz, plagioclase, and microcline. The plagioclase and microcline are in approximately equal quantities so that the rock in the north, is an adamellite. Accessory minerals are biotite, epidote, sphene, zircon, hematite, and magnetite. Alteration minerals include white mica, chlorite, and some of the epidote.

The anhedral plagioclase is fresh; it shows some cloudiness in concentric rings, which indicate composition zones, and in bands parallel to the albite twinning. The plagioclase is andesine.

The microcline and quartz are also anhedral. A little of the quartz occurs in graphic intergrowth with the microcline. Most of the white mica is enclosed by the plagioclase and has preferred orientation resembling the Widmanstatten texture which is common in iron meteorites. The mica in this rock is not necessarily the result of exsolution.

Towards the south the alkali feldspar-to-plagioclase ratio of the rock is below one third, so that the rock is a granodiorite. The plagioclase is more sodic than in the granodiorite (An_{20}).

DOGTOOTH LEUCOADAMELLITE

The Dogtooth Leucoadamellite is a pink or grey coarse grained massive rock composed essentially of quartz, plagioclase and microcline.

Detailed examination was made of twenty thin sections, fifteen of which were stained to promote simple identification of the potassium feldspar. Point counts were made on five of these (Table 10, Appendix C ,p.65).

The plagioclase is subhedral. The quartz occurs mainly as grey rounded aggregates up to 1 cm. in diameter. Some pseudo-crystal faces are developed where the quartz is enclosed by plagioclase, but all the patches of quartz are mosaic aggregates and they are not euhedral single crystals. The microcline occurs in large patches which enclose the earlier quartz and plagioclase.

In addition to quartz, plagioclase, and microcline, accessory constituents which are usually less than 5 per cent of the rock, include biotite, chlorite, muscovite, epidote, magnetite, hematite, zircon, and rarely garnet.

The plagioclase is slightly altered, and ranges in composition from oligoclase to andesine. In many cases the core is slightly more calcic than the outer rim.

Much of the microcline is perthitic. It has developed in large patches which fill the spaces between the quartz and the plagioclase. Some of the microcline appears to have replaced plagioclase.

The biotite is a dark green variety, and was present in all but two of the thin sections. An equally dark chlorite has replaced much biotite. Pleochroic haloes around the inclusions of a mineral, which is probably zircon, are common in the biotite.

Laths of white mica are common in altered plagioclase. They usually have strongly preferred orientation, a feature common in the altered plagioclase of the coarse grained acid rocks of the region (Plate 6b).

Table 8, in Appendix C, (p.63) shows the K_2O, Na_2O, and CaO compositions of six specimens of the Dogtooth Leucoadamellite.

PORPHYRYTIC ADAMELLITE

The porphyrytic adamellite is massive and contains prominent euhedral phenocrysts of microcline perthite in a coarse grained matrix. The matrix displays an igneous texture of subhedral plagioclase and anhedral microcline perthite, quartz, and biotite. The quartz has undulatory extinction, which is evidence of strain, and the development of mylonite around the phenocrysts supports this evidence.

The essential minerals are plagioclase, microcline perthite, quartz, and biotite. Accessory minerals include zircon, apatite, sphene, and opaque minerals. Alteration minerals include white mica, epidote, and carbonate.

The central portion of each plagioclase crystal is clouded by the presence of the alteration minerals, which indicates a zoning of the plagioclase. The composition of the plagioclase was estimated from the extinction angles of twinned crystals and was found to be from $Ab_{65}An_{35}$ to $Ab_{60}An_{40}$.

The biotite, which is the only essential mafic mineral, is strongly pleochroic: pale yellow to dark brown. Alteration haloes surround small crystals in the biotite.

Parts of some of the perthite phenocrysts exhibit microcline twinning and other parts of the same crystal are untwinned potassium feldspar.

Estimation of the modal composition of the Porphyrytic Adamellite was complicated by the particularly large phenocrysts, some of which are over one inch long. Therefore, a point count was made of a thin section, counting only the mineral grains in the matrix, and omitting the euhedral crystals of perthite. A second count was made on a ground and stained specimen of approximately eight square inches in area, from which the proportion of phenocryst to matrix was ascertained. The two counts were combined to give the modal analysis for the rock (Table 5).

TABLE 5

MODAL ANALYSIS OF PORPHYRYTIC ADAMELLITE FROM LOCATION 6

Mineral	Modal Percentage
Quartz	20.0
Microcline Perthite*	36.2
Plagioclase**	38.6
Biotite	5.0
Epidote	0.5

* includes perthitic albite

** includes alteration white mica, epidote and carbonate

Two colour varieties of the rock exist; one is grey and the other red. The red variety is the result of fine hematite grains which are present in both the microcline and the plagioclase.

The absence of chlorite, which is unique among the biotite bearing acid rocks in this region, and the massive texture of the rock indicates that the porphyrytic adamellite post-dates the regional metamorphism. It is, therefore, one of the youngest rocks associated with the Dryberry Dome.

PEGMATITE, GRANITE, AND APLITE DYKES

The late intrusive rocks were not examined in detail.

MELICK GNEISS GROUP

MELICK GNEISS

The Melick Gneiss consists of banded leucocratic gneiss, biotite gneiss, and amphibole gneiss.

Leucocratic Gneiss

The leucocratic gneiss consists essentially of microcline, plagioclase, and quartz. The texture is commonly seriate and porphyroblastic. Augen structures develop where the rock has been sheared (Plates 8 and 9b).

Quartz is ubiquitous, making up 25 per cent to 50 per cent of the rock. Where mylonization has affected the leucocratic gneiss, most of the quartz is in mosaic patches (Plates 9a and 9b). All the quartz shows strain shadow.

The microcline varies in abundance from a trace up to 50 per cent of the leucocratic gneiss. Some of the microcline is perthitic.

The plagioclase, which is mostly only slightly altered, lies within the oligoclase-andesine range of composition. Some of the plagioclase augen show considerable cloudiness. Muscovite laths, having preferred orientation with respect to the plagioclase, are common (Plate 6b). A similar development of muscovite in plagioclase, is reported by R. I. Harker (1962, pp.224-225) from the Inchbea Orthogneiss of Ross and Cromarty, Scotland. He concludes that it is the result of local action of potash-bearing solutions.

The accessory minerals are biotite, hornblende, muscovite, apatite, epidote, zircon, and sphene.

Biotite Gneiss

The biotite gneiss contains up to 10 per cent biotite. It is interbanded with the leucocratic gneiss, and the contrast in colour is very marked. The character of the minerals which are contained in the biotite gneiss is similar to that of the leucocratic gneiss, although the biotite is increased in amount (Plates 8 and 10).

Amphibole Gneiss

The amphibole gneiss occurs throughout the Melick Gneiss. Quartz, plagioclase, and amphibole are the essential minerals in this rock. Accessory minerals are epidote, biotite, sphene, apatite, zircon, hematite, chlorite, and carbonate.

The amphibole is hornblende, which has the following optical properties: $C \widehat{\ } Z \approx 25^{\circ}$; moderately high 2V; and pleochroism X = pale yellow-green, Y = dark green, and Z = dark blue-green.

MELICK GRANODIORITE

The Melick Granodiorite is a foliated medium to coarse grained plutonic rock. The essential minerals are andesine (45 per cent by volume), quartz (35 per cent by volume), and microcline (12 per cent by volume).

The microcline is generally smaller grained than, and interstitial to, the quartz and the plagioclase. The plagioclase crystals are cloudy at the centre and clear around the margins.

The accessory minerals are biotite, muscovite, epidote, apatite, sphene, and hematite. Leucoxene is secondary after sphene.

The biotite is pleochroic X = dark olive green, Y = olive green, and Z = pale yellow green.

PEGMATITE, GRANITE AND APLITE DYKES

No detailed mineralogy was obtained for these rocks.

APPENDIX B

THE CHEMISTRY OF THE BASIC KEEWATIN VOLCANICS

The basic members of the Keewatin Volcanics are the only rocks in the Kenora Airport Area for which there is any extensive chemical data. Nine analyses of the basic Keewatin Volcanic rock are available. The analyses (Table 6) have been published by Andrews (1965), who calculated Niggli molecular equivalent normative minerals by computer (Table 7). All but two of the specimens are oversaturated. The mineralogy of these nine specimens is given in Table 2, p.36.

Specimens 16 and 18 are basic schist, and specimens 14, 17a, 17b, 17c, 19, 22, and 23 are fine grained amphibolite. (Fig.2). Specimen 23 is not typical of the fine grained amphibolite. It was collected within 100 feet of the coarse grained amphibolite, of which its amphibole (actinolite) is typical. However, it also contains epidote which is atypical of the coarse grained amphibolite. Specimen 23 differs in mineralogy and composition (Table 6) from the other Keewatin Volcanics for which data is available. No chemical analyses of the coarse grained amphibolite have been made.

Larsen diagrams (Figure 3 (a) to (e)) of the chemical composition of six fine grained amphibolites were drawn. They show that these basic rocks are part of a differentiated sequence, although the K_2O and Na_2O plots (Figure 3 (d) and (e)) show poorly defined trends.

CARBONATE IN THE KEEWATIN VOLCANICS

A graph of the CaO and CO_2 compositions of the nine samples of Keewatin Volcanics (Figure 4) shows an inverse relationship between CO_2 and CaO. This suggests that where carbonate has been deposited, a corresponding amount of CaO has been removed.

Rock which contains little or no carbonate has a CaO content of between 12.3 and 14 wt. per cent. This may represent the original CaO composition of all the rocks before the introduction of the carbonate and the removal of the CaO. The basic schist has suffered more alteration in this manner than the fine grained amphibolite.

TABLE 6

CHEMICAL ANALYSES OF NINE BASIC KEEWATIN VOLCANICS *

Specimen Number	14	16	17a	17b	17c	18	19	22	23
SiO_2	49.6	49.1	48.8	49.8	49.9	45.7	52.1	59.4	47.4
Al_2O_3	14.9	13.1	14.8	15.0	15.2	14.8	16.5	14.8	16.0
Fe_2O_3	0.93	0.8	1.4	3.2	0.4	1.7	0.24	1.4	3.2
FeO	9.70	9.7	9.6	7.4	8.1	9.7	9.10	7.7	5.6
MgO	5.23	2.8	5.7	5.94	5.3	5.2	4.91	5.6	9.9
CaO	12.72	6.8	12.3	12.29	12.9	8.9	8.70	10.9	14.0
Na_2O	2.24	3.71	3.2	2.30	2.1	1.91	3.60	3.3	1.77
K_2O	0.41	0.85	0.3	0.35	0.3	0.80	0.15	0.15	0.18
H_2O^+	1.34	1.27	0.88	1.33	0.98	2.90	0.99	1.43	0.53
CO_2	0.30	7.06	nil	nil	0.22	5.79	0.33	2.10	0.15
TiO	1.46	2.75	1.48	1.33	1.35	1.27	1.77	0.92	0.33
P_2O_5	0.21	0.30	0.18	0.16	0.15	0.14	0.20	0.15	0.03
S	-	nil	-	-	-	nil	-	-	nil
M_nO	0.40	0.28	0.23	0.22	0.21	0.18	0.20	0.23	0.11
TOTAL	99.4	99.1	98.7	99.3	98.9	99.0	98.8	99.1	100.2
S.G.	3.10	2.88	3.11	3.11	-	2.84	3.05	-	3.03
Larsens Values	-10.7	-2.1	-11.0	-8.7	-9.4	-7.8	-4.1	-7.2	-13.5

* K. Ramlal, Analyst.
For description of specimens, see Table 2, p.36.

TABLE 7

NIGGLI MOLECULAR EQUIVALENT NORMATIVE MINERALS*

Sample No.	22	19	17b	14	17a	17c	18	16	23
Satn. Index	3.3	2.2	2.7	1.2	-4.7	2.8	13.8	13.6	-3.7
Diff.Index	33.6	36.3	26.3	24.6	30.3	24.5	36.6	52.7	17.0
Color Index	28.6	28.5	30.1	30.9	43.1	28.8	31.3	23.5	41.6
Quartz	3.3	2.2	2.7	1.2	.0	2.8	13.8	13.6	.0
Orthoclase	.9	.9	2.1	2.5	1.8	1.8	4.9	5.1	1.0
Albite	29.3	33.1	21.3	20.8	26.6	19.8	17.8	33.9	15.9
Anorthite	26.1	29.1	30.6	30.4	26.0	32.7	6.9	.0	35.3
Nepheline	.0	.0	.0	.0	1.8	.0	.0	.0	.0
Leucite	.0	.0	.0	.0	.0	.0	.0	.0	.0
Kalioph'ite	.0	.0	.0	.0	.0	.0	.0	.0	.0
Wollast'ite	5.8	4.7	12.6	12.6	.0	12.9	.0	.0	.0
Enstatite	15.9	14.0	17.1	15.0	.0	15.5	15.0	7.9	.0
Ferrosilite	9.8	11.7	7.6	12.7	.0	10.9	12.5	10.8	.0
Hypersthene	.0	.0	.0	.0	.0	.0	.0	.0	5.5
Diopside	.0	.0	.0	.0	28.8	.0	.0	.0	26.7
Olivine	.0	.0	.0	.0	10.6	.0	.0	.0	11.1
Apatite	.3	.4	.3	.4	.3	.3	.3	.0	.0
Pyrite	.0	.0	.0	.0	.0	.0	.0	.0	.0
Ilmenite	1.3	2.5	1.9	2.1	2.1	1.9	1.8	3.9	.4
Chromite	.0	.0	.0	.0	.0	.0	.0	.0	.0
Magnetite	1.4	.2	3.4	1.0	1.5	.4	1.8	.8	3.3
Hematite	.0	.0	.0	.0	.0	.0	.0	.0	.0
Acmite	.0	.0	.0	.0	.0	.0	.0	.0	.0
Corundum	.0	.0	.0	.0	.0	.0	9.4	6.7	.0
Calcite	5.4	.7	.0	.7	.0	.5	15.2	13.7	.3

* After Andrews (1964). Data obtained from Computer Programme.

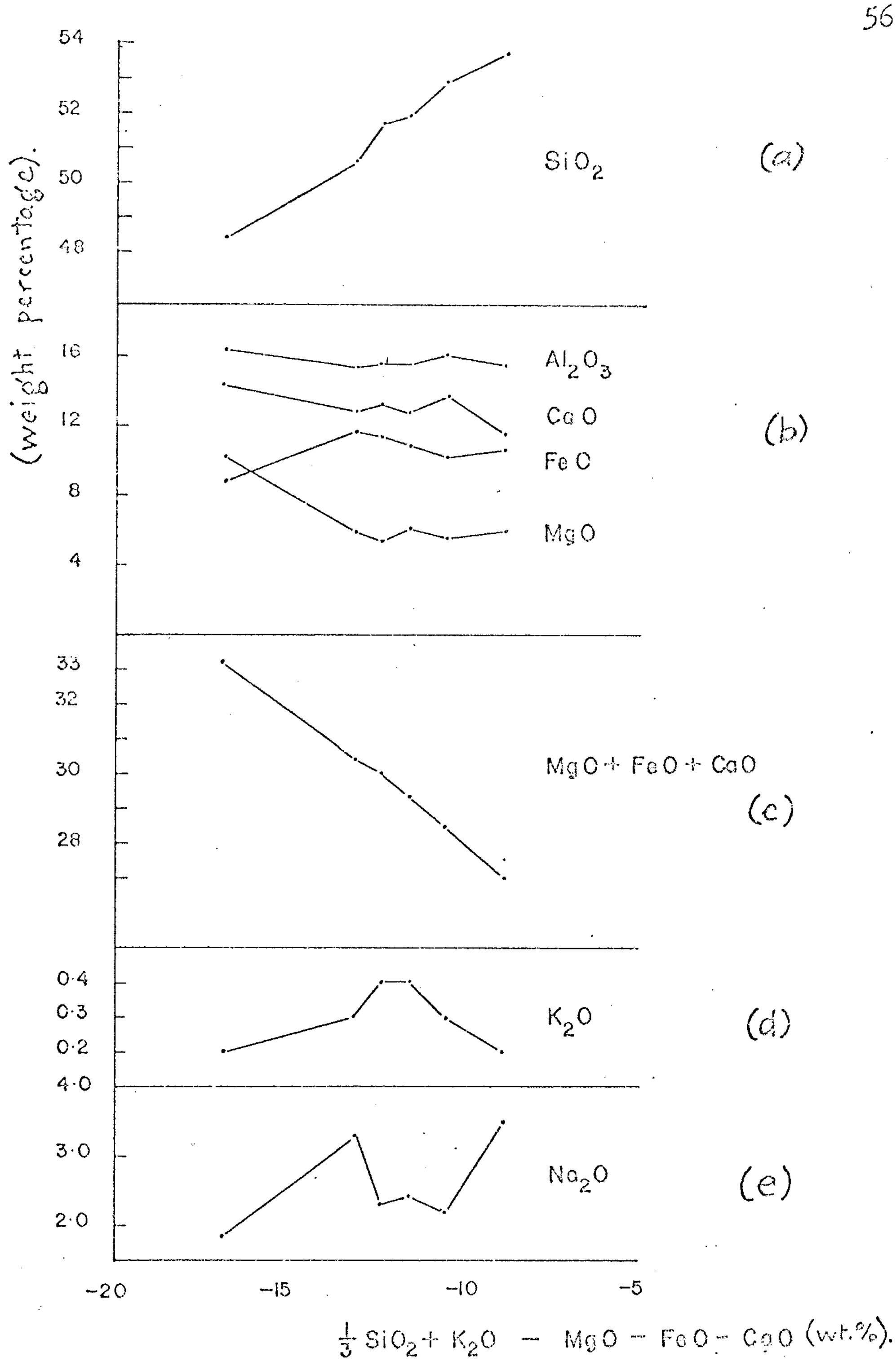

Figure 3. Plot of Chemical Analyses by Larsen's Method, for Six Specimens of Keewatin Volcanics. All specimens are fine grained amphibolite.

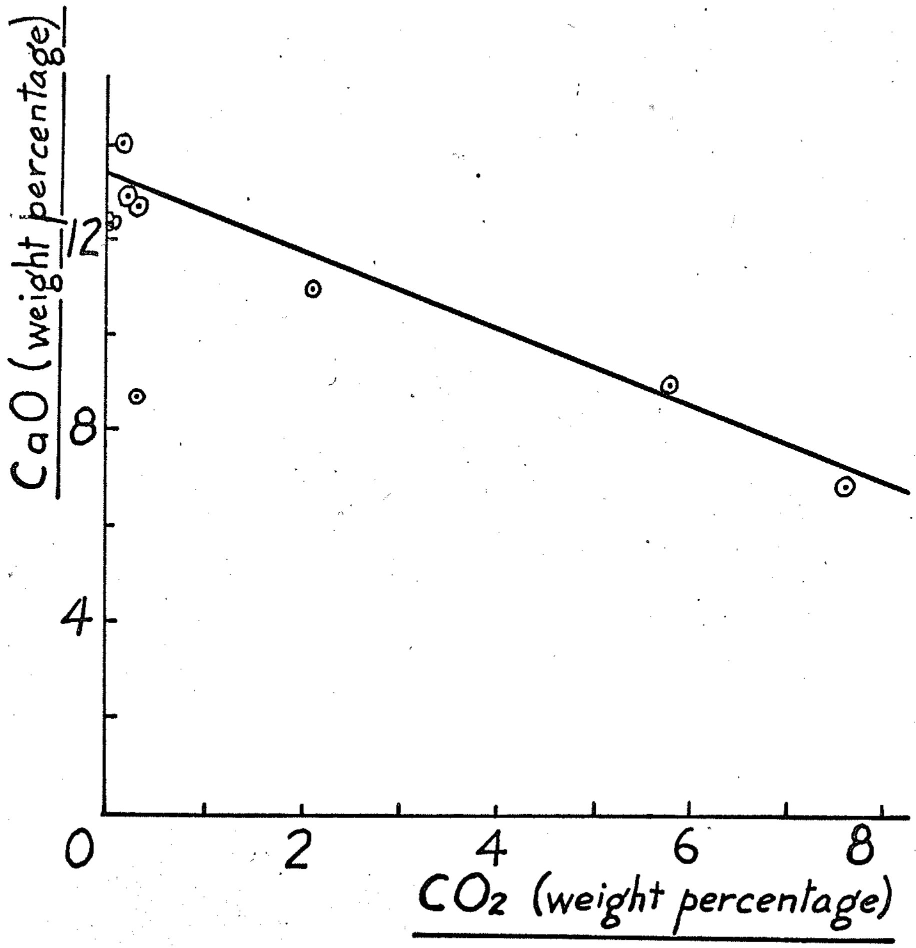

Figure 4. CaO Weight Percentage Against CO_2 Weight Percentage for Nine Basic Keewatin Volcanics. See Table 6, p.54.

APPENDIX C

THE NATURE OF THE POTASSIUM FELDSPARS IN THE DOGTOOTH LEUCOADAMELLITE

INTRODUCTION

The Dogtooth Leucoadamellite has received attention as part of a pilot investigation of its potassium feldspars. In this pilot study, the rocks were assessed for their suitability as the subject of a more extensive examination.

The variation of the obliquities or triclinicities (obliquity, an empirical measure of the deviation of the crystal from the monoclinic structure (Goldsmith and Laves, 1954)) of the potassium feldspar in the Dogtooth Leucoadamellite is from 0.85 to 1.00 ($\pm$ 0.025). Because of this small range of obliquities, the rock has been rejected for work in the immediate future on the feldspar problem, although the results of this pilot study have been of use.

A BRIEF STATEMENT OF THE PROBLEM

Ferguson, Traill, and Taylor (1958) and Ferguson (1960) suggest that bonding in the feldspar structure is essentially ionic and that the Si-Al distribution in the lowest temperature feldspars will be, in general, that which yields the most satisfactory charge balance.

The structure of a feldspar is determined primarily by the arrangement (i.e., ordering) of the Al and the Si ions;

this in turn depends upon the potassium, the sodium, and the calcium contents of the structure and the temperature at the time at which the ordering occurred.

If the K, Na, and Ca ions can migrate, as during perthitization by exsolution, at temperatures below which the Al-Si ordering is "frozen", then the final composition of the mineral is not necessarily related to the Al-Si ordering. But, if the K, Na, and Ca ions have remained within the cooling rock, although not within the mineral, a relationship might exist between the structure of the feldspars and the K, Na, and Ca content of the whole rock. It was to seek such a relationship that the Dogtooth Leucoadamellite was examined.

Several workers (e.g., Emerson,1960) have examined the relationship between the obliquity of potassium feldspars from igneous rocks and the chemical composition of the mineral, yet no relationship has been established.

Trembath (1961) compared obliquity with the K: Na ratio of whole rock analyses for a group of igneous and metamorphic gneisses from the Thompson-Moak Lake area of Manitoba. A linear relationship was observed for the metamorphic gneisses, but not for the igneous gneisses.

Pollock (1965) examined the influence of the calcium content in addition to the K:Na ratio in a group of rocks from the Duval Lake area of Manitoba. This work led to the analysis of Trembath's specimens for calcium. A correlation has been observed between the obliquity and the Ca:Na ratio of Trembath's specimens.

Six of the specimens collected from the Dogtooth Leuco-adamellite during the present study were analysed for K, Na, and Ca, and the results were combined with those from the Thompson-Moak Lake area and the Duval Lake area, all of which have been described by Ferguson et al (1963). The present thesis records the data from the Dogtooth area, which was used by Ferguson et al (1963).

EXPERIMENTAL METHODS

Twenty-three thin sections were cut. Potassium feldspars from fourteen of these specimens were X-rayed to determine obliquity (Tables 8 and 9); and rock samples of six out of this fourteen were analysed for K_2O, Na_2O, and CaO (Table 10). Five of the thin sections for which the chemical analysis is available were measured for modal percentage composition (Table 8).

MINERAL SEPARATION

Approximately 25 grams of each of twenty-three specimens were crushed in a steel mortar and screened with Tyler Standard screens. The fraction which passed through the 100 mesh screen and was retained by the 200 mesh screen was used for heavy liquid separations.

A mixture of bromoform and acetone was adjusted to float fragments of microcline and orthoclase (S.G.=2.59), and to permit to settle quartz (S.G.=2.65) and cleavlandite (S.G.=2.62). The fraction was centrifuged and the floating grains were taken and cleaned with acetone. Each fraction was centrifuged three times to increase the purity of the potassium feldspar sample. In cases where albite was not separated by this method, it is believed to be because alteration of the albite has reduced its average density so that it is equal or less than the density of potassium feldspar.

DETERMINATION OF OBLIQUITY

X-ray powder diffraction photographs of the potassium feldspar separations were taken on the 114.53 mm. diameter Phillips Powder Camera, the $d_{(131)}$ and $d_{(1\bar{3}1)}$ lines were measured and the obliquities were calculated by the method of Goldsmith and Laves (1954) using the formula $\triangle = 12(d_{131} - d_{1\bar{3}1})$. As all obliquities were greater than 0.85 there was no problem of overlap of the 131 and the $1\bar{3}1$ lines.

Fourteen of the specimens provided obliquity values satisfactorily. Ten of these are Dogtooth Leucoadamellite, one is Dogtooth Granodiorite, and three are Longbow Granodiorite Gneiss (Figure 5). The other nine contained too much albite, as explained above.

CHEMICAL ANALYSIS

Six of the fourteen rock specimens for which potassium feldspar obliquities had been obtained were chemically analysed (Table 10). The analyses were performed by K. Ramlal, Department Analyst, using a Coleman flame photometer for K_2O and Na_2O and a titration method for CaO.

RESULTS

The potassium feldspars from the Dogtooth Leucoadamellite and surrounding rocks have high obliquities. The values range from 0.85 to 1.00 ($\pm$ 0.025). This restricted range of obliquities makes the Dogtooth Leucoadamellite unsuitable for a statistical study of the correlation between obliquity values of the potassium feldspars and the composition of the rock.

The ternary diagram (Figure 6) indicates no significant correlation between obliquity and Na_2O, K_2O and CaO composition of the rock.

Figure 7 shows an inverse correlation between modal quartz and microcline in the Dogtooth Leucoadamellite although plagioclase remains fairly constant. A correlation between modal microcline and obliquity is indicated in Figure 7. Future work on a pluton of more variable composition than the Dogtooth Leucoadamellite should be initiated to see if this indicated trend can be found in it.

TABLE 8

THE OBLIQUITIES, PARTIAL CHEMICAL ANALYSES, AND PARTIAL MODAL ANALYSES FOR SAMPLES OF DOGTOOTH LEUCOADAMELLITE.
For Sample Locations see Figure 5.

Sample Number	Obliquity of Potassium Feldspar	Weight Per Cent of Total Rock*			Mode Per Cent	
		K_2O	Na_2O	CaO	Muscovite	Biotite
63	1.00	3.05	4.38	1.14	6.3	nil
71	0.86	2.17	4.21	1.54	1.9	1.0
76	0.99	2.39	4.38	1.28	2.5	tr
82	0.90	2.54	4.52	1.42	2.8	0.8
83	0.90	1.88	5.14	1.89	1.9	0.7
86	0.86	1.94	4.68	1.31	N.D.	N.D.

* K. Ramlal, Analyst.

TABLE 9

THE OBLIQUITIES OF EIGHT SAMPLES OF POTASSIUM FELDSPAR FROM THE DRYBERRY DOME

Sample Number	Obliquity
24	0.95
25	0.85
26	0.85
60	0.95
78	0.95
79	0.95
84	0.90
87	0.95

For location of samples 24,25 and 26, see Figure 2, Appendix

For location of samples 60,78,79,84 and 87, see Figure 5, Appendix

TABLE 10

MODAL PERCENTAGES FOR THE DOGTOOTH LEUCOADAMELLITE

Sample Number	63	71	76	82	83
Quartz	21.4	36.6	28.4	30.0	48.7
Plagioclase	45.5	47.9	45.8	44.0	43.2
Microcline	23.9	10.7	21.4	20.0	4.3
Muscovite	6.2	1.9	2.5	2.8	1.9
Epidote	3.0	1.6	1.9	2.4	1.0
Biotite	nil	1.0	tr	0.8	0.7
Chlorite	nil	0.3	tr	tr	0.2
Magnetite	nil	nil	nil	tr	tr
Total	100.00	100.0	100.0	100.0	100.0
Number of Points Counted	2008	1488	1724	1499	1788

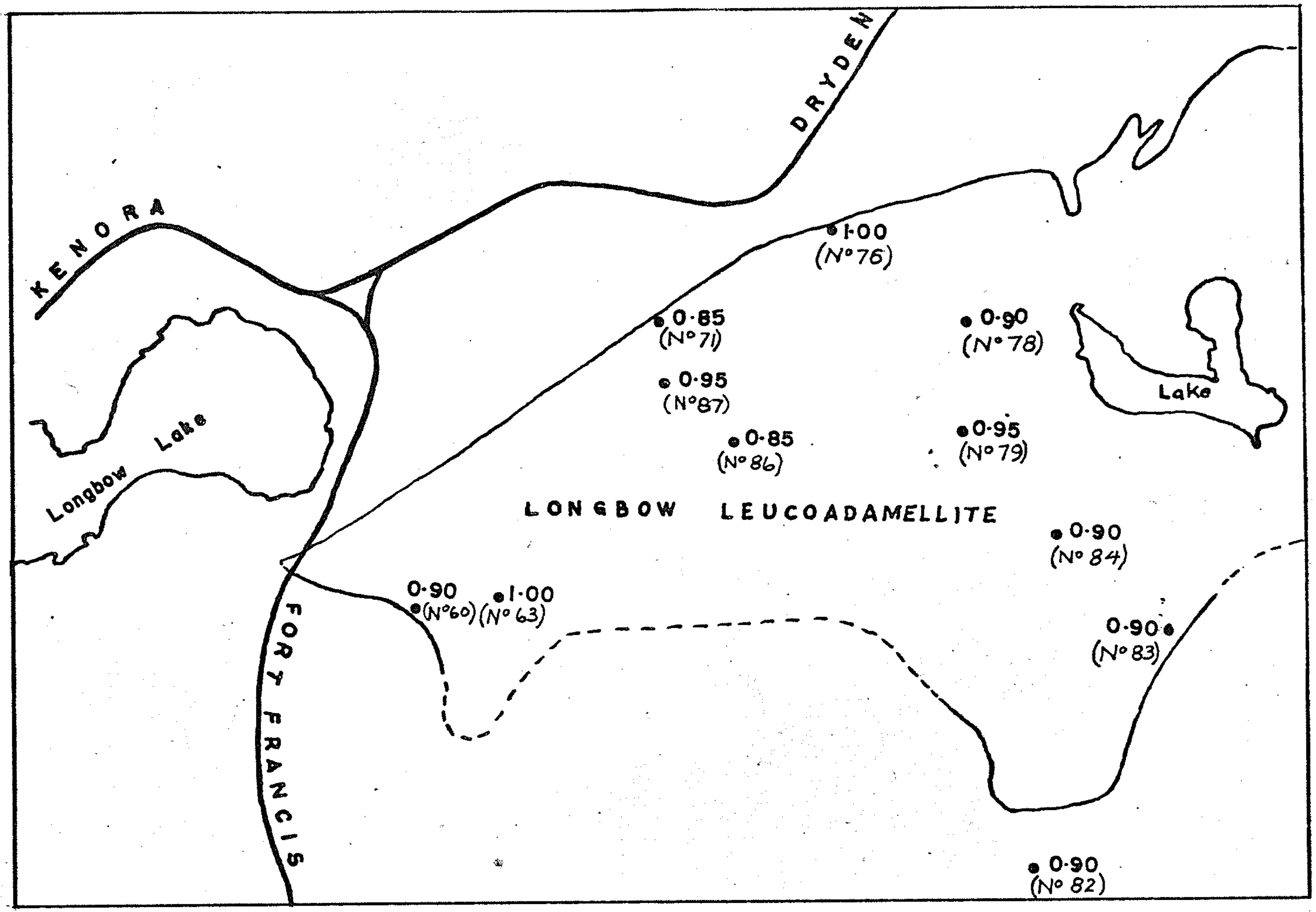

Figure 5. Map of Longbow Leucoadamellite: Shows Potassium Feldspar Locations and Obliquities (to nearest ±0.025). Scale 4 inches to 1 mile.

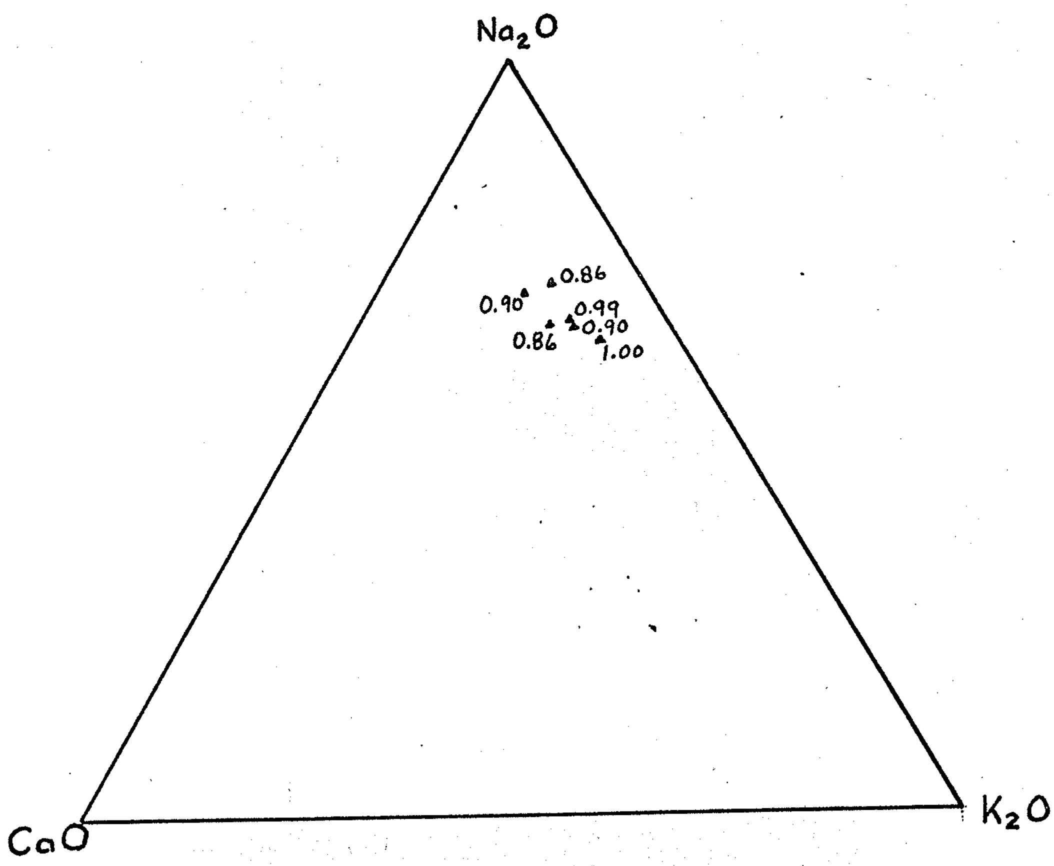

Figure 6. Obliquity of Dogtooth Leucoadamellite Compared with K_2O, Na_2O, and CaO Composition of Whole Rock.

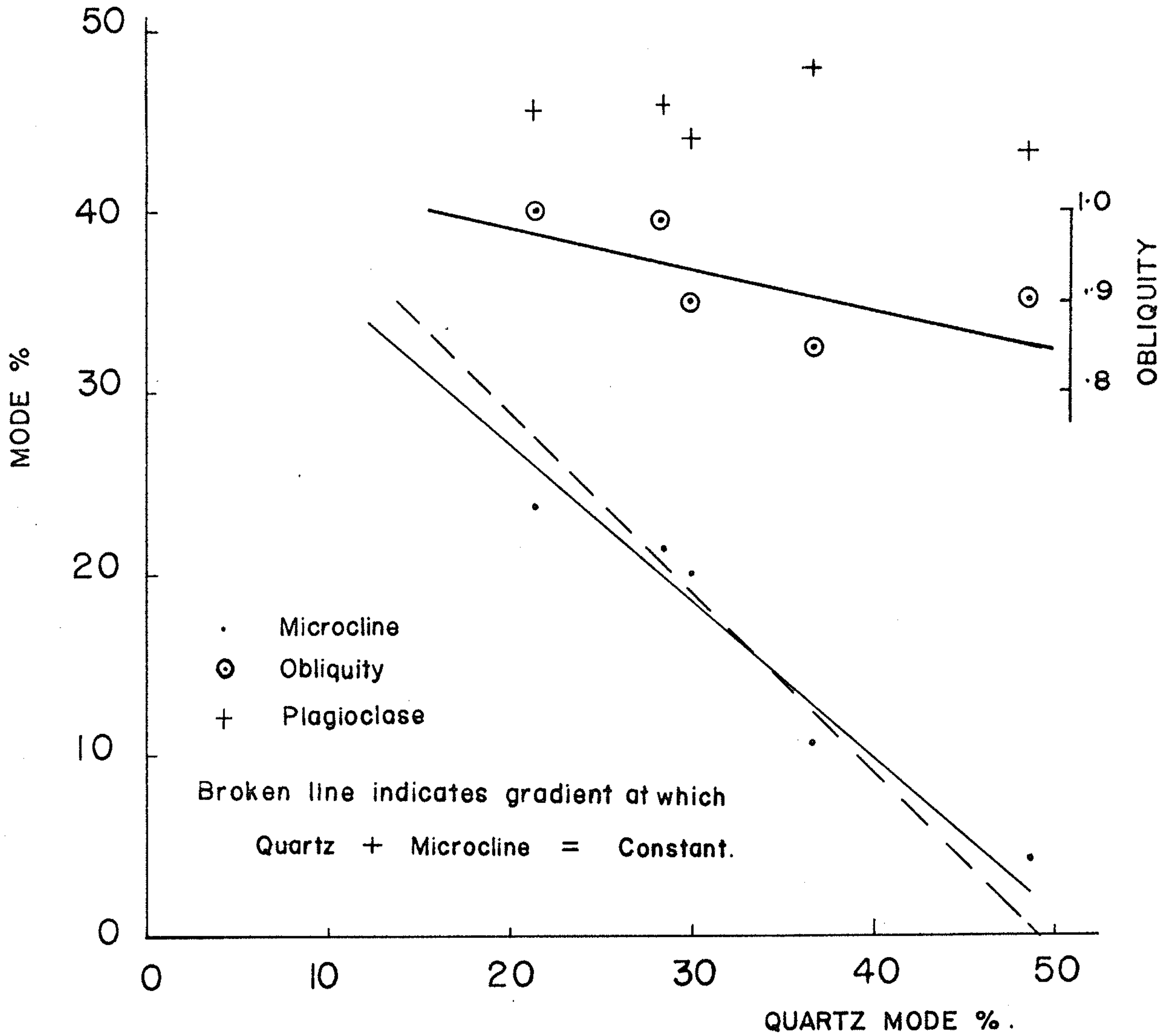

Figure 7. Mode Percentage of Potassium Feldspar and Plagioclase and Obliquity of Potassium Feldspar vs. Mode Percentage of Quartz.

APPENDIX D

PHOTOMICROGRAPHS OF ROCKS FROM THE KENORA AIRPORT AREA

This appendix contains nineteen photomicrographs of rocks from the Kenora Airport Area.

PLATE 1a. Fine Grained Amphibolite, Keewatin Volcanics, Contains essential hornblende, plagioclase, and epidote. (Specimen Number 14, ordinary light). Also see Table 2.

PLATE 1b. Fine Grained Amphibolite, Keewatin Volcanics. Laths of plagioclase with hornblende. (Specimen Number 15, cross-nicols).

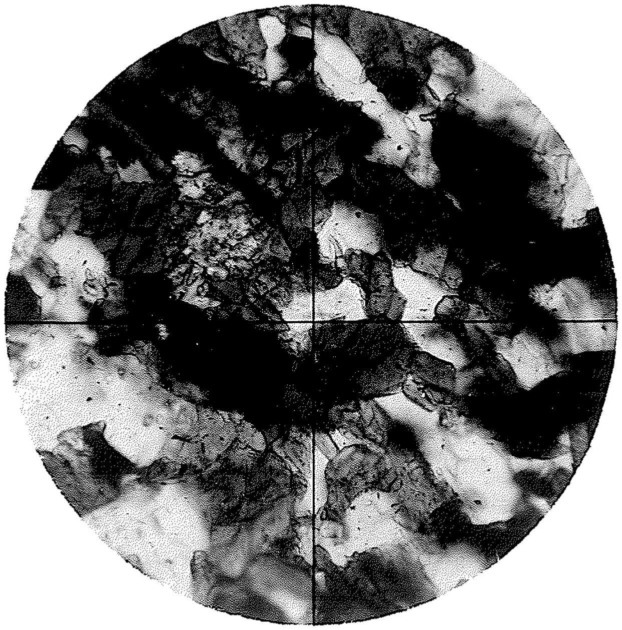

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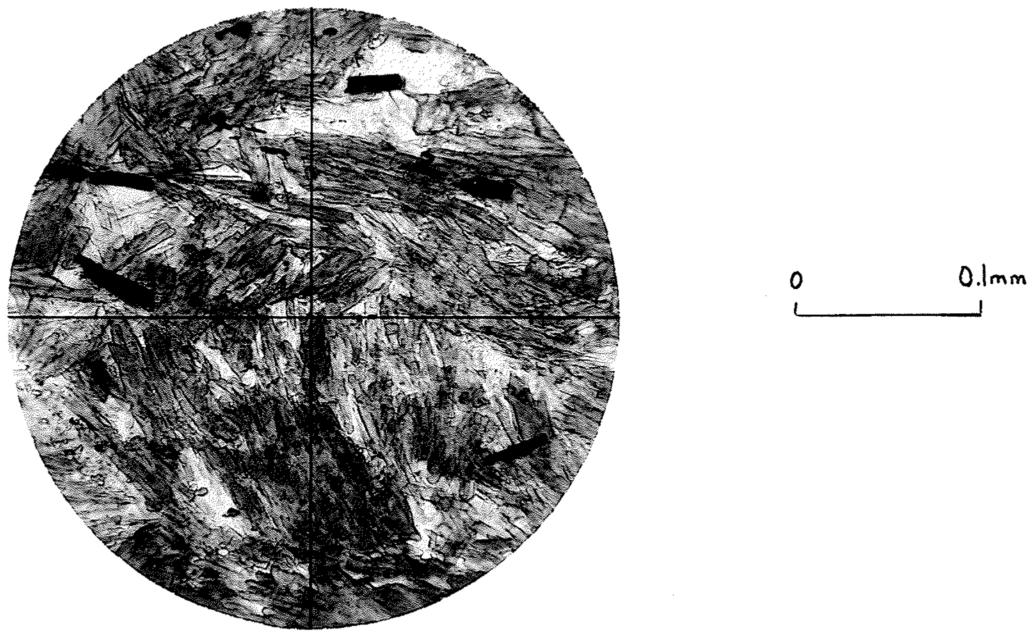
PLATE 2a. Fine Grained Amphibolite, Keewatin Volcanics. Hornblende more prismatic than above. (Specimen Number 17a, ordinary light). Also see Table 2).

PLATE 2b. Fine Grained Amphibolite, Keewatin Volcanics. Monomineralic Zoning of epidote, carbonate, and garnet, filling cavity between pillows in pillow lava. (Specimen Number 6b, ordinary light).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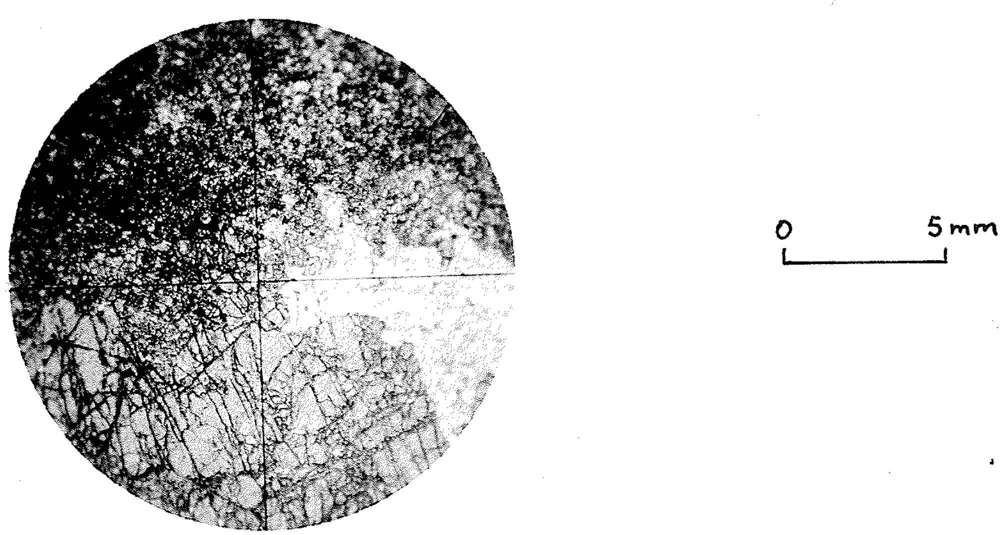
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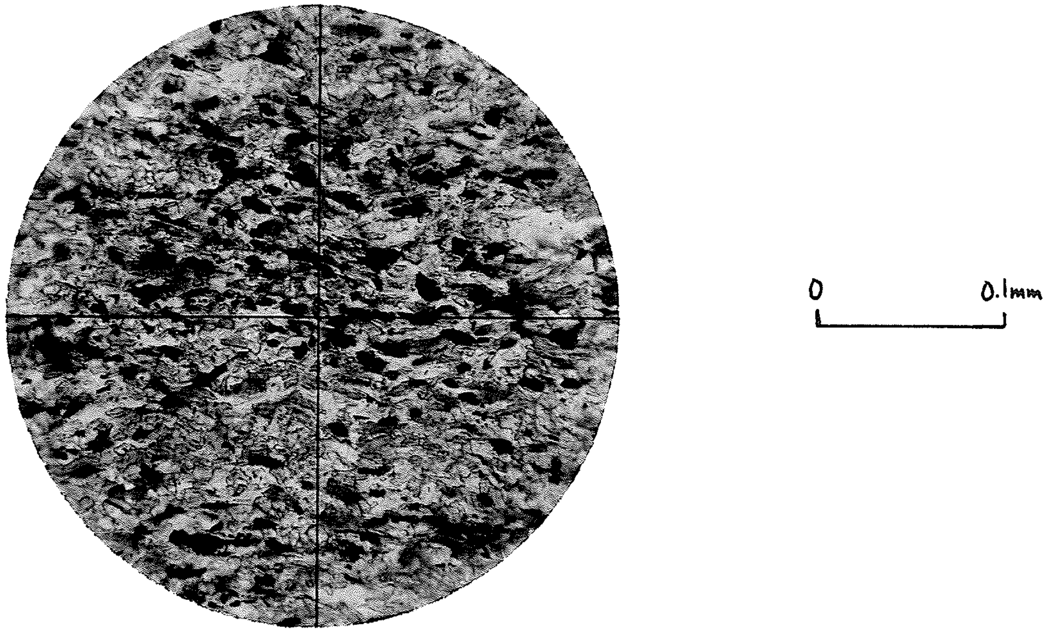
PLATE 3a. Basic Schist, Keewatin Volcanics. Very fine grained, banded biotite schist, with biotite, plagioclase, magnetite and carbonate. (Specimen Number 16, ordinary light). See also Table 2.

PLATE 3b. Metasediment, Keewatin Volcanics. Fine grained, banded biotite schist with porphyroblasts of plagioclase. (Specimen Number 8, ordinary light).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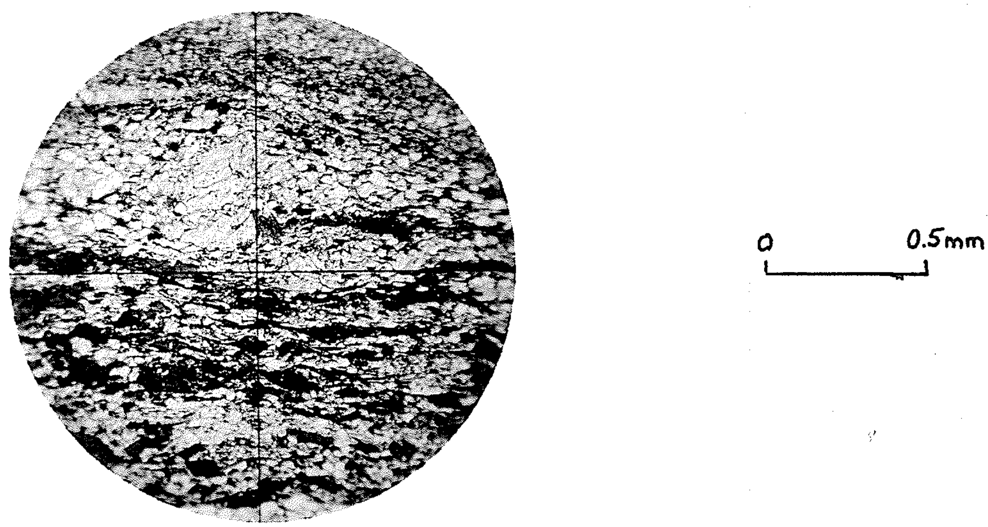
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PLATE 4a. Coarse Grained Amphibolite, Keewatin Group. With more intense colour around crystal margins; laths of amphibole are also present in the plagioclase matrix. (Specimen Number 11, ordinary light).

PLATE 4b. Coarse Grained Amphibolite, Keewatin Volcanics. With very pale fibrous amphibolite, probably tremalite; associated with a matrix of serpentine. (Specimen Number 12, ordinary light).

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PLATE 5a. Porphyrytic Adamellite. Quartz clear, plagioclase cloudy microcline cross-hatched interstitial. (Specimen Number 6a, ordinary light.

PLATE 5b. Same as 5a under cross-nicols.

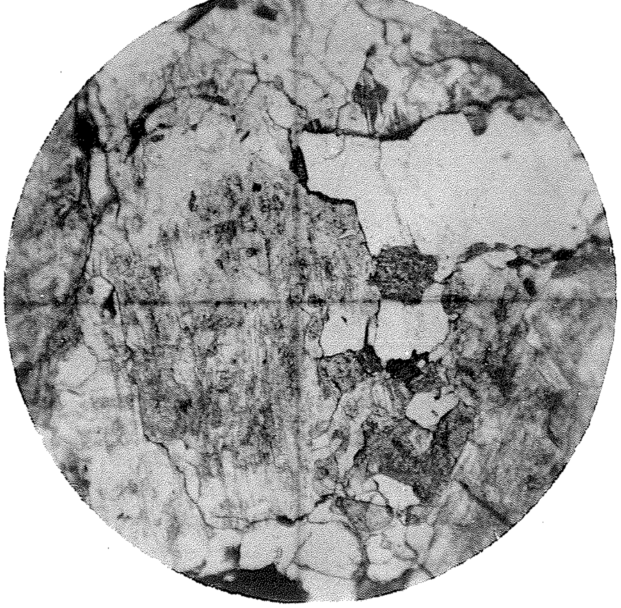

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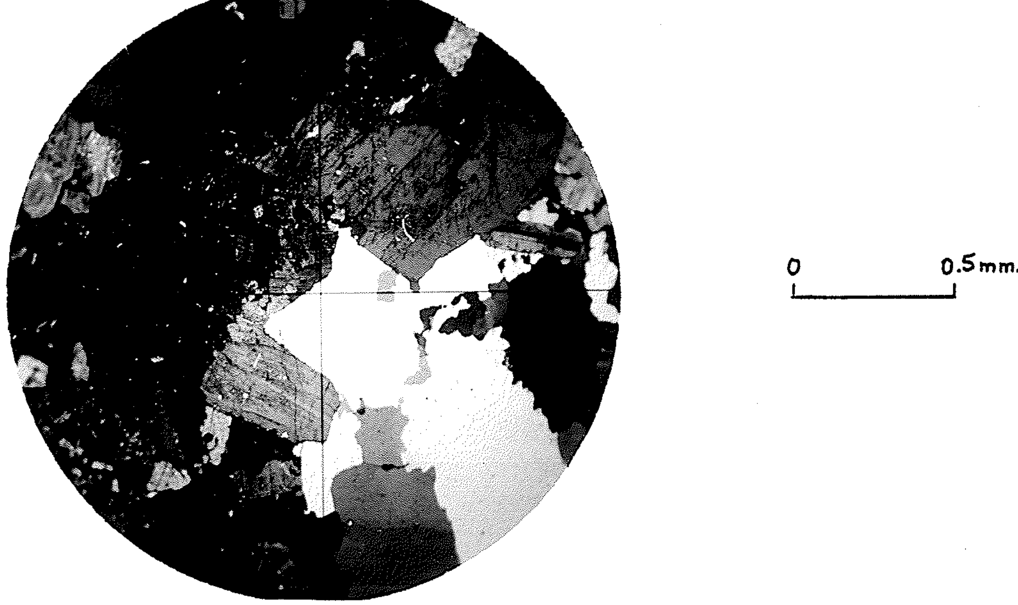
PLATE 6a. Dogtooth Leucoadamellite. Quartz, plagioclase, and microcline. (Specimen Number 71, cross-nicols).

PLATE 6b. Plagioclase crystal from Dogtooth Leucoadamellite, shows white mica with preferred orientation, with epidote. (Specimen Number 10, cross-nicols).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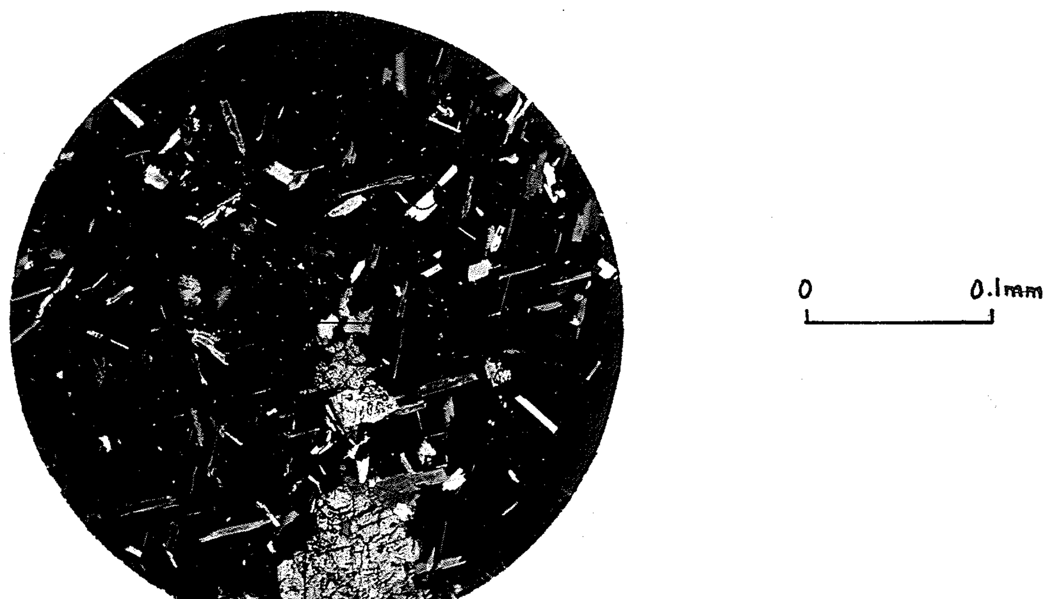
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PLATE 7a. Longbow Foliated Granodiorite. Saussuritized plagioclase, clear quartz biotite flakes. (Specimen Number 7, Ordinary light).

PLATE 7b. Hornblende Gneiss, Melick Gneiss. Contains plagioclase hornblende and epidote. (Specimen Number 1, ordinary light).

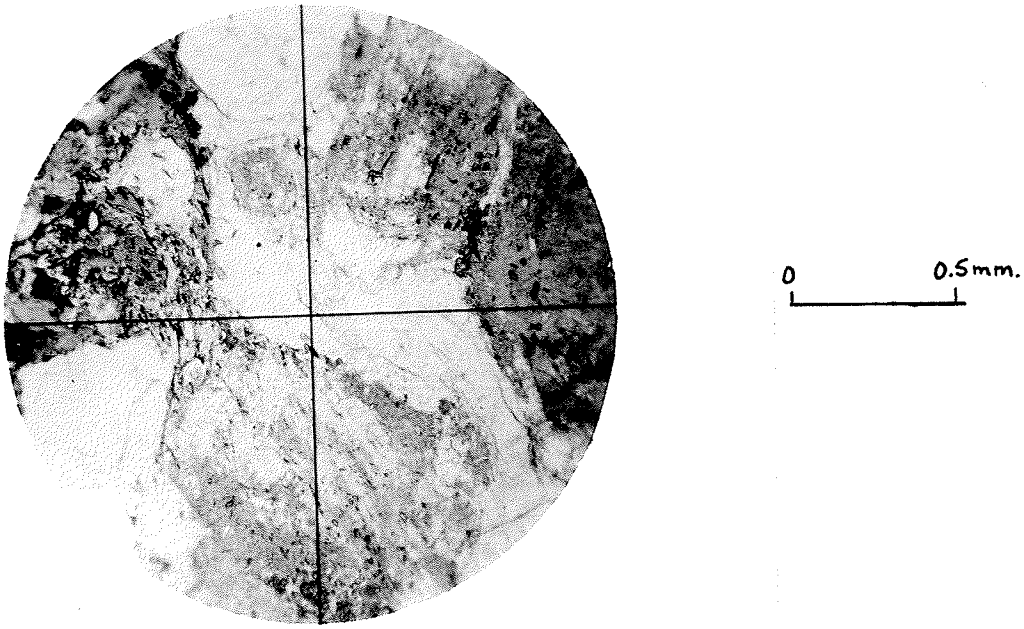
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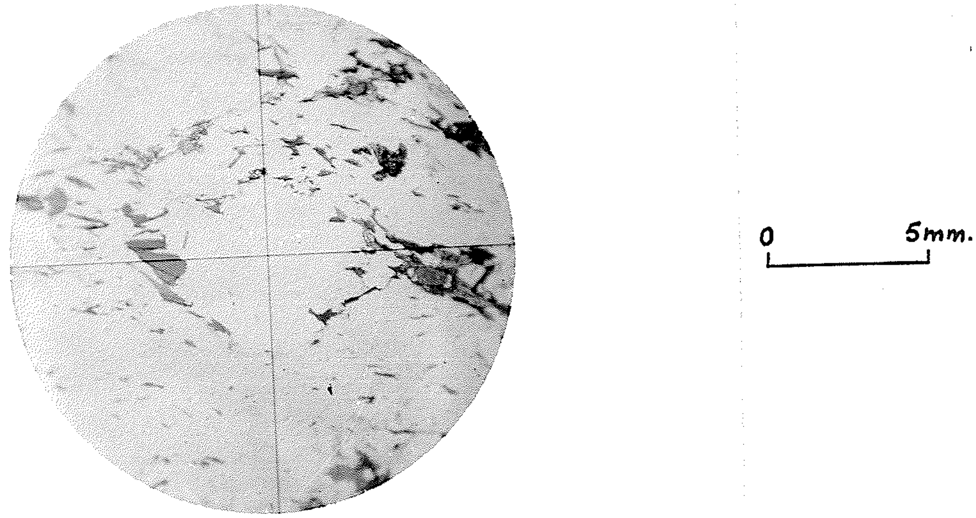
PLATE 8a. Melick Gneiss. Biotite gneiss with plagioclase augen.(Specimen Number 5, ordinary light).

PLATE 8b. Same as 8a under cross-nicols.



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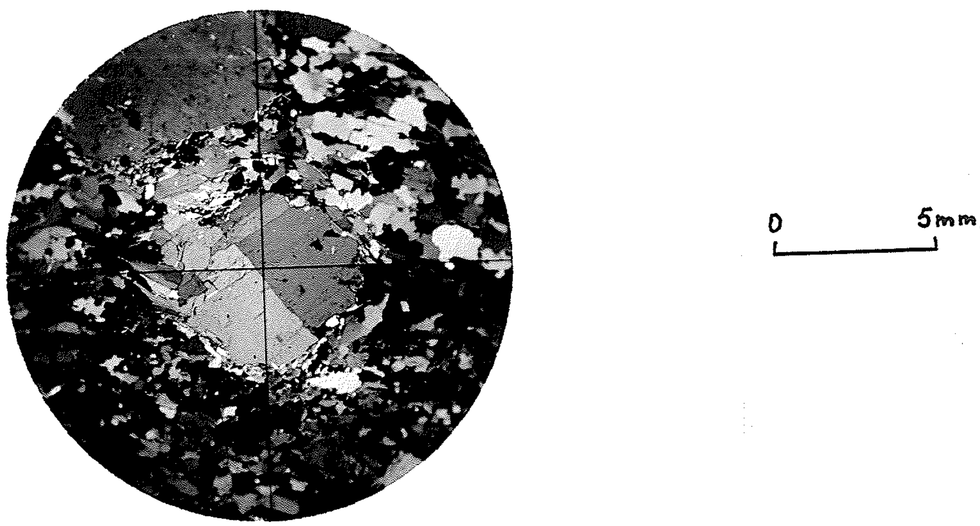

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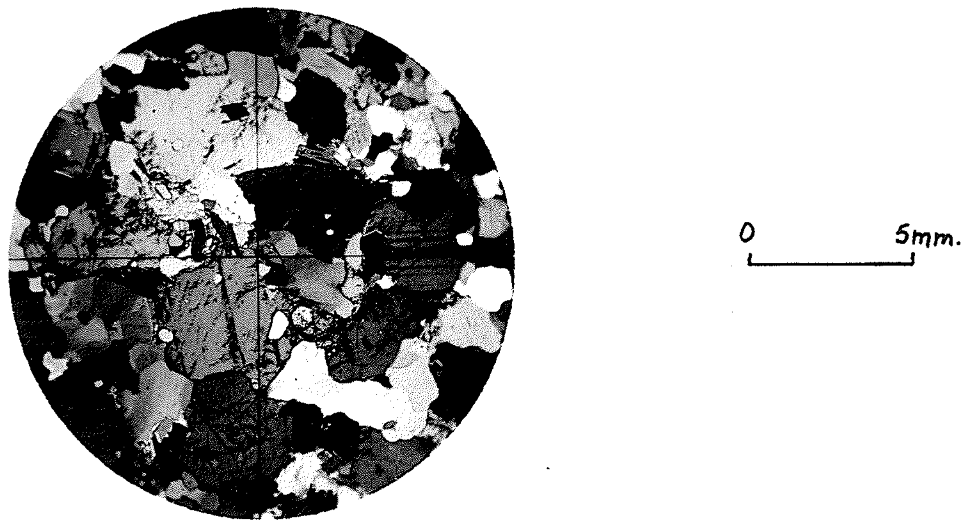
PLATE 9a. Melick Gneiss, Leucocratic Gneiss. Typical texture of Melick Gneiss. (Specimen Number 3, cross-nicols).

PLATE 9b. Melick Gneiss, Leucocratic Gneiss. With euhedral porphyroblasts of feldspar in fine grained quartz-feldspathic mosaic. (Specimen Number 4, cross-nicols).


0
5mm.

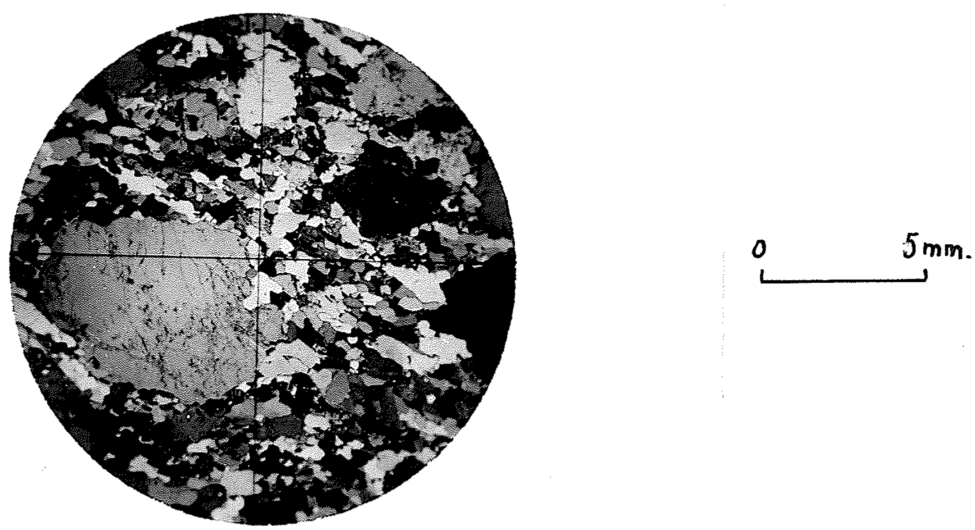

0
5mm.

PLATE 10. Contact between Leucocratic Gneiss and Biotite Gneiss, Melick Gneiss. (Specimen Number 2, cross-nicols)

0 5mm.

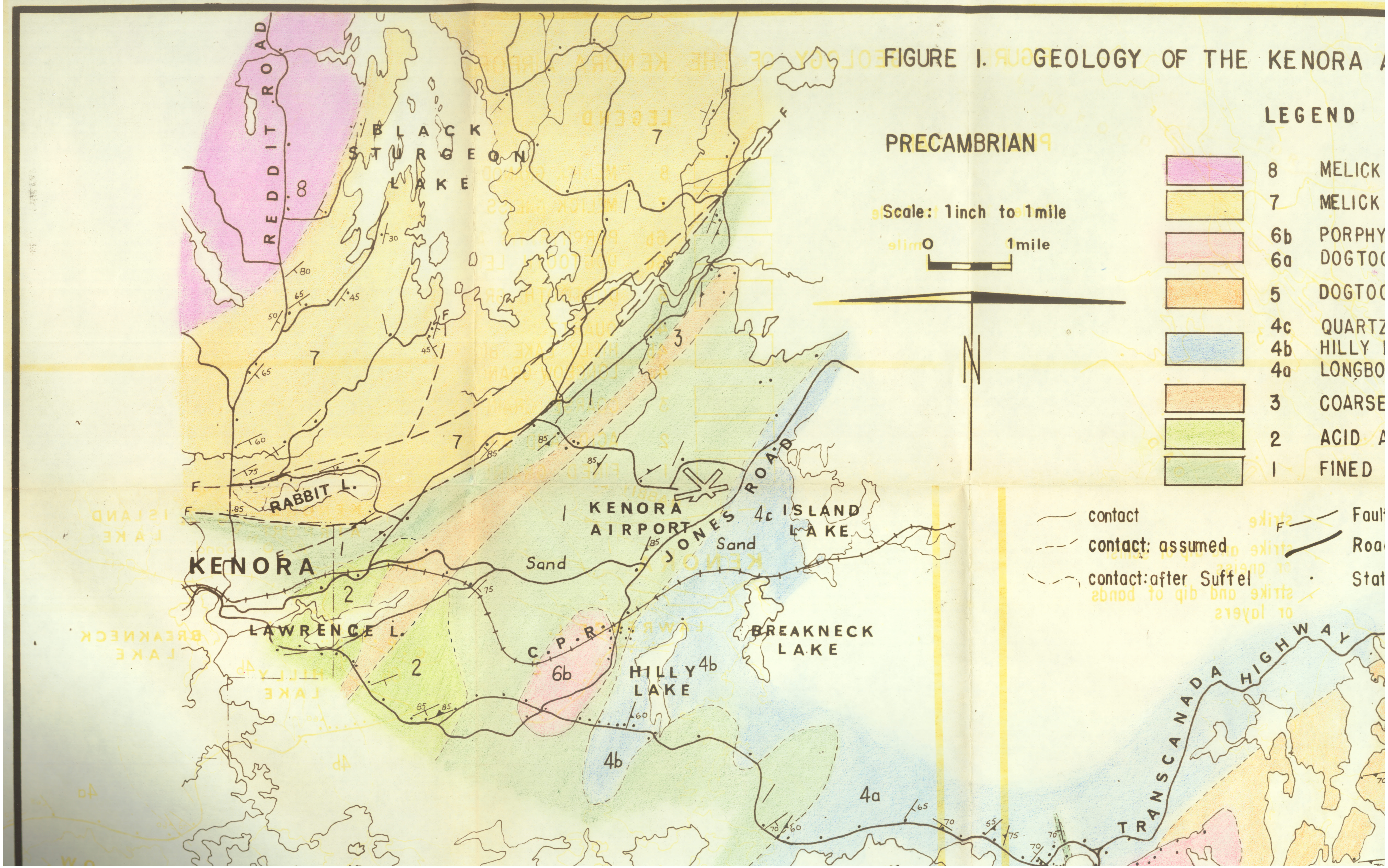
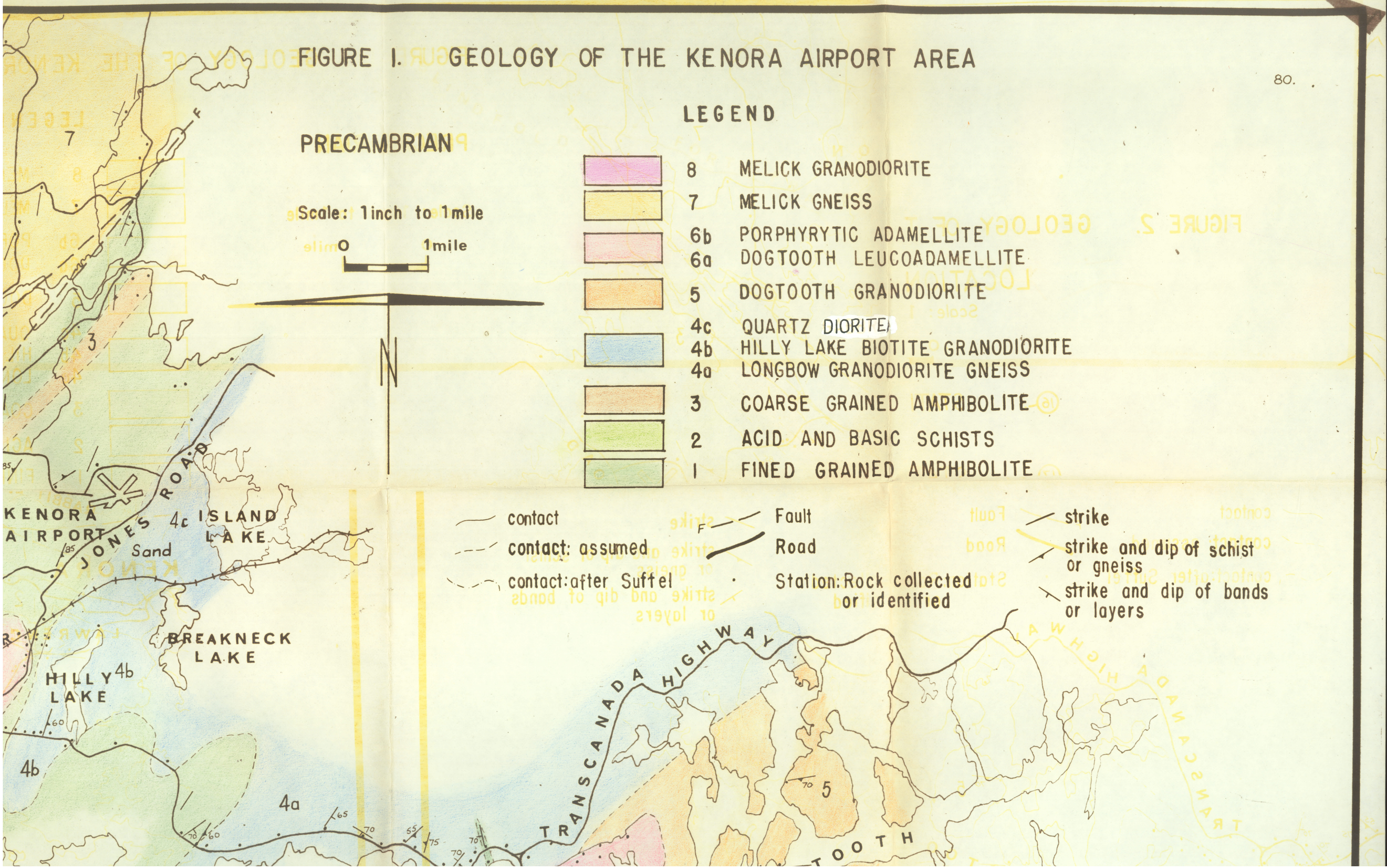
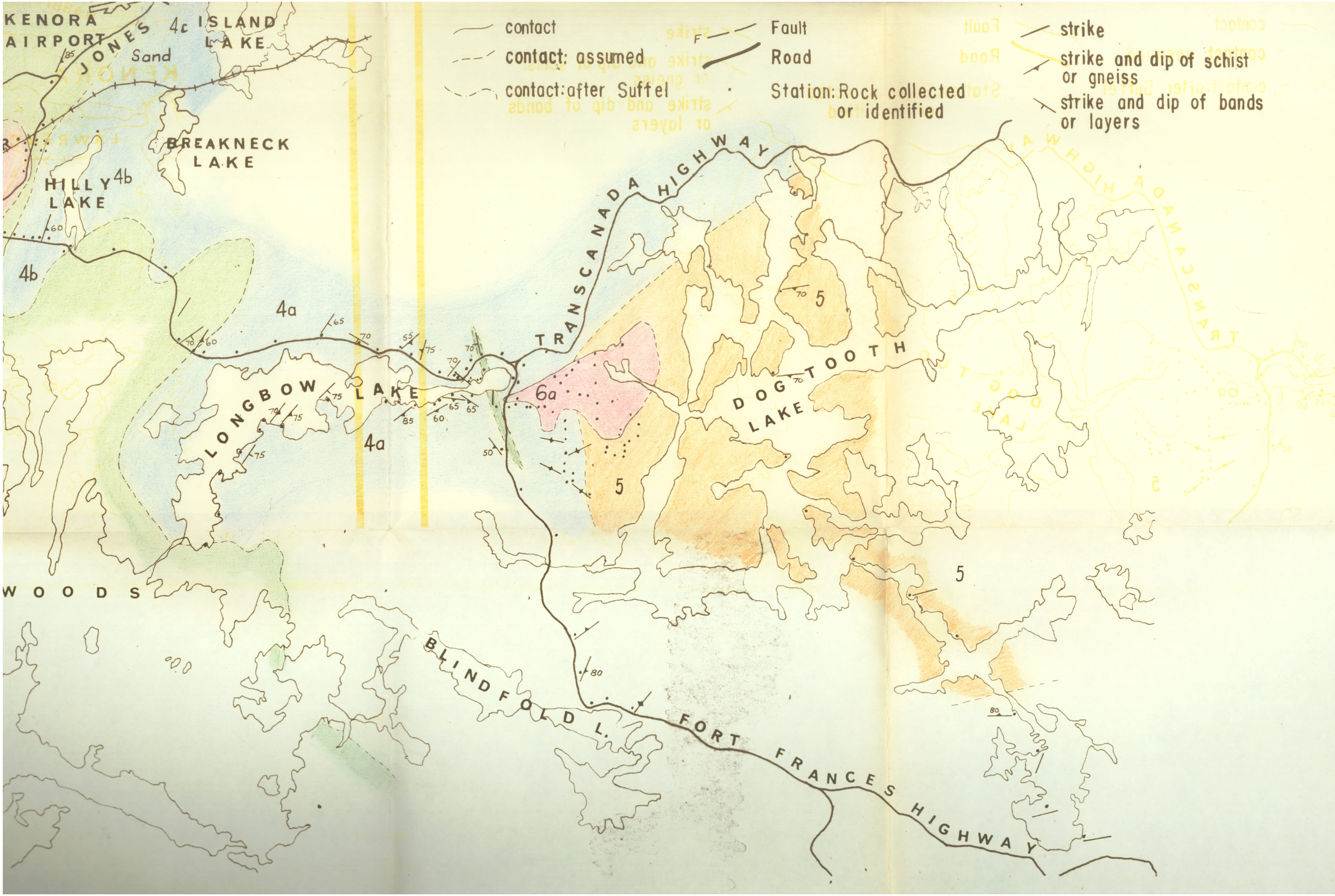


FIGURE I. GEOLOGY OF THE KENORA A
LEGEND
PRECAMBRIAN
8 MELICK
7 MELICK
6b PORPHY
6a DOGTOO
5 DOGTOO
4c QUARTZ
4b HILLY
4a LONGBO
3 COARSE
2 ACID A
1 FINED
Scale: 1inch to 1mile
0 1mile
N
contact
contact: assumed
contact: after Suftel
Faul
Roa
Stat
REDDIT ROAD
BLACK STURGEON LAKE
RABBIT L.
KENORA
LAWRENCE L.
KENORA AIRPORT
JONES ROAD
ISLAND LAKE
BREAKNECK LAKE
HILLY LAKE
C.P.R.
Sand
TRANSCANADA HIGHWAY

FIGURE I. GEOLOGY OF THE KENORA AIRPORT AREA




contact
contact: assumed
contact: after Suftel
KENORA
KENORA AIRPORT
JONES
Sand
Sand
ISLAND LAKE
4c
LAWRENCE L.
C.P.R.
6b
HILLY LAKE
4b
BREAKNECK LAKE
2
1
4a
LONGBOW LAKE
6a
5
TRANSCANADA HIGHWAY
LAKE OF THE WOODS
BLINDFOLD L.
FORT



contact
contact: assumed
contact: after Suffel
F
Fault
Road
Station: Rock collected or identified
strike
strike and dip of schist or gneiss
strike and dip of bands or layers
KENORA AIRPORT
JONES
Sand
4c
ISLAND LAKE
BREAKNECK LAKE
HILLY LAKE
4b
4a
LONGBOW LAKE
TRANSCANADA HIGHWAY
6a
5
DOGTOOTH LAKE
WOODS
BLINDFOLD L.
FORT FRANCES HIGHWAY
85
60
65
70
55
75
50
80

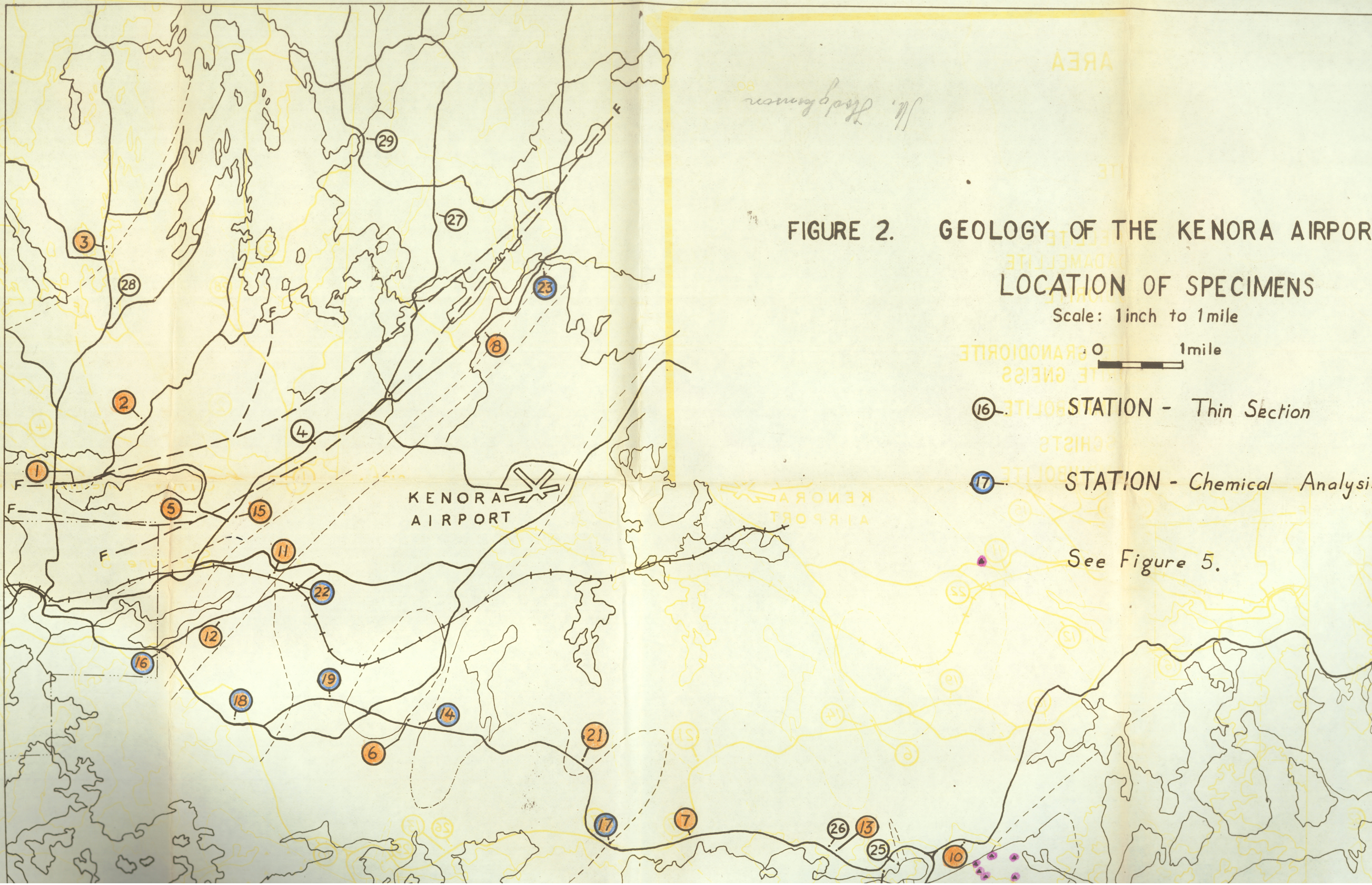


FIGURE 2. GEOLOGY OF THE KENORA AIRPORT
LOCATION OF SPECIMENS
Scale: 1 inch to 1 mile
0
1 mile
16 STATION - Thin Section
17 STATION - Chemical Analysis
See Figure 5.
KENORA
AIRPORT
F
F
F
F
F
1
2
3
4
5
6
7
8
10
11
12
13
14
15
16
17
18
19
21
22
23
25
26
27
28
29

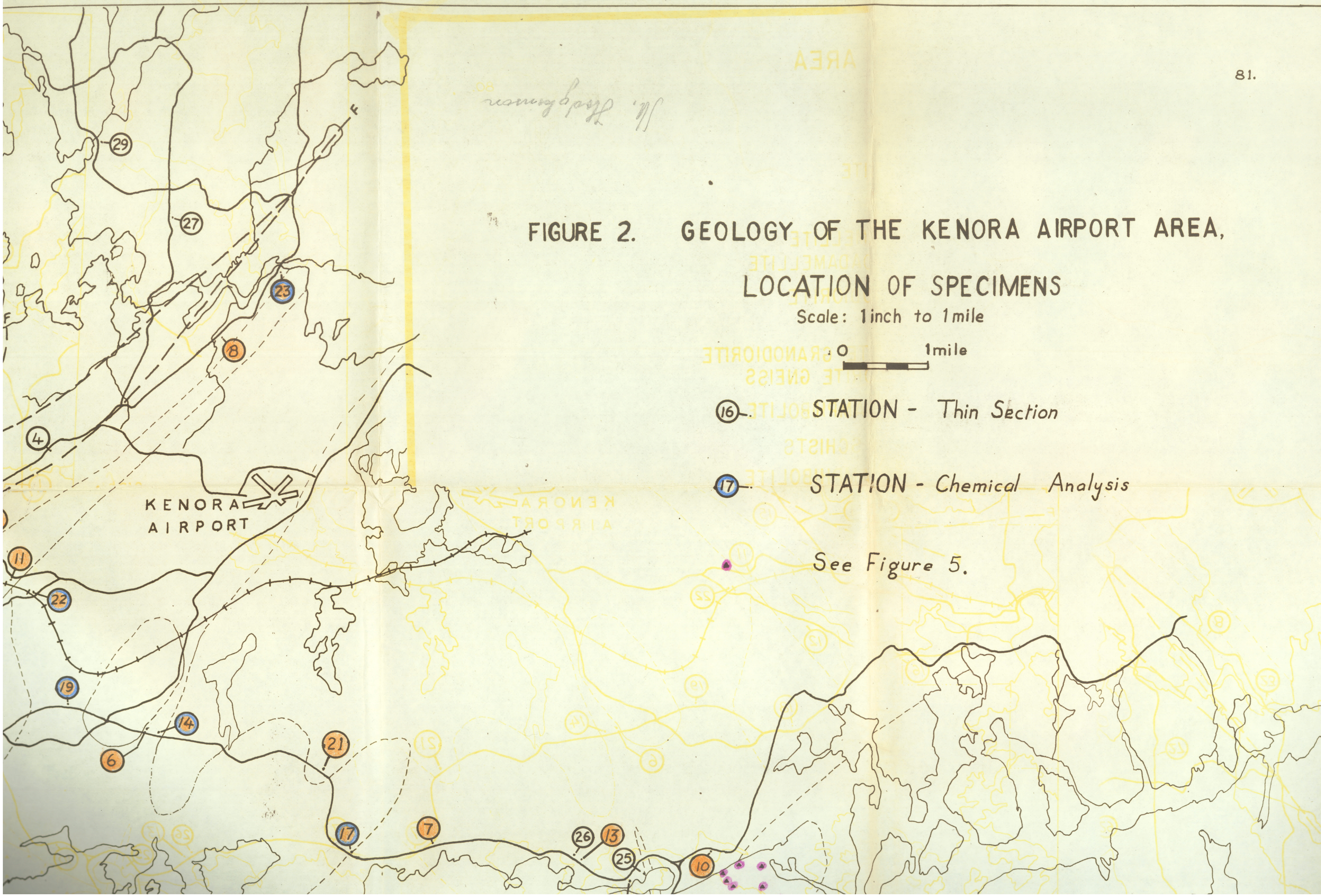
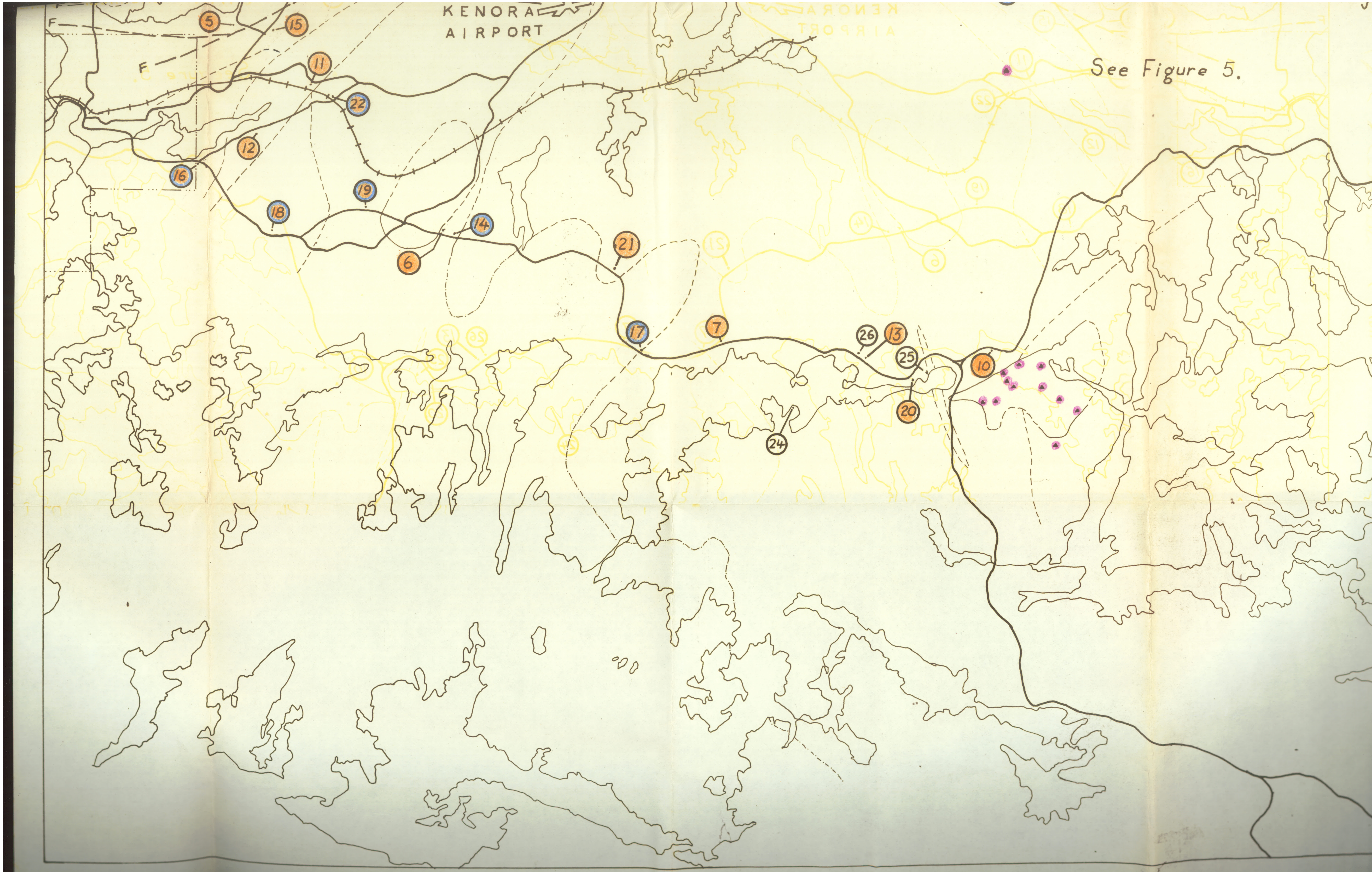


FIGURE 2. GEOLOGY OF THE KENORA AIRPORT AREA, LOCATION OF SPECIMENS



KENORA
AIRPORT
See Figure 5.
F
F
F
5
15
11
22
12
16
19
18
14
6
21
17
7
26
13
25
10
20
24

KENORA
AIRPORT
See Figure 5.
15
11
22
19
18
14
21
6
17
7
26
13
25
10
20
24
J. Hodgkinson, M.Sc. Thesis, 1968.